The Commonwealth of Massachusetts

MASSACHUSETTS HIGHWAY DEPARTMENT

Standard Specifications For Highways and Bridges

Boston, Massachusetts

1988

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DIVISION I

GENERAL REQUIREMENTS AND COVENANTS

SECTION 1.00

DEFINITION OF TERMS

1.01 Definition of Terms.

Wherever in these specifications or other contract documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

1.02 Abbreviations ..... Wherever the following abbreviations are used in these specifications or on the plans, they are to be construed the same as the respective expressions represented:

AAN — American Association of Nurserymen
AAR — Association of American Railroads
AASHTO — American Association of State Highway and Transportation Officials
AGC — Associated General Contractors of America
AIA — American Institute of Architects
ANSI — American National Standards Institute
ARA — American Railway Association
AREA — American Railway Engineering Association
ASA — American Standards Association
ASCE — American Society of Civil Engineers
ASLA — American Society of Landscape Architects
ASTM — American Society for Testing and Materials
AWPA — American Wood Preservers Association
AWWA — American Water Works Association
AWS — American Welding Society
DEQE — Department of Environmental Quality Engineering
EIA — Electronics Industry Association
EIS — Environmental Impact Statement
EPA — Environmental Protection Agency
FHWA — Federal Highway Administration Department of Transportation
FSS — Federal Specifications and Standards
GSA — General Services Administration
IES — Illumination Engineering Society
IMSA — International Municipal Signal Association
ITE — Institute of Traffic Engineers
MEC — Massachusetts Electrical Code
MUTCD — Manual on Uniform Traffic Control Devices
NEC — National Electrical Code
NEMA — National Electrical Manufacturers Association
OSHA — Occupational Safety and Health Administration
SAE — Society of Automotive Engineers
UL — Underwriters Laboratories
USAI — United States of America Standards Institute

1.03 Advertisement ..... The notice, as required by law, inviting bids (proposals) for work to be performed or materials to be furnished.

1.04 Alteration ..... A change or substitution in the form, character, or detail of the work done or to be done within the original scope of the Contract at unit prices stated in the Contract, which alteration makes a change in the item originally contracted for or a substitution from that item to a similar item at the same unit price.

1.05 Award ..... The acceptance by the Department of a bid (proposal) contemplating the execution and delivery of a contract.

1.06 Bid ..... See Proposal.

Bid, informal as to form ... Any informal bid other than a bid that is informal as to substance.

Bid, informal as to substance ..... A bid which contains a deficiency or deviation from what is requested by the Department for inclusion in the Proposal which affects the price, quantity, quality or delivery of the articles offered and therefore is prejudicial to the rights of other bidders.

1.07 Bidder (Proposer) .... Any individual, firm, partnership, corporation or joint venture submitting a Proposal for the work contemplated, acting directly or through a duly authorized representative.

1.08 Bridge ..... The term "bridge" shall apply to any structure whether single or multiple span construction that spans a body of water, depression, highway or railway, and affords passage for pedestrians, or vehicles of all kinds, or any combination thereof having a total length of 20 feet or more.

Length ..... In general, the "length" of a bridge is that distance measured horizontally along the centerline of roadway between extreme centerlines of bridge shoes or bearings, or when shoes or bearing are not used the distance between vertical faces of abutments, or spring lines of arches, or extreme ends of openings for multiple reinforced concrete boxes.

Roadway Width ..... The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers or in the case of multiple height or curbs, between the bottom of the lower risers.

1.09 Commission ..... A commission of five members as specified in General Laws Chapter 16, Section 1.

1.10 Commonwealth ..... The Commonwealth of Massachusetts.

1.11 Contract ..... The written agreement executed between the Party of the First Part and the Contractor setting forth the obligations of the Parties thereunder, including, but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The Contract includes the Notice to Contractors, proposal, contract form and contract bond, specifications, supplemental specifications, special provisions, general and detailed plans, any extra work orders and agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

1.12 Contractor ..... The Party of the Second Part to the Contract, acting directly or through an authorized lawful agent or employee.

1.13 Contract Item (Pay Item) ..... A specifically described unit of work for which a price is provided in the contract.

1.14 Contract Time ..... The number of days allowed for completion of the Contract.
In case a calendar date of completion is shown in the Proposal in lieu of the number of days, the Contract shall be completed by that date.

1.15 Culvert ..... A structure not classified as a bridge which provides an opening under the roadway.

1.16 Day ..... Every day shown on the calendar, Sundays and Holidays included.

1.17 Department ..... The Department of Public Works of the Commonwealth of Massachusetts.

1.18 Differ substantially or materially ... When the character of the work encountered in exposing subsurface or latent physical conditions, while the work is in progress, is found to be essentially different in nature from that shown on the plans or indicated on the contract documents or from that ordinarily encountered and generally recognized as inherent in work of the character provided for in the plans and contract documents and are of such a nature as to cause an increase or decrease in the cost of performance of the work or a change in the construction methods required for the performance of the work, resulting in any increase or decrease in the cost of the work.

1.19 Engineer ..... The Chief Engineer of the Department acting directly or through an authorized representative, such representative acting within the scope of the particular duties entrusted to him.

1.20 Extra Work ..... Work which
1. was not originally anticipated and/or contained in the contract: and therefore
2. is determined by the Engineer to be necessary for the proper completion of the project: and
3. bears a reasonable subsidiary relation to the full execution of the work originally described in the Contract.

1.21 Extra Work Order ... An order in writing issued by the Engineer to the Contractor prior to performing the work, setting forth the Extra Work to be done, the basis of payment and time adjustments, if any.

1.22 Invitation for Bids (Invitation for Proposals) .... The advertisement for Proposals for all work or materials on which bids are required. Such advertisement will indicate the approximate project value and location of the work to be done and the time and place of the opening of Proposals.

1.23 Latent Physical Conditions ..... Actual physical conditions at the site that were indiscernible; hidden; not visible or apparent, and which as a basis for a request for an equitable adjustment, differ substantially and materially from those shown on the plans or indicated in the contract documents.

1.24 Layout Plans ..... Plans showing layout (locations) lines, property lines, corner markers, names of property owners, access and nonaccess (if Limited Access Highway) points, and the location of bounds.

1.25 Location Lines ..... Lines indicating the limits of the Right-of-Way.

1.26 Material ..... Any substances specified for use in the construction of the project and its appurtenances.

1.27 Party of the First Part In contracts with the Department, the Party of the First Part shall be the Department.
In contracts made by a municipality with a Contractor under the provisions of Chapter 90 of the General Laws the Party of the First Part shall be the municipality (town or city) by its duly authorized officials.
In contracts made by a municipality with another party the Party of the First Part shall be the municipality (town or city) by its duly authorized officials.

1.28 Pavement Structure .. The combination of sub-base, base course and surface course placed on a subgrade to support the traffic load and distribute it to the subgrade.

1.29 Plans ..... Approved contract drawings, Department Standards, working drawings, supplemental drawings, Detail Sheets or exact reproductions thereof, which show the location, character, dimensions and details of the work to be done.

1.30 Project ..... The specific section of the highway together will all appurtenances and construction to be performed thereon under the Contract.

1.31 Proposal ..... The written offer of the Bidder, on the prescribed form, to perform the work and to furnish the labor and materials at the prices quoted.

1.32 Proposal Form ..... The approved form on which the Department requires bids to be prepared and submitted for the work.

1.33 Reference ..... Where reference is made in the Contract Documents to Publications or Standards issued by Associations or Societies, the intent shall be to specify the current edition of such Publications or Standards in effect on the date of the contract advertisement, notwithstanding any reference to a particular date.

1.34 Right-of-Way ..... That area which has been laid out or acquired for highway purposes.

1.35 Sieves ..... All sieves referred to in the Specifications shall be standard woven wire cloth sieves and shall conform to the requirements of AASHTO Designation M92.

1.36 Special Provisions .... The special agreements and provisions prepared for proposed work on a specific project. These special provisions shall be included within the general term specifications and shall be made a part of the Contract with the express purpose that they shall prevail over all other specifications.

1.37 Specifications ..... The directions, provisions and requirements contained herein, designated as Standard Specifications, together with all written agreements made or to be made pertaining to the method and manner of performing the work, or the quantities and qualities of materials to be furnished under the Contract.

1.38 Subcontractor ..... An individual, firm, partnership or joint venture to whom the contractor with prior written approval of the Engineer sublets any part of the Contract.

1.39 Subgrade ..... The plane at the bottom of the subbase.

1.40 Supplemental Specifications ..... Additions and revisions to the standard specifications that are issued prior to the opening of bids.

1.41 Unbalanced Bid ..... An unrealistic bid price which is abnormally high or abnormally low for an item of work and does not reflect the actual cost of performing such item of work.

1.42 Work ..... Work shall mean the furnishing of all labor, materials, equipment and other incidentals necessary for or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the Contract. Work shall include in addition to work to be performed on the project location in the actual construction process, necessary shop plans, computations, ordering of materials and equipment, fabrication of material, parts and components, etc.

1.43 ..... In order to avoid cumbersome and confusing repetition of expressions in these specifications, it is provided that whenever anything is, or is to be done, if, as, or, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected, or condemned", it shall be understood as if the expression were followed by the words "by the Engineer" or "to the Engineer".

SECTION 2.00

PROPOSAL REQUIREMENTS AND CONDITIONS

2.01 Proposal Forms and Plans.

A. Prequalification Prior to Requesting Proposal Forms.

Subject to the requirements of Chapter 29, Section 8B of the General Laws, each prospective Bidder proposing to bid on any work, excepting the construction, reconstruction, repair or alteration of buildings, to be awarded by the Department or by a municipality under the provisions of Section 34 of Chapter 90, must be prequalified and certified in accordance with the "Regulations Governing Classification and Rating of Prospective Bidders", if the amount of his proposal added to the value of his uncompleted work already under contract with the Department will aggregate $50,000 or more.

For work aggregating under $50,000, prequalification and certification is desirable but not required.

B. Issuance of Proposal Forms and Plans.

All prospective Bidders who intend to bid on work to be awarded by the Department or by a municipality under the provisions of Section 34, Chapter 90 of the General Laws, must first obtain from the Engineer, CSD — 681 "Request for Proposal Forms" and submit same properly filled out to the Engineer for approval. The Department shall consider each "Request for Proposal Forms" and determine whether or not an officially numbered non-transferable proposal form shall be issued to the prospective Bidder. If the "Request for Proposal Form" is approved, an "Approval for Proposal Form" will be given to the Contractor, who will forward that "Approval for Proposal Form" to the Cashier, Room 5441, 10 Park Plaza, Boston, Massachusetts, accompanied by cash, bank check, certified check or money order in the amount stated in the "Notice to Contractors", made payable to the Massachusetts Department of Public Works.

The required payment shall entitle a prospective Bidder whose request is approved to receive a pamphlet containing an officially numbered non-transferable, itemized proposal form specifying the location and description of the contemplated work: the approximate estimates of the various quantities of work to be performed and materials to be furnished: the time in which the work must be completed; and also a Notice to Contractors and Special Provisions or requirements for the particular project. The payment shall also entitle the

prospective Bidder to a set of project plans and profiles, either full size or reduced size at the option of the Department, a set of full size bridge plans, and detail sheets showing the preliminary estimate of quantities with information pertinent thereto.

The amount will be refunded to only those who submit a formal bid for the project within the time stipulated on the proposal form furnished by the Department, provided the Notice to Contractors so specifies and further provided that the plans are returned in good condition within one week from the date of bid opening, or to a common carrier or the post office department not later than the Friday following bid opening for subsequent delivery to the Department.

Any person may purchase copies of the aforementioned documents, for informational purposes only, upon payment of such fees as the Department shall determine.

2.02 Interpretation of Basic Estimate of Quantities.

A. All bids will be compared on the estimate of quantities of work to be done, as shown in the Proposal.

The parties expressly agree that these quantities are being set forth as a basis for the comparison of bids only and the parties also expressly agree that the actual amount of work may not correspond therewith. The Department expressly reserves the right to adjust said quantities in accordance with actual conditions as found to exist during the course of work.

Bidders agree to submit their estimate upon the following express condition, which shall apply to and become part of every bid received, viz:

An increase or decrease in the quantity for any item shall not be regarded as cause for an increase or decrease in the contract unit prices, nor in the time allowed for the completion of the work, except as provided in the Contract. (Also see Subsections 4.06 and 9.03.)

B. The excavation, masonry and other parts of the work have been divided into classes and items in order to enable the Bidder to bid on the different portions of the work in accordance with his estimate of their cost, so that in the event of an increase or decrease in the quantities of any particular class of work the actual quantities executed shall be paid for at the price bid for that particular class of work, (except in structures bid as a lump sum item where the payment for an increase or decrease in the quantities of concrete will be adjusted as stipulated in Section 995).

2.03 Examination of Plans, Specifications, Special Provisions, and Site of Work.

The Department will prepare plans and specifications giving directions which will enable any competent mechanic or contractor to carry them out. The Bidder is expected to examine carefully the site of the proposed work, the proposal, plans, specifications, supplemental specifications, special provisions, and contract forms, before submitting a Proposal. The submission of a bid shall be considered prima facie evidence that the Bidder has made such examination of the site of the proposed work, plans, proposal, etc. and is familiar with the conditions to be encountered in performing the work and as to the requirements of the plans, specifications, supplemental specifications, special provisions, and Contract.

2.04 Preparation of Proposals.

A. Bid Prices.

The Bidder shall submit his proposal upon the blank forms furnished by the Department. The Bidder shall specify a unit price, in both words and figures, for each item for which a quantity is given, and shall also show the products of the respective unit prices and quantities written in figures in the column provided for that purpose, and the total amount of the proposal obtained by adding the amounts of the several items. All words and figures shall be in ink. In case of a discrepancy between the unit prices written in words and unit prices written in figures, the written words shall govern.

When an item in the Proposal contains a choice to be made by the Bidder, the Bidder shall indicate his choice in accordance with the specifications for that particular item, and thereafter no further choice will be permitted.

The price for any item, bid and contracted for, unless otherwise noted or specified, shall include full compensation for all materials, equipment, tools, labor and incidental work, necessary to complete the item to the satisfaction of the Engineer. The prices, without exception, shall be net, not subject to discount, and shall include all royalties and costs arising from patents, trade marks, and copyrights in any way involved in the work.

B. Signatures.

All Proposals shall be signed correctly with ink in the proper place provided, as follows:

If the Proposal is made by an individual, his name and post office address shall be stated.

If the Proposal is made by a firm, partnership or corporation, it shall be signed by a person having such legal authority from the said firm, partnership or corporation and the person so signing the Proposal shall give his own name and title (if any) in addition to the name and address of the firm, partnership or corporation. If the Proposal is made by a firm or partnership the names and addresses of the individual members shall be given.

If the Proposal is made by a corporation, the name of the State under the laws of which the corporation was chartered and the names, titles and business addresses of the President, Treasurer and Clerk shall be given.

If a Proposal is made by two or more individuals, partnerships, or corporations, or any combination of these as a joint venture, each party joining to make the Proposal shall submit attached to and made part of the Proposal all information and all signatures in compliance with the foregoing provisions applicable to an individual, firm, partnership or corporation. In addition, if any of the joint venture are a corporation, an attested copy of the vote of the corporation authorizing such joint venture shall be attached to the Proposal.

C. Affidavits.

The Bidder shall file a sworn statement executed by or on behalf of the person, firm, association or corporation submitting the bid, certifying that such person, firm, association or corporation has not, either directly or indirectly, entered into an agreement, participated in any collusion, or otherwise taken any action, in restraint of free competitive bidding in connection with the submitted bid. This sworn statement shall be in the form of an affidavit sworn to under the pains and penalties of perjury. The required form for the affidavit will be provided with the Proposal. Failure to submit the sworn statement on the required form as part of the bid approval package shall make the bid informal as to substance and not eligible for award consideration.

2.05 Delivery of Proposals.

The Bidder shall submit prior to the time set for opening of the bid his Proposal properly sealed, delivered or mailed in the envelopes furnished by the Department and in accordance with the instructions printed thereon. A Proposal shall not be accepted unless it is submitted in the envelopes furnished by the Department.

2.06 Proposal Guaranty Required.

In order to insure the faithful fulfillment of its terms, each Proposal shall be accompanied by a bid deposit in the amount required in the Notice to Contractors.

The bid deposit shall be a bid bond in a form satisfactory to the Party of the First Part furnished by a surety company incorporated pursuant to Chapter 175, Section 105 of the General Laws or authorized to do business in the Commonwealth under Chapter 175, Section 106 of the General Laws and satisfactory to the Party of the First Part; or cash; or a certified check drawn on a responsible bank or trust company (or a treasurer's or cashier's check issued by such bank or trust company), payable to the Party of the First Part.

The bid deposit shall not be enclosed in the sealed envelope with the Proposal but shall be delivered to the Supervisor of Fiscal Management or his agent.

The bid deposit will be returned to the Bidder unless retained by the Party of the First Part under conditions hereinafter stipulated.

2.07 Withdrawal of Proposals.

A Bidder may withdraw his Proposal provided the request in writing is in the hands of the Engineer by the time set for opening Proposals. When such proposal is reached during the opening of the bids it will be returned to the bidder unread.

2.08 Public Opening of Proposals.

Proposals will be opened and the total price of each bid read publicly at the time and place indicated in the "Notice to Contractors". Any person may at reasonable times and in the presence of the Engineer examine any or all Proposals after they have been opened and read.

2.09 Rejection of Proposals.

Proposals which fail to meet the requirements of Subsections 2.04, 2.05 and 2.06 or which are incomplete, conditional or obscure, or which contain additions not called for, erasures, alterations or irregularities of any kind, or in which errors occur, or which contain abnormally high or abnormally low prices for any class or item of work, may be declared informal, provided however that the Commission may, if it deems it to be in the public interest, waive any or all informalities as to form. Informalities as to substance, however, shall not be waived.

More than one Proposal from the same Bidder, whether or not the same or different names appear on the

signature page, will not be considered. Reasonable proof for believing that any Bidder is so interested in more than one Proposal for the work contemplated will cause the rejection of all Proposals made by him directly or indirectly. Any Proposals will be rejected if there is reason for believing that collusion exist among the Bidders. (See Subsection 3.01.)

2.10 Disqualification of Bidders.

Bidders whose Proposals have been rejected because of evidence of collusion, as specified in Subsection 2.09 shall not be considered in future Proposals for the same work and such Bidders may be disqualified from bidding on future work.

2.11 Competency of Bidders.

No contract will be awarded except to a responsible Bidder who has been prequalified and certified in accordance with the "Regulations Governing Classification and Rating of Prospective Bidders" and adjudged capable of performing the class of work contemplated, when the bid amount added to the value of the Bidder's uncompleted work already under contract with the Department would aggregate $50,000 or more.

For projects for which prequalification is not required, the low Bidder or the lowest responsible Bidder (if requested by the Engineer) shall submit within ten days after the opening of bids for which he has submitted a Proposal, a post-qualification statement, duly signed and sworn to, outlining his experience, equipment and financial resources, on forms prescribed and supplied by this Department, unless he has submitted such a statement within 12 months prior to said bid opening. A Bidder who fails to comply with this requirement will not be considered for award of the Contract.

2.12 Determination of Lowest Bid.

The lowest bid shall be determined by the Department on the basis of the total price for which the entire work will be performed, arrived at by a correct computation of all the items specified in the Proposal at their estimated quantities and the unit prices submitted therefor.

2.13 Material Guaranty.

Before any Contract is awarded, the Bidder may be required to furnish without expense to the Department a complete statement of the origin, composition and manufacture of any or all materials proposed to be used in the construction of the work, together with samples, which may be subjected to the tests required by the Department to determine the quality and fitness of the material.

SECTION 3.00

AWARD AND EXECUTION OF THE CONTRACT

3.01 Consideration of Proposals.

The Party of the First Part reserves the right to reject any or all Proposals, to waive technicalities, to waive informalities as to form, to advertise for new Proposals, or to proceed to do the work otherwise, as may be deemed to be in the best interest of the Commonwealth.

3.02 Award of Contract.

Subject to the reservations in Subsection 3.01, the Contract will be awarded to the lowest eligible responsible Bidder.

It is anticipated that the Contract will be awarded within 30 days after the opening of bids, or, for projects requiring concurrence by the FHWA, or other Agencies, within 45 days after the opening of bids.

The successful bidder will be notified by mail or otherwise that his bid has been accepted and that he has been awarded the Contract.

3.03 Retention of Proposal Guaranty.

The two lowest Bidders shall keep their bids open for at least 30 days after the opening of bids, or, for projects requiring concurrence by the FHWA, or other Agencies, for at least 45 days after the opening of bids. The Proposal guaranties of the two lowest Bidders will be retained until after execution of the Contract, previous to which, however, either Bidder may substitute a bid bond, cash or certified check (or cashier's or treasurer's check), all as described in Subsection 2.06, for the guaranty already deposited with the Supervisor of Fiscal Management of the Department. The Proposal guaranties of all Bidders other than the two lowest Bidders will be returned within three days after the opening of bids.

After the bid has been kept open for the required number of days the low Bidder may withdraw his bid and request the return of his proposal guaranty, in which case the guaranty of both the two lowest Bidders will be returned and the second lowest Bidder's Proposal shall not be considered for award. After the bid has been kept open for the required number of days the second lowest Bidder may withdraw his bid and request the return of his proposal guaranty, in which case only the proposal guaranty of the second lowest Bidder will be returned.

3.04 Contract Bonds Required.

A. A *Performance Bond* in the full amount of the Contract will be required by the Party of the First Part to ensure the faithful performance of the Contract, including Subsection 7.18.

B. A *Payment Bond* in an amount of the contract price will be required to be furnished by the Contractor to the Party of the First Part as security for payment by the Contractor and Subcontractors for labor, materials, rental equipment and for such other purposes as are more specifically set forth in General Laws, Chapter 149, Section 29 and Chapter 30, Section 39A and all amendments thereto.

The payment bond referred to in Chapter 149, Section 29 and Chapter 30, Section 39A is the sole security, under said sections for payment by the Contractor and Subcontractor for labor performed or furnished and materials used or employed therein; said security to remain in force until the validity of all such claims shall be established and finally determined and if determined and established as valid, all such claims shall be paid by the surety.

The Performance Bond and the Payment Bond shall be in a form satisfactory to the Party of the First Part, furnished by a surety company incorporated pursuant to Chapter 175, Section 105 of the General Laws or authorized to do business in the Commonwealth under Chapter 175, Section 106 of the General Laws and satisfactory to the awarding authority. The name of the agency or agent writing these bonds shall be identified with or on the bond.

All alterations, extensions of time, extra work and any other changes authorized under these specifications, or under any part of the Contract may be made without obtaining the consent of the surety or sureties on the contract bonds.

3.05 Execution of Contract.

The prepared Contract forms, bond forms and certificate of insurance forms will be sent with the notification of award to the successful Bidder who shall execute and deliver the Contract and furnish the required surety to the Department within 14 days after the date of the notice of award.

The Contract shall be in writing. When the Party of the First Part is the Commonwealth, the Contract shall be executed in duplicate, one of which duplicates shall be kept by the Department and one delivered to the Contractor. When the Party of the First Part is a municipality it shall be executed in triplicate, one of which triplicates shall be kept by the municipality, one delivered to the Department, and one delivered to the Contractor.

3.06 Failure to Execute Contract.

Should the successful bidder fail to execute the contract and furnish the bonds and certificate of insurance within the time stipulated, the Party of the First Part may, at its option, determine that the Bidder has abandoned the Contract and thereupon the Proposal and acceptance shall be null and void. The guaranty accompanying the Proposal shall be retained and collected by the Party of the First Part as liquidated damages for the delay and expense caused by the abandonment of the Contract.

SECTION 4.00

SCOPE OF WORK

4.01 Intent of the Contract.

The intent of the Contract is to prescribe the complete work or improvement. The Contractor shall perform all the items of work stipulated in the Proposal in accordance with the lines, grades, typical cross sections and dimensions shown on the plans or supplemental plans, standards, or modifications of them as required by change conditions in the field, and as authorized or directed. The Contractor shall do all clearing and grubbing; make all excavations and embankments; do all shaping and surfacing; construct all drainage structures, bridges and other appurtenant structures, as indicated in the Contract; remove all obstructions from within the lines of the improvement; and shall do such additional, extra and incidental work as may be considered necessary to complete the work in a substantial and acceptable manner; and when it is so completed he shall leave the work in a neat and finished condition.

The Contractor shall do all the work and furnish all the materials, tools and appliances, except as otherwise specified, necessary or proper for performing and completing the work required by the Contract, in the manner and within the time specified. He shall complete the entire work to the satisfaction of the Engineer, and in accordance with the specifications and drawings for the work at the prices agreed upon.

All the work, labor and materials to be done and furnished under the Contract shall be done and furnished pursuant to, and in conformity with the specifications and the drawings for the work, which said specifications and drawings shall form part of the Contract. Further the Contractor shall follow the directions of the Engineer as given from time to time during the progress of the work under the terms of the Contract.

The Contract shall include grading outside the right-of-way together with the work of loaming surfaces, constructing walks, driveways, drains, and other miscellaneous work as shown on the plans and as directed.

The Contract shall, at the discretion of the Party of the First Part, be extended when the safety and convenience of the public necessitates the construction of access roads or approaches to existing roadways or bridges and the nature of such additional work bears a reasonable subsidiary relation to the original Contract.

Copies of all ASTM and AASHTO Specifications will be available for reference at the office of the Engineer.

4.02 Alterations.

Should it be found desirable by the Engineer to make alterations in the form, character, or detail of any of the work done or to be done, the Engineer may order such alterations to be made, defining them in writing, supplemented by drawings when in the judgment of the Engineer it is necessary, and the alterations shall be made accordingly.

The Contractor shall accept as full compensation for work performed under an alteration order the contract unit prices stipulated in the Contract for the actual quantity of work performed in an acceptable manner.

4.03 Extra Work (Also see Subsection 4.05).

The Contractor shall do any work not herein otherwise provided for when and as ordered in writing by the Engineer, such written order to contain particular reference to this Subsection and to designate the work to be done as Extra Work.

Unless specifically noted in the Extra Work Order, Extra Work will not extend the time of completion of the Contract as stipulated in Subsection 8.10, Part F.

The determination of the Engineer shall be final upon all questions concerning the amount and value of Extra Work (except as provided in Subsection 7.16).

Payment for extra work will be as provided in Subsection 9.03.

4.04 Changed Conditions.

In accordance with Chapter 30, Section 39N of the General Laws, as amended, the following paragraph is included in its entirety:

If, during the progress of the work, the Contractor or the awarding authority discovers that the actual subsurface or latent physical conditions encountered at the site differ substantially or materially from those shown

on the plans or indicated in the contract documents either the Contractor or the contracting authority may request an equitable adjustment in the contract price of the Contract applying to work affected by the differing site conditions. A request for such an adjustment shall be in writing and shall be delivered by the party making such claim to the other party as soon as possible after such conditions are discovered. Upon receipt of such a claim from a Contractor, or upon its own initiative, the contracting authority shall make an investigation of such physical conditions, and, if they differ substantially or materially from those shown on the plans or indicated in the contract documents or from those ordinarily encountered and generally recognized as inherent in work of the character provided for in the plans and contract documents and are of such a nature as to cause an increase or decrease in the cost of performance of the work or a change in the construction methods required for the performance of the work which results in an increase or decrease in the cost of the work, the contracting authority shall make an equitable adjustment in the contract price and the Contract shall be modified in writing accordingly.

The filing, investigation and settlement of all claims made under said Chapter and Section shall be as follows:

(a) The Contractor shall promptly, and before such conditions are disturbed notify the Engineer in writing describing in full detail the subsurface or latent physical conditions at the site which he maintains differ substantially or materially from those shown on the plans or indicated in the contract documents. The Engineer shall promptly investigate the conditions, and shall promptly submit a written report of his findings and determinations to the Commission with a copy of same to the Contractor, and if he finds that such conditions as have been described in detail by the Contractor do exist and in fact do so differ materially or substantially, an equitable adjustment shall be made and the Contract modified in writing accordingly. No such claim of the Contractor shall be allowed unless the Contractor has given the detailed notice specified, nor shall it be allowed if such conditions are disturbed prior to their investigation by the Engineer.

(b) No adjustment or allowance of any kind except as provided in Subsection 8.10 will be made to the Contractor on account of any delay or suspension of work or any portion thereof where the actual subsurface or latent physical conditions encountered at the site differ substantially and materially from those shown on the plans or indicated in the contract documents.

(c) No claim will be approved or any adjustment or allowance made on account of encountering subsurface or latent physical conditions at the site that differ substantially and materially from those shown on the plans or indicated in the contract documents unless such conditions were in existence at the time of the award of the Contract.

(d) Any dispute concerning a question of fact under this Subsection which is not disposed of by agreement shall be decided by the Chief Engineer.

(e) If as provided in (a) of this Subsection an equitable adjustment is to be made or contemplated, the Contractor shall submit promptly in writing to the Engineer an itemized statement of the details and amount of work together with his estimated costs for the same and the Engineer shall require the Contractor to keep actual costs and certify the same to the Department in writing.

If the Contractor and the Department fail to agree on an equitable adjustment to be made under this Subsection, then the Contractor shall accept as full payment for the work in dispute an amount equal to the following:

(1) The actual cost for direct labor, materials and use of equipment, plus 10 percent of this total for overhead.

(2) Plus actual cost of Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits, Social Security deductions, Employment Security Benefits and such additional fringe benefits which the Contractor is required to pay as a result of Union Labor Agreements and/or is required by authorized governmental agencies.

(3) Plus 10 percent of the total of (1) and (2).

(4) Plus the estimated proportionate cost of surety bonds. For work performed by a Subcontractor, the Contractor shall accept as full payment therefor an amount equal to the actual cost to the Contractor of such work as determined by the Engineer plus 10 percent of such cost.

No allowance shall be made for general superintendence and the use of small tools and manual equipment.

The Contractor shall, when requested by the Engineer, furnish itemized statements of the cost of the work ordered and give the Engineer access to all accounts, bills and vouchers relating thereto, and unless the Contractor shall furnish all such itemized statements, access to all accounts, bills and vouchers he shall not be entitled to payment for any items of extra work for which such information is sought by the Engineer.

Pending final decision of any dispute hereunder unless otherwise ordered by the Chief Engineer, the Contractor shall proceed diligently with the performance of the Contract and in accordance with the Chief Engineer's decision.

The Contract shall be considered modified in writing by the processing of an Extra Work Order.

The Contractor shall be estopped to rely on and deemed to waive under said Section 39N and this Subsection his right to have an equitable adjustment of a unit price bid by him which, in the opinion of the Chief Engineer, is an unrealistic unit price, abnormally low for the unit item priced and which does not reflect the actual cost of performing such unit item of work. It shall be the obligation of the Chief Engineer to notify the Contractor prior to award of the Contract of any unit price that has been determined to be abnormally low for the unit item priced and that the unrealistic low unit price not reflecting the actual cost of performing such unit item of work would bar the Contractor from an equitable adjustment under said Section 39N and this Subsection.

Any unit item price determined by the Chief Engineer to be an unrealistically high unit price not reflecting the actual cost of performing such unit item of work is subject to the provisions of said Section 39N and this Subsection.

The provisions of Section 39N of Chapter 30 of the General Laws, as amended, do not apply to:

(1) Construction Contracts entered into on behalf of the Commonwealth which provide that payments for the work be made on a lump sum basis.

(2) Construction Contracts entered into on behalf of a municipality under the provisions of Section 34, Chapter 90 of the General Laws.

4.05 Validity of Extra Work.

The Engineer shall be authorized to issue Extra Work Orders for such additional work outside the scope of the original Contract as in his judgment is reasonably necessary for the satisfactory completion of the project provided that the work to be done under such an Extra Work Order, either standing alone or in conjunction with any previously authorized Extra Work Order, shall not result in a change of such magnitude as to be incompatible with the provisions of Chapter 29, Section 20A and Chapter 149, Section 44J of the General Laws.

4.06 Increased or Decreased Contract Quantities.

When the accepted quantities of work vary from the quantities in the bid schedule, the Contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit prices for the accepted quantities of work done.

The Engineer may order omitted from the work any items or portions of the work found unnecessary to the improvement and such omission shall not operate as a waiver of any condition of the Contract nor invalidate any of the provisions thereof, nor shall the Contractor have any claim for anticipated profit.

No allowance will be made for any increased expenses, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly or indirectly from such increased or decreased quantities or from unbalanced allocation, among the contract items of overhead expense on the part of the Bidder and subsequent loss of expected reimbursement therefor or from any other cause.

4.07 Maintenance of Detours.

A. Where the Department authorizes or directs general traffic from a travelled way to be detoured over Town or City streets, the Department will be responsible for maintenance of such detours and placing them in the equivalent condition they were in prior to general traffic being detoured over same. The Contractor shall do all work required hereunder as directed by the Engineer.

Payment for such work shall be made as specified in Subsection 9.03, Payment for Extra Work.

B. Where a Contractor uses public roads or streets as haul roads, unless the road is properly posted for tonnage limitations, the Contractor has a legal right to use such roads or streets if his vehicles are properly registered.

C. Inferred or alleged overloading, causing either excessive weight beyond registered capacity, or spillage is a Police matter for the local authorities.

D. Where a Contractor uses a private way for hauling, it is a matter between the Contractor and the owners of the private way.

E. It shall be the Contractor's responsibility to ascertain whether haul routes are over accepted public or private ways prior to using same for hauling purposes and it is his further responsibility to ascertain if any have posted legal weight limitations or other restrictions and to abide by them.

4.08 Removal and Disposal of Structures and Obstructions.

Existing structures such as bridges, culverts or drainage pipes found within the location lines, which are to be replaced or rendered useless by new construction shall be removed by the Contractor at his own expense unless otherwise provided in these specifications or in the Special Provisions. When their location is such as not to interfere with the work, the removal shall not be done until the new structures replacing them are ready for traffic or other purpose for which the replaced structures are designed, or until the Engineer shall permit.

All material in the above mentioned types of existing structures requiring removal shall remain the property of the owner. The material shall be removed without damage, in sections which will permit easy handling and disposal, to locations within the limits of the project, and convenient for their subsequent removal by the owner, or as directed by the Engineer.

Unless otherwise provided the material from any existing structure may be used temporarily by the Contractor during construction. Such material shall not be cut, bent, broken or otherwise damaged. All discarded material, rubbish, or debris shall be removed from the work and disposed of as directed. No foreign material or debris shall be permitted to remain or move in a waterway.

4.09 Rights in the Use of Materials Found on the Work.

The Contractor, with the prior written approval of the Engineer, may take suitable ledge, gravel, sand, loam, clay or other material from within the location lines of the project under construction and use it on the same project for other purposes than for forming embankments. If such use necessitates securing additional material for forming embankments, the Contractor shall replace at his own expense material of a satisfactory quality. (See Section 120.) The Contractor shall not excavate or remove any material which is not within the excavation as indicated by the slope stakes and grade lines without written approval. No excavated material suitable for use shall be wasted unless otherwise directed.

Nothing in the Contract shall be construed as vesting in the Contractor any right of property in the materials used after they have been attached or affixed to the work or the soil; but all such materials shall, upon being so attached or affixed, become the property of the Party of the First Part.

4.10 Final Cleaning Up.

Upon completion of the work and before acceptance and final payment, the Contractor shall remove and dispose of in an approved manner, at his own expense, from the right-of-way, construction site, dredging site and adjoining property, all temporary structures and all surplus materials and rubbish which the Contractor may have accumulated during the prosecution of the work, and shall leave the areas in a neat and orderly condition.

No equipment or material shall be left within any of the aforementioned areas after acceptance of the Contract without the written permission of the Engineer. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value.

SECTION 5.00

CONTROL OF WORK

5.01 Authority of the Engineer.

The Engineer shall decide all questions which may arise as to the interpretation of the plans and specifications, and he may alter, adjust and approve same when necessary; all questions which may arise as to the quality, quantity, value and acceptability of materials furnished or to be furnished and work performed or to be performed; all questions which may arise as to the progress of the work and need for and manner of correcting same, and also the need for and terms of delays and suspensions; all questions relating to the need for and terms of extra work; all questions relating to the supervision, control and direction of work on the site and the use thereof; all questions as to the acceptable fulfillment of the Contract on the part of the Contractor.

5.02 Plans and Detail Drawings.

Approved plans, profiles and sections on file in the office of the Department will show the location, details and dimensions of the highway, bridges and other work contemplated, and all work shall be in conformity therewith and with the specifications.

Supplemental plans and detail drawings as required in the specifications and furnished by the Contractor or the Department shall upon approval, become part of the complete plans. Supplemental plans for temporary structures, steel sheeting, cofferdams, sign and traffic signal supports, etc., the original design for which is the responsibility of the Contractor, shall bear the seal of a Professional Engineer registered in Massachusetts.

Such approval by the Engineer of supplemental plans or detail drawings, however, shall not operate to relieve the Contractor of any of his responsibility under the Contract nor for errors in dimensions, details or quantities or for nonconformance with details of the original approved design. Any work done or materials ordered for the structures involved prior to the approval of supplemental plans and detail drawings shall be at the Contractor's own risk.

Nothing in the above shall be construed to hold the Contractor liable for the design of any of the permanent structures.

When submitting detail drawings for approval, complete sets of prints as directed shall be furnished the Engineer who will return one set either approved or with corrections marked thereon. Finally, the Contractor shall furnish the Engineer with complete sets of prints as directed of the corrected and approved detail drawings. No changes shall be made in the approved drawing without the written consent of the Engineer.

All computations, shop drawings, design plans and other criteria submitted to the Department for review and approval shall be stamped by a Professional Engineer registered in Massachusetts.

The shop drawings, other than Department Standards, which do not contain original design shall be stamped by a Professional Engineer registered in Massachusetts as an indication of compliance with the design or appropriate standards, but shall not be construed as indicating any responsibility for the original design.

Detail drawings will not be accepted from other than approved suppliers as noted in Subsection 6.01.

The Contractor, upon completion of the work shall submit to the Engineer a 35 mm microfilm copy of each structural steel detail drawing, which shall become the property of the Department. For all overhead and cantilever sign structures and all steel mast arm assemblies, the Contractor shall submit to the Engineer one (1) silver master aperture card and one (1) diazo duplicate of each shop drawing. All microfilm shall be prepared in accordance with the instructions of the Department's Microfilm section.

The contract prices shall include the cost of furnishing all detail drawings and microfilms and the Contractor will be allowed no extra compensation therefor.

5.03 Conformity with Plans and Specifications.

Attention is directed to Chapter 30, Section 39I which provides that no wilful and substantial deviation from plans and specifications shall be made unless authorized in writing by the awarding authority or by the Engineer in charge of the work who is duly authorized by the awarding authority to approve such deviation. This act further provides that in order to avoid delays in the prosecution of the work, such deviation may be authorized by a written order of the awarding authority, or such Engineer as is authorized to approve such deviation, and that within 30 days thereafter such written order shall be confirmed by a certificate of the awarding authority.

All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions, details, gradations, physical and chemical characteristics of materials and other specific requirements of the Contract. Where the terms "in conformity with", "in agreement with", "in compliance with" or terms of like exactness occur in these specifications they shall be construed to mean "in reasonable close conformity with".

Where definite tolerances are specified in the Contract, such tolerances shall fix the limits of reasonably close conformity. Where tolerances are not specified in the Contract, the Engineer will determine the limits of reasonably close conformity in each individual case and his decision shall be final and conclusive and mutually accepted by all parties.

In the event the Engineer finds the materials or the finished product in which the materials are used not within reasonably close conformity with the plans and specifications but that reasonably acceptable work has been produced, he shall then make a determination if the work shall be accepted and remain in place. In this event, the Engineer will document the basis of acceptance by contract modification which will provide for an appropriate adjustment in the contract price for such work or materials as he deems necessary to conform to his determination based on engineering judgment, and in accordance with current construction practices.

In the event the Engineer finds the materials or the finished product in which the materials are used or the work performed are not in reasonably close conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, the work or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

Deviations from the approved plans and working drawings, that may be required by the need of the construction, will be determined by the Engineer and authorized by him in writing.

5.04 Coordination of Special Provisions, Plans, Supplemental Specifications and Standard Specifications.

The Special Provisions, Plans (including Departmental Standards), Supplemental Specifications, Standard Specifications and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In the event of any discrepancy between the drawing and figures written thereon, the figures, unless obviously incorrect, are to govern over scaled dimensions. In the case of any discrepancy between the plans and the specifications, the plans are to govern. If there is a discrepancy between these Standard Specifications and Supplemental Specifications, the Supplemental Specifications are to govern. Special Provisions shall govern over Supplemental Specifications, plans and Standard Specifications.

The Contractor shall take no advantage of any apparent error or omission in the plans or specifications. In the event the Contractor discovers such an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Contract.

5.05 Cooperation by Contractor.

The Contractor will be given three copies of full size approved contract drawings, detail sheets and contract specifications (except Standard Specifications).

The Contractor shall purchase any required Standard Specifications from the Department. The Contractor may request and the Engineer may approve furnishing additional copies of contract drawings either full or halfsize at the Contractor's expense. He shall have one copy of all such information and a copy of the Standard Specifications on the work site and available for reference at all times during the prosecution of the work. The Contractor shall have on the work at all times, as his agent, a competent superintendent or foreman capable of reading and thoroughly understanding the plans and specifications and thoroughly experienced in the type of work being performed, authorized to receive orders and to act for him.

Whenever the Contractor is not present on any part of the work, if it is necessary or desirable that directions be given, such directions or orders will be given by the Engineer and they shall be received and executed by the foreman or superintendent who is in charge of the particular work with reference to which the orders are given.

The Contractor shall provide all reasonable facilities to enable the Engineer to make necessary measurements and to inspect the workmanship and materials entering into the work. He shall cooperate in the matter of setting and preserving stakes, bench marks, etc., for controlling the work.

The Contractor shall so carry on his work under the direction of the Engineer that Public Service Corporations, or Municipal Departments may enter on the work to make changes in their structures or to place new structures and connections therewith without interference, and the Contractor shall have no claim for, or on account of any delay which may be due to or result from said work of Public Service Corporations or Municipal Departments. No allowance of any kind will be made except as provided in Subsection 8.10. Nothing contained herein shall be construed to hold the Contractor responsible for any acts or omissions by such Public Service Corporations, Municipal Departments or their Contractors.

5.06 Adjacent Contracts.

The Department reserves the right at any time to contract for and perform other or additional work on or near the work covered by the Contract. The intent of this section is to provide for the cooperation of Contractors in cases where the Department deems it expedient or necessary and in the best interest of the Commonwealth to let a separate Contract for the performance of other work on or near the same project location as the work being performed under the Contract, but it is not intended to indicate any intention on the part of the Department to let a separate Contract for any work within the scope of or necessary for the successful completion of the Contract.

When separate Contracts are let within the limits of any one project (either prior to award of Contract, or as specified in project proposal, or as specified above), each Contractor shall conduct his work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as directed.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with his Contract and shall protect and save harmless the Department from any and all damage or claims that may arise because of inconvenience, delay, or loss experienced by him because of the presence and operations of other Contractors working within the limits of the same project. No allowance of any kind will be made except as provided in Subsection 8.10.

The Contractor shall arrange his work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. He shall join his work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

5.07 Construction (Stakes) Stakings.

The Department will furnish the following survey work:

A. Establishment of base lines or centerlines of construction for main roadways, ramps, service roads, side streets and other major dry land items. Reproduction of base lines and centerlines, or lines offset to them when roadway cuts and fills have been completed. Levels may be taken on the points marking these lines.

B. General bench mark control for the project.

C. Original grade stakes at 50′ intervals.

D. Preliminary and final surveys of pits (if borrow is paid by pit measure) and dredging areas, semifinal cross sections on ledge, peat, loam, etc.

E. Control for structures, which shall consist of range lines on centerline of bearings or centerline of piers, face of abutments and wingwalls, horizontal and vertical control for beam seats, along with bench marks close to structures for vertical control. Structures shall include but shall not be limited to bridges, culverts, dams, buildings and walls.

F. Control for alignment of curbing or edging on ramps and at other complicated locations.

G. Bound points and sideline stakes.

H. All necessary stakes for pipes and head walls, and establish all catch basin and manhole locations as to line and grade.

The Contractor shall employ qualified engineering personnel to insure adequate control and shall furnish and set stakes of the quality used by the Department for control staking. Rough stakes may be used to denote top and bottom of slopes, edge of pavement, gutter lines, etc.

The Contractor shall furnish and set, at his own expense, all remaining stakes (such as batter boards, slope stakes, pins, offset stakes, etc.) required for the construction operations and he shall be solely responsible for the accuracy of the line and grade of all features of his work.

The Contractor shall be held responsible for the preservation of all stakes and marks placed by the Engineer. If any of such stakes or marks are disturbed or destroyed by the Contractor the cost of replacing them shall be deducted from the payment for the work as stipulated in Subsection 9.05.

5.08 Authority and Duties of Engineer's Assistants.

The Engineer may appoint such assistants and representatives as he desires and they shall be authorized to inspect work and materials, to give directions pertaining to the work or to the safety and convenience of the public, to approve or reject materials, to make measurements of quantities and to perform such other duties as may be designated by the Engineer.

In case of any dispute arising between the Contractor and the Engineer's assistants, as to materials furnished or the manner of performing the work, the Engineer's assistants shall have the authority to reject the materials or to suspend the work until the question at issue can be referred to and decided by the Engineer:

Engineer's assistants are not authorized to revoke, alter, enlarge, relax or release any requirements of these specifications nor to issue instructions contrary to the plans and specifications.

In no case shall the Engineer's assistants act as foremen or perform other duties for the Contractor.

5.09 Inspection of Work.

All materials and each part or detail of the work shall be subject to inspection by the Engineer. The Engineer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection, (such assistance may include furnishing labor, boats, tools, equipment, etc., at no expense to the Department).

If the Engineer so requests, the Contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed, will be at the Contractor's expense.

Any work done or materials used without authorization by the Engineer may be ordered removed and replaced at the Contractor's expense.

The Contractor shall furnish written information to the Engineer stating the original sources of supply of all materials manufactured away from the actual site of the work. In order to insure a proper time sequence for required inspection and approval this information shall be furnished at least two week (or as otherwise directed by the Engineer) in advance of the incorporation in the work of any such materials.

For the purpose of observing work that affects their respective properties, inspectors for the municipalities, public agencies and the utility companies shall be permitted access to the work, but all official orders and directives to the Contractor will be issued by the Engineer.

Such inspection shall in no sense make any unit of government or political subdivision a party to this Contract, and shall in no way interfere with the rights of either party hereunder.

The inspection of the work shall not relieve the Contractor of any of his obligations to fulfill the terms of the Contract as herein prescribed by the plans and specifications.

Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered, nor obligate the Department to make final acceptance.

The Contractor shall give prior notice to the Engineer when work on the various items is to be performed by him or his Subcontractors. If work is suspended on any item, prior notice shall be given to the Engineer before resumption of such work. Except in case of an unforeseen emergency, neither the Contractor nor any Subcontractor shall perform any work requiring inspection at hours other than during the normal work day without prior approval of the Engineer.

5.10 Removal of Defective or Unauthorized Work.

All defective work shall be removed, repaired or made good, not withstanding that such work has previously been inspected and approved or estimated for payment. If the work or any part thereof shall be found defective at any time before the final acceptance of the whole work, the Contractor shall at his own expense make good such defect in a satisfactory manner.

Any work done beyond the lines and grades shown on the plans or as given, except as herein provided, or any extra work done without authority, shall be considered as unauthorized and at the expense of the Contractor. Such work will not be measured nor compensation allowed therefor. Work so done may be ordered removed at the Contractor's expense.

Upon failure of the Contractor to remove and satisfactorily dispose of any or all defective or unauthorized work, and to remedy the same after being so notified, the Engineer may cause such defective work to be remedied, removed and replaced; and such unauthorized work to be removed, and to deduct the costs therefor from any moneys due or to become due the Contractor.

5.11 Final Acceptance (Also see Subsections 7.20 and 9.05)

Upon due notice from the Contractor by certified mail of presumptive completion of the entire project, the Engineer will make an inspection. If all construction provided for and contemplated by the Contract is found completed to his satisfaction, that inspection shall constitute the final inspection and the Chief Engineer shall in writing make acceptance of the physical work, which acceptance shall relieve the Contractor from further responsibility only with respect to the physical work. Subsequent to the final acceptance of the physical work and upon compliance with the terms of the Contract relating to submission of contractually required reports or other documents, the Engineer will recommend final acceptance of the Contract to the Board of Commissioners (see Subsection 9.05).

If the work or any part thereof is not acceptable to the Engineer at the time of the inspection, the Contractor will be notified in writing of the particular defects or parts to be remedied before final acceptance. If the Contractor has not arranged within a period of five days after the date of transmittal of such notice of nonacceptability, to complete the work speedily as described by the Engineer, the Engineer may without further notice and without in any way affecting the Contract make such other arrangements as may be considered necessary to insure the satisfactory completion of the project. The cost of so completing the work shall be deducted from any moneys due or which may become due the Contractor under the Contract.

After the Contractor has finished installing the controller and all other associated traffic signal control equipment and after the Contractor has set the signal equipment to operate as specified in the contract documents, the fine tuning, adjusting and testing period shall begin. During this period, the Contractor, under the direction of the Engineer and with the cooperation of the local community representatives, if applicable, will make necessary adjustments and tests to ensure safe and efficient operation of the equipment. This period shall not last for more than 30 days, and the contract completion date has taken this testing period into consideration. No request for final acceptance will be considered until successful completion of the testing period.

SECTION 6.00

CONTROL OF MATERIALS

6.01 Source of Supply and Quality.

If the Engineer so desires, materials may be approved at the source of supply before delivery is started.

The Department reserves the right to require approval of the source of supply for any material to be incorporated into the work prior to delivery or manufacture.

The Engineer reserves the right to prohibit the use of materials, products or components which in his opinion may be supplied in a manner not reasonably consistent with contract requirements.

The determination of the Engineer shall be final upon all questions which pertain to supplier approval.

Unless otherwise stipulated in the Special Provisions, the Contractor shall furnish all materials required for the work specified in the Contract, and said materials shall meet the requirements of the specifications for the kind of work involving their use.

Chapter 7, Section 22, Clause 17, of the General Laws, as amended, shall apply to the purchase by the Contractor of supplies and materials to be used in the execution of this Contract.

The rules referred to require a preference in the purchase of supplies and materials, other considerations being equal, in favor first, of supplies and materials manufactured and sold within the Commonwealth, and second, of supplies and materials manufactured and sold within the United States. On Federal Aid Projects the following shall also apply:

No requirements shall be imposed and no procedure shall be enforced by any State in connection with a project which may operate to require the use or provide a price differential in favor of articles or materials produced within the State, or otherwise to prohibit, restrict or discriminate against the use of articles or materials shipped from or prepared, made or produced in any State, territory or possession of the United States.

In Contracts requiring structural steel, the Contractor shall furnish approved erection procedures to the inspector of structural materials at the source of supply or site of fabrication. The inspector shall not stamp his approval or release material for shipment until such approved procedures are received.

Unless otherwise provided, only new and first quality materials conforming to the requirements of these specifications and approved by the Engineer shall be used in the work, except for material used by the Contractor for his convenience and which is not to be incorporated in the permanent work.

If, after test(s), it is found that sources of supply which have been approved do not furnish a uniform product, or if the product from such source proves unacceptable at any time, the Contractor shall, at his own expense, take any and all steps necessary to furnish approved materials.

Where no inspection of materials is arranged for by the Party of the First Part and before such materials are incorporated into the work, the Contractor shall be required to submit to the Party of the First Part for approval, three copies of the Manufacturer's or Supplier's statement for each kind of material furnished, which shall certify compliance with the specifications and shall contain the following information:

1. Contract Number, City or Town, Name of Road and Federal Aid Number:
2. Name of the Contractor to which the material is supplied:
3. Kind of material supplied:
4. Quantity of material represented by the certificate:
5. Means of identifying the consignment, such as label, marking, seal number, etc.:
6. Date and method of shipment:
7. Statement to the effect that the material has been tested and found in conformity with the pertinent parts of the Contract:
8. Results of all required tests including the chemical analysis in the case of metal: or in lieu of furnishing the results a statement that results of all required tests pertinent to the certificate and not submitted shall be maintained available by the undersigned for a period of not less than three years from date of final acceptance or not less than three years from date of final payment to the State from Federal Funds (whichever period is the longest shall apply):
9. Signature of a person having legal authority to bind the supplier.

If the Contractor has new materials purchased for use on a previous Department Contract which have never been used and which comply with the specifications, these materials may be furnished and used provided the Contractor submits his own sworn statement certifying that such materials were purchased for use on a

previous Contract (naming and identifying such Contract) and that certificates of compliance were furnished for such materials on the previous Contract, to which reference can be made.

Any cost involved in furnishing the certificate shall be borne by the Contractor.

6.02 Samples and Tests.

The inspection and sampling of materials will be carried out, ordinarily, at the source or at the site of the Contract work in accordance with established policies and procedures of the Department; but the Department will not assume any obligation for the inspection and sampling of materials at the source. The responsibility of incorporating satisfactory material in the work rests entirely with the Contractor, notwithstanding any prior inspection or test.

Tests of materials will be made by the Department or under its direction in accordance with the Standards of the test as designated. The Contractor or his suppliers shall furnish such facilities as the Engineer may require for collecting and forwarding samples, and shall not make use of, nor incorporate in the work, any material represented by the samples until the required tests have been made and the material accepted, unless otherwise directed. The Contractor in all cases shall furnish the required samples without charge.

Materials such as crushed stone, gravel borrow, ordinary borrow, etc., will be sampled at the source and approved for use. However, such preliminary approval by the Engineer does not relieve the Contractor of the responsibility for placing satisfactory material in the work as determined by subsequent samples taken at the source or on the project prior to the material being incorporated into the work and if the project samples test satisfactorily the material will be considered to meet the Contract requirements as to quality. If such sampling and testing reveal that the material is unsatisfactory it will then be the responsibility of the Contractor to remove it from the work or blend it with such other materials so that an acceptable material will be produced. The removal and blending of such material shall be done by the Contractor without additional compensation.

6.03 Delivery and Storage of Materials.

Materials and equipment shall be progressively delivered at the site so that there will be neither delay in the progress of the work nor an accumulation of materials that is not to be used within a reasonable time.

Materials shall be so stored as to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the Contractor's plant and equipment, but any additional space required therefor must be provided by the Contractor at his expense. Private property shall not be used for storage purposes without written permission of the owner or lessee, and if requested by the Engineer copies of such written permission shall be furnished to him. All storage sites shall be restored to their original condition by the Contractor at his expense. This shall not apply to the stripping and storing of topsoil, or to other materials salvaged from the work.

6.04 Defective Materials.

Materials not conforming to these specifications shall be rejected and removed from the work by the Contractor as directed. No rejected material, the defects of which have been subsequently corrected, shall be used except with the permission of the Engineer. Should the Contractor fail to remove defective material within the time indicated in writing, the Engineer shall have the authority to remove and replace the defective material, and the cost of such removal and replacement will be deducted from any moneys due or to become due the Contractor.

SECTION 7.00

LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

7.01 Laws to be Observed.

A. General.

The Contractor shall keep himself fully informed of all state and national laws and municipal ordinances and regulations in any manner affecting those engaged or employed in the work, or the materials used in the work, or in any way affecting the conduct of the work, and of all orders and decrees of bodies or tribunals, having any jurisdiction or authority over the same. If any discrepancy or inconsistency is discovered in

the Contract for the work in relation to any law, ordinance, regulation, order or decree; the Contractor shall forthwith report the same to the Engineer in writing. He shall at all times observe and comply with, and shall cause all his agents and employees to observe and comply with all existing laws, ordinances, regulations, orders and decrees.

The Contractor, if a foreign corporation, (a corporation established, organized or chartered under laws other than those of the Commonwealth) shall comply with the provisions of Sections 3 and 5 of Chapter 181 of the General Laws as amended. Section 3 provides that the State Secretary shall be appointed for the service of legal process in the case of a foreign corporation doing business in this Commonwealth. Section 5 requires every such corporation to file with the said secretary copies of its charter, certificate of incorporation, a true copy of its bylaws and other information.

The Contractor shall file with the Department with each bid, a certificate from the State Secretary stating that such corporation has complied with Sections 3 and 5 of Chapter 181 and the date of such compliance.

Other out-of-state business organizations, such as individual proprietorship, partnership, etc. shall appoint an agent in this Commonwealth for the service of legal process and furnish a copy of such appointment to the State Secretary prior to the issuance of a Contract by the Department.

It shall be the responsibility of the Contractor to observe and practice to the fullest extent practicable controls, procedures and methods lending themselves to protection of the human and natural environment.

The Contractor shall at all times observe and comply with and shall cause all his agents and employees to observe and comply with all existing laws, ordinances, regulations, orders and decrees especially in their relationship to the protection of the total environment.

Executive Order 130 (Anti Boycott Covenant)

The Contractor warrants, represents and agrees that during the time this contract is in effect, neither it nor any affiliated company, as hereafter defined, participates in or cooperates with an international boycott, as defined in Section 999 (b) (3) and (4) of the Internal Revenue Code of 1954, as amended, or engages in conduct declared to be unlawful by Section 2 of Chapter 151 E, Massachusetts General Laws. If there shall be a breach in the warranty, representation and agreement contained in this paragraph, then without limiting such other rights as it may have the Commonwealth shall be entitled to rescind this contract.

As used herein, an affiliated company shall be any business entity of which at least 51% of the ownership interests are directly or indirectly owned by the Contractor or by a person or persons or business entity or entities directly or indirectly owning at least 51% of the ownership interests of the Contractor, or which directly or indirectly owns at least 51% of the ownership interests of the Contractor.

Executive Order No. 195

In compliance with Executive Order No. 195 of the Governor of the Commonwealth, the Governor or his designee, the Secretary of Administration and Finance, and the State Auditor or his designee shall have the right at reasonable times and upon reasonable notice to examine the books, records and other compilations of data of the contractor which pertain to the performance of the provisions and requirements of this contract.

Minimum Dump Truck Rates.

In accordance with the provisions of Chapter 694 of the Acts of 1951, the minimum dump truck rates and transportation charges shall be as prescribed by the Department of Public Utilities with respect to common and contract carriers who engage in dump-truck operations.

B. Air Pollution Control.

The Contractor shall comply with the provisions of Chapter 111, as amended, of the General Laws of the Commonwealth, pertaining to and establishing the Air Pollution Control Districts in the Commonwealth. The burning of trees, brush, etc. will not be permitted. The Contractor shall provide other satisfactory, approved methods of disposal without additional compensation.

C. Prevention of Water Pollution (See Subsection 7.02).

Attention of the Contractor's directed to Section 42 of the Massachusetts Clean Waters Act (Chapter 21 of the General Laws as amended).

D. Plant Pest Control.

The Contractor's attention is directed to the provisions of The Federal Plant Quarantine Act of 1912, as amended (7 U.S.C. 151-165 and 167); The Terminal Inspection Act of March 4, 1915, as amended (7 U.S.C. 166); Organic Act of 1944, as amended (7 U.S.C. 150aa-150jj); Cooperation with States in Administration and Enforcement of Certain Federal Laws, approved September 28, 1962 (7 U.S.C. 450).

All soil moving equipment operating in regulated areas in Massachusetts will be subject to plant quarantine regulations. In general, these regulations require the thorough cleaning of soil from equipment by the Contractor before such equipment is moved from regulated areas within Massachusetts to uninfested areas either within or without the Commonwealth. The cost of such cleaning shall be included in the contract prices and shall not be in addition thereto.

Complete information may be obtained from the Massachusetts Department of Agriculture, Plant Pest Control Division, 100 Cambridge Street, Boston. For interstate movement of soil moving equipment, the following should be contacted:

U.S. Department of Agriculture,
Plant Pest Control Division
424 Trapelo Road,
Waltham, Massachusetts

7.02 Prevention of Water Pollution — Sanitary Provisions.

A. General.

The Contractor shall exercise every reasonable precaution to prevent or minimize the silting of rivers, streams or water impoundments during actual construction and periods when the work may be temporarily suspended. Similar precautionary measures shall be taken with respect to temporary roads and access roads to borrow pits. This work shall also consist of temporary control measures ordered by the Engineer during the life of the Contract to control water pollution, through use of berms, dikes, dams, sediment basins, crushed stone, gravel, mulches, grasses, waterways, and other erosion control devices or methods.

The temporary pollution control provisions contained herein shall be coordinated with the permanent erosion control features specified elsewhere in the Contract to the extent practical to assure economical, effective and continuous erosion control throughout the construction and post-construction period.

B. Schedule of Work.

At the preconstruction conference, the Contractor shall submit for acceptance and approval his procedure for the accomplishment of temporary erosion control work, and his schedule for the accomplishment of permanent erosion control work for all applicable phases of construction.

Since circumstances may require that certain pollution control work be done as promptly as possible, the Contractor's procedure must indicate his ability with men, equipment and material to take the necessary action.

C. Borrow Pits, Haul Roads and Disposal Areas.

Prior to entering or constructing haul roads or opening any borrow pit or waste disposal area, the Contractor shall submit his work plan for erosion control of such roads, pits or disposal areas. No work shall be started until the erosion control program and methods of operation have been accepted and are approved by the Engineer.

Wherever practicable so to do, unless objection thereto is made by the borrow pit owner, the Contractor shall save sufficient good topsoil from the excavated area and use it in establishing a vegetative cover which will blend the pit area into the surrounding landscape when the work on the project is completed. Vegetative cover will be similarly established in areas where waste material is placed. (See also Subsection 150.21 Borrow Pit Restrictions).

D. Construction Requirements.

The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing or excavation, borrow and fill operations and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds or areas of water impoundment. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, waterways, and use of temporary mulches, seeding or other control devices or methods as necessary to control erosion. All slopes shall be seeded and mulched as the earthwork proceeds to the extent considered desirable as practicable.

Where erosion is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion control measures will be required between successive construction stages.

The Engineer will limit the area of excavation, borrow and embankment operations in progress commensurate with the Contractor's capability in keeping the finish grading, mulching, seeding and other such permanent pollution control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

If, in the judgment of the Engineer, the surface area of erodible earth material exposed has the potential for causing water pollution, the Engineer shall direct the Contractor to cease the applicable operations until satisfactory temporary or permanent erosion control measures are taken. In the event of conflict between these requirements and pollution control laws, rules or regulations of other Federal or State or local agencies, the more restrictive laws, rules or regulations shall apply.

The Contractor will be required to incorporate all permanent erosion control features into the project at the earliest practicable time, as outlined in his accepted schedule. Temporary pollution control measures will be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent pollution control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

The Contractor shall take reasonable precaution to prevent grass and brush fires within the work site thereby eliminating further sources of erosion due to burned over areas.

E. Work in or Near Streams, Rivers and Impoundments.

The fording of streams with equipment shall be kept to a minimum. Where frequent stream crossings are contemplated and where fording might create sediment detrimental to fish, wildlife, water supplies or irrigation systems, temporary bridges or culverts shall be installed, the cost of which shall be absorbed by the Contractor.

Unless otherwise approved in writing by the Engineer, construction operations in rivers, streams and impoundments shall be restricted to those areas where channel changes are shown on the plans and to those areas which must be entered for the construction of temporary or permanent structures. Rivers, streams and impoundments shall be promptly cleared of all falsework, piling, debris, or other obstructions placed therein or caused by the construction operations.

Excavation from the roadway, channel changes, cofferdams, etc., shall not be deposited in or so near to rivers, streams, or impoundments that it will be washed away by high water or runoff.

When the Contractor uses water from natural sources for any of his operations, intake methods shall be such as to avoid contaminating the source of supply and maintain adequate downstream flow when the source is a stream.

Pollutants such as chemicals, fuels, lubricants, bitumens, raw sewage and other harmful waste shall not be discharged into or alongside of rivers, streams, impoundments or into natural or man-made channels leading thereto.

F. Sanitary Provisions.

The Contractor shall provide and maintain in a neat sanitary condition such accommodations for use of his employees as may be necessary to comply with the requirements of the Department of Public Health, local health officials or other authorities having jurisdiction.

7.03 Permits and Licenses.

The Contractor shall procure all required permits and licenses, pay all charges, fees and taxes and shall give all notices necessary and incidental to the due and lawful prosecution of the work. The cost thereof shall be included in the prices bid for the various items listed in the Proposal. Copies of all required permits and licenses shall be filed with the Engineer prior to the beginning of work.

The Contractor's attention is directed to the provisions of General Laws, Chapter 90, Section 9 as amended, in which it is provided that earth-moving motor vehicles which exceed certain dimensions or weight limits as specified in said Act, and which are used exclusively for building, repair and maintenance of highways, may be operated without registration for a distance not exceeding 300 yards on any way adjacent to any highway or toll road being constructed, relocated or improved provided a permit, authorizing such use, to be issued by the Commissioner of Public Works or by the Board or officer having charge of such way, has been procured by the Contractor.

7.04 Motor Vehicles.

All motor vehicles (except vehicles used solely for transporting employee(s) to and from the project) used wholly or in part within the Commonwealth by the Contractor or any Subcontractor, or by any person directly or indirectly employed by them in the execution of the Contract, shall be registered in the Commonwealth of Massachusetts and bear Massachusetts registration plates except as stipulated in Subsection 7.03.

Motor vehicles used solely for transporting employee(s) to and from the project shall be registered as required under General Laws, Chapter 90, Section 3, as amended.

No vehicle shall be driven on any way, as defined in Section 1 of Chapter 90 of the General Laws, unless such vehicle is constructed or loaded so as to prevent any of its load from dropping, sifting, leaking, or otherwise escaping therefrom, except that sand may be dropped for the purpose of securing traction or water or other substance may be sprinkled on such a way in cleaning or maintaining the same. (General Laws, Chapter 85, Section 30, as amended.)

7.05 Insurance Requirements.

A. Workmen's Compensation Insurance.

The Contractor, before commencing performance of the work required to be done under the Contract, shall provide for the payment of the compensation provided by Massachusetts General Laws, Chapter 152, as amended, to all persons to be employed by him in connection with the said performance, and he shall continue in full force and effect throughout the period required for the completion of the improvement such insurance as may be required under said chapter. The persons for whom compensation is to be provided by such insurance shall include those reserve or special police officers employed by the Contractor for the purpose of directing or maintaining traffic or other similar purposes within the site of the improvement and paid directly by him for such services; they shall not include, however, any regular police officers employed for said purpose.

Failure to provide and continue in force such insurance as aforesaid shall be deemed a material breach of the Contract and shall operate as an immediate termination thereof.

No cancellation of such insurance whether by the insurer or by the insured, shall be valid unless written notice thereof is given by the party proposing cancellation to the other party and to the officer or agent who awarded the Contract at least 30 days prior to the intended effective date thereof, which date shall be expressed in said notice. Notice of cancellation sent to the party proposing cancellation by registered mail, postage prepaid, with a return receipt of the addressee requested, shall be sufficient notice. An affidavit of any officer, agent or employee of the insurer or of the insured, as the case may be, duly authorized for the purpose, that he has so sent such notice addressed as aforesaid, shall be prima facie evidence of the sending thereof as aforesaid. This section shall apply to the legal representatives, trustee in bankruptcy, receiver, assignee, trustee and the successor in interest of any such Contractor.

The aforesaid insurance except that required for traffic officers, shall be taken out and maintained with no compensation therefor other than that provided by the contract unit prices.

B. Public Liability Insurance.

The Contractor shall take out and maintain insurance of the following kinds and amounts in addition to any other kinds or bonds required under other provisions of the Contract, with no compensation therefor other than that provided by the contract unit prices.

1. Contractor's Public Liability and Property Damage Liability Insurance.

The Contractor shall furnish evidence to the Department that, with respect to the operations he performs, he carries regular Contractors' Public Liability Insurance providing for a limit of not less than $500,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of bodily injuries to or death of one person, and, subject to that limit for each person, a total limit of $1,000,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of bodily injuries to or death of two or more persons in any one accident and regular Contractor's Property Damage Liability Insurance providing for a limit of not less than $500,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of injury to or destruction of property in any one accident, and subject to that limit per accident, a total or aggregate limit of $1,000,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of injury to or destruction of property during the policy period.

2. Contractor's Protective Public Liability and Property Damage Liability Insurance.

The Contractor shall furnish evidence to the Department that, with respect to the operations performed for him by Subcontractors, he carries in his own behalf regular Contractor's Protective Public Liability Insurance providing for a limit of not less than $500,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of bodily injuries to or death of one person, and subject to that limit for each person, a total limit of $1,000,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of bodily injuries to or death of two or more persons in any one accident, and regular Contractor's Protective Property Damage Liability Insurance providing for a limit of not less than $500,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of injury to or destruction of property in any one accident and, subject to that limit per accident a total (or aggregate) limit of $1,000,000 unless higher or lower limits are stipulated in the Special Provisions for all damages arising out of injury to or destruction of property during the policy period.

3. Railroads' Protective Liability and Property Damage Liability Insurance.

In addition to the above, the Contractor shall furnish evidence to the Department that, with respect to the operation he or any of his Subcontractors perform, he has provided for and in behalf of the Railroad Company affected by this Contract Regular Protective Liability Insurance providing for a limit of not less than the amount named in the Special Provisions for all damages arising out of bodily injuries to or death of one person, and, subject to that limit for each person, a total limit of the amount named in the Special Provisions for all damages

arising out of bodily injuries to or death of two or more persons in any one accident, and Regular Protective Property Damage Liability Insurance for a limit of not less than the amount named in the Special Provisions for all damages arising out of injury to or destruction of property in any one accident and, subject to that limit per accident, a total (or aggregate) limit of the amount named in the Special Provisions for all damages arising out of injury to or destruction of property during the policy period.

C. General.

1. The insurance requirements hereinbefore stipulated shall cover all damage to property whether above or below the ground, shall apply to the entire project, except that such insurance as may be required for the protection of a railroad shall apply only to that portion of the project which is in the immediate vicinity of the railroad property.

2. All insurance policies shall contain suitable stipulations providing for blasting operations if and when required.

3. If any part of the work is sublet, similar insurance to that required of the Contractor shall be provided by or in behalf of the Subcontractors to cover their operations, in accordance with the hereinbefore provisions of "A. Compensation Insurance," and "B. 1, Contractor's Public Liability and Property Damage Liability Insurance," with the same minimum limits as required of the Contractor, or such lower minimum limits as the Engineer may approve.

4. All insurance required of the Contractor shall be carried until all work required to be performed under the terms of the Contract or Subcontracts has been satisfactorily completed. In the case of the Contractor, this shall be evidenced by the written acceptance of the physical work by the Chief Engineer.

5. Before the commencement of the performance of the Contract or of any Subcontract the Contractor shall furnish the Department two complete copies of the policies he has provided for and in behalf of the Railroad and he shall file with the Department suitable insurer's certifications showing, for each policy of all required insurance, the following; the name and address of the insurer and of the insured, the policy period, the details of coverage including limits of liability, the rates and cost of such insurance, and a statement that each policy is endorsed to provide that the insurance company shall notify all insured parties and the Department by registered mail at least 30 days in advance of termination or any change in the policy.

7.06 Patented Devices, Materials and Processes.

Whenever the Contractor desires to use any design, device, material, or process covered by letters patent or copyright, the right for such use shall be secured by suitable legal agreement with the patentee or owner, and a copy of this agreement shall be filed with the Party of the First Part.

This article shall not be construed as imposing any obligation on the Party of the First Part to see that such agreements are secured or filed or complied with. The Contractor shall be solely responsible for the use of any such design, device, material or process.

7.07 Restoration of Surfaces Opened by Permit.

The Contractor shall not allow any party to make an opening in the highway for any purpose except upon the direction of the Engineer and the presentation of a duly authorized permit. The holder of such a permit shall be considered in the same class as a Contractor on an adjacent project, and the provisions of Subsections 5.05 and 5.06 shall apply.

7.08 Federal Participation (Applicable only to Contracts where the cost of any portion thereof is paid out of Federal Funds).

Attention is directed to the provisions of the Federal Highway Act of November 9, 1921 (42 U.S. Statutes at large, page 212) as modified and as extended, and 72 U.S. Statutes at large 885, U.S. Code Title 23, and any other provisions of law, or amendments thereto whereby such Federal Participation is authorized, and any regulations properly and lawfully promulgated thereunder, under which the United States shall aid the individual states in the construction of highways. When the United States Government is to pay any portion of the cost of the project the above act of Congress provides that the construction work and labor in each State shall be done in accordance with the laws of that state and applicable Federal Laws. The work embraced in this Contract will therefore be subject to such inspection by the Federal Highway Administration as may be necessary to meet the above requirements. Such inspection shall however, in no sense make the United States Government a party to this Contract, and will in no way interfere with the rights of either party hereunder.

7.09 Public Safety and Convenience.

The Contractor shall at all times, until written acceptance of the physical work by the Chief Engineer, be responsible for the protection of the work and shall take all precautions for preventing injuries to persons or damage to property on or about the project. If the Contractor constructs temporary bridges or provides temporary crossings of streams, his responsibility for accidents shall include the roadway and sidewalk approaches as well as the structures of such crossings.

Where the Contract involves dredging, excavation or other construction work in navigable waters, the work shall be so conducted as to cause no unnecessary obstruction to the free passage of vessels.

The decision for routing traffic through or around the work and provisions for the control of same will be made by the Engineer. Whenever it is deemed advisable, special detours will be provided for truck or bus traffic. On major projects and projects in urban areas traffic patterns and schedules will be studied in the design stage and include in the Special Provisions.

Subject to the approval of the Engineer, the Contractor shall schedule the temporary or permanent closing of highways to travel only after consultation with the Police Chief and Fire Chief of the municipality or municipalities concerned. The temporary closing of highways shall be kept to a minimum.

When a road or portion thereof is under construction and is closed to through traffic and when detours around the work are provided on existing city or town ways, the Contractor shall maintain such city or town ways as required in Subsection 4.07 and be compensated as specified in Subsection 4.07.

Where the new construction coincides with the present traveled way, the Contractor shall carry on his work in a manner acceptable to the Engineer so that a reasonably safe uninterrupted traffic flow is maintained through the project during the entire construction period over traffic lane patterns approved by the Engineer; and he shall provide and maintain in a reasonably safe condition the temporary approaches and the crossings of intersecting highways. When grading operations are in progress, each level of excavation or fill shall be graded as near as practicable to an even surface so as to provide a satisfactory passageway for the use of traffic.

The Contractor shall maintain all temporary roadways in a manner which will provide reasonably safe and convenient travel. When temporary roadways outside the project limits are abandoned, the surfaces shall be removed and all fill graded to a smooth, neat, natural appearance, free from water pockets and as directed by the Engineer.

Abandoned temporary or existing roads beyond the limits of the main roadway slopes, but within the project limits, shall be excavated, graded, loamed and seeded as directed to present a neat, natural appearance and provide for proper drainage. Compensation for this work will be included under the respective items of work involved.

Snow removal on detours or present traveled ways will not be required of the Contractor.

The Contractor, as directed, shall at all times so conduct the work that the abutters shall have reasonable access to their property. When public or private property is isolated by the closure of a road, the Contractor shall be responsible for providing such reasonably safe means of access to a public way as the Engineer deems essential and he shall be compensated for all such work directed by the Engineer at the contract unit prices for the type of work and materials involved. When it is necessary to leave materials and equipment upon the highway they shall be placed so as to cause the least possible obstruction to drainage, pedestrians and other travel.

When the work in any way affects the operation, management, maintenance, business or traffic on any railroad, such work shall be carried on in a manner satisfactory to the said railroad; but all orders, directions or instructions to the Contractor relative to work under the Contract will be issued only by the Engineer of the Department. The Contractor shall use all possible vigilance in order effectively to guard against all accidents or damages on the railroad due to his work, and the Contractor shall at all times during the progress of the work so manage and execute the same as to cause the least possible interference with the operation, management, business or traffic of the railroad.

Trenches shall not be opened in traveled ways until all materials and equipment required for the work are at the site and available for immediate use. When work is not in progress trenches in areas subject to public travel shall be covered with steel plates capable of safely sustaining a 36.5-ton truckload with impact. The work at each trench shall be practically continuous, with the placing of conduit and piping, backfilling and patching of the surface closely following each preceding operation.

Pending installation of castings, all structures in travel ways or deemed hazardous by the Engineer shall be protected with suitable covers (steel plates or equal) capable of withstanding a 36.5 ton truckload with impact. The cost of necessary covers or plates will be considered incidental to the item involved with no separate payment.

7.10 Barricades and Warning Signs.

The Department may furnish, erect and maintain regulatory, warning and guide signs, traffic control signals, markings, safety lighting and any other traffic devices as it deems necessary for the safe flow of traffic during construction.

Highways wholly or partly closed to traffic shall be protected by suitable barricades, barrier fences, traffic signs and other traffic devices, furnished and erected by the Contractor at locations shown on the plans, or as directed, and he shall be compensated therefor in accordance with the contract unit prices for the items of work involved.

The Contractor shall at his own expense provide and erect, acceptable or ad directed, barricades, barrier fences, traffic signs, and all other traffic devices, not covered in his Contract as a payment item, to protect the work from traffic, pedestrians, or animals. He shall at his own expense provide sufficient temporary lighting such as flares, lanterns, or other approved illuminated traffic signs and devices, not covered in his Contract as a payment item, to afford adequate protection to the travelling public. He shall also at his own expense furnish a sufficient number of watchmen at all times to protect the work.

All barricades, barrier fences, traffic signs and other traffic devices must conform with the Department's manual on Uniform Traffic Control Devices.

The Contractor shall be held responsible for all damage to the work due to any failure of barricades, barriers, warning signs or lights to properly protect the work from traffic, pedestrians or other causes.

7.11 Traffic Officers and Railroad Flagging Service.

The Contractor shall provide such police officers as the Engineer deems necessary for the direction and control of traffic within the site of the improvement. Such officers shall wear regulation policemen's uniforms. They may be reserve or special officers subject to the control of and paid directly by the Contractor; or regular officers not subject to the control of the Contractor. Compensation for the services of said regular police officers may be paid by the Contractor to their employers, or paid directly by the Contractor to such regular police officers, or paid by the Contractor to a designated municipal official, at a patrolman's rate of pay, subject to all rules and regulations, ordinances or by-laws in effect in the city or town in which the work is to be performed.

The Party of the First Part will reimburse the Contractor for payments made for the services of all required traffic officers, together with such payments as he will have made for reserve or special officers under the Massachusetts Workmen's Compensation Act (General Laws, Chapter 152, Section 1, as amended), Liability Insurance, and for payments as the Contractor is required in writing by proper authority to make under the Massachusetts Employment Security Act (General Laws, Chapter 151A) and the Federal Social Security Act (United States Code, Title 26 and 42). The Contractor is required to submit to the Engineer copies of this written requirement for the Massachusetts Employment Security Act and the Federal Social Security Act.

The rates of wages paid by the Contractor to such police officers shall be the same as those paid to police officers working on special details. When the Contractor is required to submit weekly certified copies of payroll, separate certified copies of payroll covering only such reserve and special police officers shall be submitted containing complete payroll information.

If any of the work required to be done by the Contractor may obstruct the tracks of a railroad or in any way endanger the operation of its trains, and the services of a flagman or flagmen or other railroad employees are required by the Chief Engineer of the railroad company and men are assigned by him for the protection of the property and traffic of the Railroad against hazards capable of being caused by the Contractor, the cost of all such flagging services shall be borne by the Contractor and no compensation therefor shall be made other than that provided by the contract unit prices.

The Department will reimburse the Contractor for the above costs required by the Railroad when the preliminary estimate of bid items for a project is $100,000 or less.

7.12 Use of Explosives.

When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life and property including new work and whenever directed, the number and size of the charges shall be reduced. The Contractor shall be responsible for all damage resulting from the use of explosives. All explosives shall be stored in a secure manner in conformance with all the State laws and regulations, as well as any local requirements; and all such storage places shall be marked — "Dangerous — Explosives".

The Contractor shall be required to conform to the regulations of the Massachusetts Department of Public Safety concerning storage, handling and use of explosives.

Prior to start of the blasting, the Contractor shall give at least a 24-hour notice and a schedule of his operations thereof to the operating official, company, or companies, leasing, owning or responsible for pipes, conduits, poles, wires, railroad tracks, or any other public or private utility which may be endangered by the blasting in order that a representative of said owner or lessee may be present at the site. The Contractor shall take proper precaution to prevent injury to said properties during all blasting operations.

7.13 Protection and Restoration of Property.

The Contractor shall, at his own expense, preserve and protect from injury all property either public or private along and adjacent to the proposed work, and he shall be responsible for and repair at his own expense any and all damage and injury thereto, arising out of or in consequence of any act of omission, neglect or misconduct in the execution of the work, or in consequence of the non-execution thereof by the Contractor or his employees or Subcontractors in the performance of the work covered by the Contract prior to completion and acceptance thereof. He shall exercise special care during his operations to avoid injury to underground structures such as water or gas mains, pipes, conduits, manholes, catch basins, etc.

Written notice shall be given by the Contractor to all public service corporations or officials owning or having charge of public or private utilities of his intention to commence operations affecting such utilities at least 48 hours (exclusive of Saturdays, Sundays and legal holidays) in advance of the start of such operations in accordance with Chapter 82. Section 40 of the General Laws, as amended, and the Contractor shall at the same time file a copy of said notice with the Engineer.

When necessary, the Contractor shall cooperate with representatives of public service companies in order to avoid damage to their structures by furnishing and erecting suitable supports, props, shoring or other means of protection. Fire hydrants adjacent to the work at all times shall be readily accessible to fire apparatus and no material or other obstructions shall be placed within a radius of ten feet of a fire hydrant.

Although the plans may indicate the approximate location of existing subsurface utilities in the vicinity of the work, the accuracy and completeness of the information is not guaranteed by the Department. Before commencing any work or operations which may endanger or damage any subsurface structures, the Contractor shall carefully locate all such structures and conduct his operations in such manner as to avoid damage thereto. He shall not interrupt live services until new services have been provided. All abandoned services shall be plugged or otherwise made secure.

The Contractor shall receive no extra compensation for such work unless said compensation is authorized in writing by the Engineer, as specified under Subsection 4.03 for Extra Work, (except test pits as directed to be made in order to locate existing underground structures).

If the Contractor wishes to have any utilities temporarily relocated for his convenience other than contemplated by the Department, he shall make the necessary arrangement with the owners and make reimbursement for the cost thereof at his own expense.

Land monuments and property marks shall be carefully protected and if necessary to remove the same, he shall do so only at the Engineer's direction and after an authorized agent has witnessed or otherwise referenced their location. the Contractor shall not injure or remove trees or shrubs without proper authority. Insofar as possible the Contractor shall confine his movements and operations to the area within the limits of the location and the area outside the scope of the work shall not be disturbed except as directed.

The Contractor's attention is directed to Chapter 231 of the Acts of 1977 which stipulates that, surveyors of highways, road commissioners, or any other person, agency, or authority responsible for road or highway repairs shall notify the Massachusetts Bay Transportation Authority not later than forty-eight hours prior to the repair, construction or reconstruction of any road or highway used by said Authority in the operation of regular route service if such repairs, construction or reconstruction shall prohibit the operation of regular route service by the Authority over such road or highway.

The bidders attention is directed to the AASHTO Guide on Occupational Safety on Highway Construction Projects, Subpart N, 1926.550, relating to construction equipment clearances at overhead electric lines, which states in part "... the minimum clearance between the lines and any part of the crane or load must be at least 10 feet from lines rates 50 KV or below, and greater distances for higher voltage...". For the protection of personnel and equipment, the Contractor should be aware of this regulation especially during paving operations using large semi-trailer vehicles.

7.14 Responsibility for Damage Claims.

The Contractor shall indemnify, defend and save harmless the Commonwealth, the Department, the municipality and all of its or their offices, agents and employees against all suits, claims or liability of every name

and nature, for or on account of any injuries to persons or damage to property arising out of or in consequence of the acts of the Contractor in the performance of the work covered by the Contract or failure to comply with the terms and conditions of said Contract, whether by himself or his employees or Subcontractors, but only in respect of such injuries or damages sustained during the performance and prior to the completion and acceptance of the work covered by the Contract.

The Contractor will be held responsible for any and all claims for damage to underground structures such as, but not restricted to, water or gas mains, pipes, conduits, manholes or catch basins, due to his operation or to the operations of any of his Subcontractors.

The Contractor's attention is directed to the provisions of General Laws, Chapter 30, Section 39H as amended. In accordance therewith, the Commonwealth agrees to indemnify the Contractor against loss by reason of the liability to pay damages to others for entry upon any land included within the boundaries of the area within which the work is to be performed as set forth in the construction Contract and the plans and specifications applying to such Contract or any approved changes thereof or for damage sustained upon any lands adjoining said land by reason of the flowage or drainage of water thereto or therefrom. In any case wherein such damages result from the failure of the Commonwealth to take an interest or easement in such adjoining area, provided that the Commonwealth acting by an authorized representative thereof has issued a notice in writing to the Contractor prior to the making of an entry upon such premises directing or permitting him to proceed with his Contract and to make such entry upon the premises for the purpose of performing the work required by said Contract, or any approved alteration thereof, and provided, further, that the Contractor has given notice in writing to the contracting authority within 15 days after receiving notice of any claim to come in and settle the same and upon the commencement of any action against him to come in and defend said action, but in no event shall any such damage claim be compromised or adjusted without the written consent of the Commonwealth. The provisions of this section shall in no way relieve the Contractor from any liability for damage to property of others caused by his negligence or that of his employees nor shall they be construed to require the Commonwealth to indemnify the Contractor against any loss resulting from such acts of negligence.

7.15 Claims Against Contractors for Payment of Labor, Materials and Other Purposes.

The Contractor shall pay all bills for labor, materials, rental of equipment and for such other purposes as are more specially set forth in Chapter 149, Section 29 and Chapter 30, Section 39A, General Laws, and all amendments thereto. It is understood that the Payment Bond required by Subsection 3.04, Paragraph B, is the sole security for petitions brought pursuant to said sections. The Contractor and Party of the First Part shall also comply with the provisions of Chapter 30, Section 39F and G.

Chapter 149, Section 29, of the General Laws as amended reads as follows: Officers or agents contracting in behalf of the Commonwealth or in behalf of any county, city, town, district or other political subdivision of the Commonwealth or other public instrumentality for the construction, reconstruction, alteration, remodeling, repair or demolition of public buildings or other public works when the amount of the Contract in the case of the Commonwealth is more than five thousand dollars, and in any other case is more than two thousand dollars, shall obtain security by bond in an amount not less than one half of the total contract price, for payment by the Contractor and Subcontractors for labor performed or furnished and materials used or employed therein, including lumber so employed which is not incorporated therein and is not wholly or necessarily consumed or made so worthless as to lose its identity, but only to the extent of its purchase price less its fair salvage value, and including also any material specially fabricated at the order of the Contractor or Subcontractor for use as a component part of said public building or other public work so as to be unsuitable for use elsewhere, even though such material has not been delivered and incorporated into the public building or public work, but only to the extent of its purchase price less its fair salvage value and only to the extent that such specially fabricated material is in conformity with the Contract, plans and specifications or any changes therein duly made; for payment of transportation charges for materials used or employed therein which are consigned to the Contractor or to a Subcontractor who has a direct contractual relationship with the Contractor; for payment by such Contractor and Subcontractors of any sums due for the rental or hire of vehicles, steam shovels, rollers propelled by steam or other power, concrete mixers, tools and other appliances and equipment employed in such construction, reconstruction, alteration, remodeling, repair or demolition; for payment of transportation charges directly related to such rental or hire; and for payment by such Contractor and Subcontractors of any sums due trustees or other persons authorized to collect such payments from the Contractor or Subcontractors, based upon the labor performed or furnished as aforesaid, for health and welfare plans, supplementary unemployment benefit plans and other fringe benefits which are payable in cash and provided for in collective bargaining agreements between organized labor and the Contractor or Subcontractors; provided, that any such

trustees or other persons authorized to collect such payments for health and welfare plans, supplementary unemployment benefit plans and other fringe benefits shall, subject to the following provisions, be entitled to the benefit of the security only in an amount based upon labor performed or furnished as aforesaid for a maximum of two hundred and forty consecutive calendar days.

In order to obtain the benefit of such bond for any amount claimed, due and unpaid at any time, any claimant having a contractual relationship with the Contractor principal furnishing the bond, who has not been paid in full or any amount claimed due for the labor, materials, equipment, appliances or transportation included in the paragraph (1) coverage within sixty-five days after the due date for same, shall have the right to enforce any such claim (*a*) by filing a petition in equity within one year after the day on which such claimant last performed the labor or furnished the labor, materials, equipment, appliances or transportation included in the claim and (*b*) by prosecuting the claim thereafter by trial in the superior court to final adjudication and execution for the sums justly due the claimant as provided in this section.

Any claimant having a contractual relationship with a Subcontractor performing labor or both performing labor and furnishing materials pursuant to a Contract with the general Contractor but no contractual relationship with the Contractor principal furnishing the bond shall have the right to enforce any such claim as provided in subparagraphs (*a*) and (*b*) of paragraph (2) only if such claimant gives written notice to the Contractor principal within sixty-five days after the day on which the claimant last performed the labor or furnished the labor, materials, equipment, appliances or transportation included in the paragraphs (1) coverage, stating with substantial accuracy the amount claimed, the name of the party for whom such labor was performed or such labor, materials, equipment, appliances or transportation were furnished; provided, that any such claimant shall have the right to enforce any part of a claim covering specially fabricated material included in the paragraph (1) coverage only if such claimant has given the Contractor principal written notice of the placement of the order and the amount thereof not later than twenty days after receiving the final approval in writing for the use of the material. The notices provided for in this paragraph (3) shall be served by mailing the same by registered or certified mail postage prepaid in an envelope addressed to the Contractor principal at any place at which the Contractor principal maintains an office or conducts his business, or at the Contractor principal's residence, or in any manner in which civil process may be served.

Upon motion of any party, the court shall advance for speedy trial a petition to enforce a claim pursuant to this section. Sections fifty-nine and fifty-nine B of Chapter two hundred thirty-one shall apply to petitions to enforce claims pursuant to this section. The court shall enter an interlocutory decree upon which execution shall issue for any part of a claim found due pursuant to said Sections fifty-nine or fifty-nine B and shall, upon motion of any party, advance for speedy trial the petition to enforce the remainder of the claim. Any party aggrieved by such interlocutory decree shall have the right to appeal therefrom as from a final decree. The court shall not consolidate for trial the petition of any claimant under this section with the petition of one or more other claimants on the same bond, unless the court finds that a substantial portion of the evidence of the same events during the course of construction (other than the fact that the claims sought to be consolidated arise under the same general Contract) is applicable to the petitions sought to be consolidated, and that such consolidation will prevent unnecessary duplication of evidence.

The court shall not dismiss any petition on the ground that it was filed before the sixty-fifth day after the day the claimant last performed the labor or furnished the labor, materials, equipment, appliances or transportation included in the claim, nor shall the court dismiss any petition on the ground that a claim involves more than one Contract with the same party and that the one year period has elapsed as to any one Contract; provided, that the court shall not enter a decree upon any claim or part thereof prior to the seventieth day after the day the claimant last performed the labor or furnished the labor, materials, equipment, appliances or transportation included in the claim.

A decree in favor of any claimant under this section shall include reasonable legal fees based upon the time spent and the results accomplished as approved by the court and such legal fees shall not in any event be less than published rate of any recommended fee schedule of a state-wide bar association or of a bar association in which the office of counsel for claimant is located, whichever is higher.

Any person employing persons on any public works hereinbefore referred to shall post conspicuously, at such place or places as will provide reasonable opportunity for all employees to read the same, a correct copy of this section. The Department shall enforce this paragraph. (Refers to the Department of Labor and Industries).

In conformity with the requirements of Chapter 30, Section 39F of the General Laws, as amended, the following is quoted from Chapter 30, Section 39F.

"(1) Every contract awarded pursuant to sections forty-four A to L. inclusive, of chapter one hundred

and forty-nine shall contain the following subparagraphs (*a*) through (*i*) and every contract awarded pursuant to section thirty-nine M of chapter thirty shall contain the following subparagraphs (*a*) through (*h*) and in each case those subparagraphs shall be binding between the general contractor and each subcontractor.

"(*a*) Forthwith after the general contractor receives payment on account of a periodic estimate, the general contractor shall pay to each subcontractor the amount paid for the labor performed and the materials furnished by that subcontractor, less any amount specified in any court proceedings barring such payment and also less any amount claimed due from the subcontractor by the general contractor.

"(*b*) Not later than the sixty-fifth day after each subcontractor substantially completes his work in accordance with the plans and specifications, the entire balance due under the subcontract less amounts retained by the awarding authority as the estimated cost of completing the incomplete and unsatisfactory items of work, shall be due the subcontractor; and the awarding authority shall pay that amount to the general contractor. The general contractor shall forthwith pay to the subcontractor the full amount received from the awarding authority less any amount specified in any court proceedings barring such payment and also less any amount claimed due from the subcontractor by the general contractor.

"(*c*) Each payment made by the awarding authority to the general contractor pursuant to subparagraphs (*a*) and (*b*) of this paragraph for the labor performed and the materials furnished by a subcontractor shall be made to the general contractor for the account of that subcontractor; and the awarding authority shall take reasonable steps to compel the general contractor to make each such payment to each such subcontractor. If the awarding authority has received a demand for direct payment from a subcontractor for any amount which has already been included in a payment to the general contractor or which is to be included in a payment to the general contractor for payment to the subcontractor as provided in subparagraphs (*a*) and (*b*), the awarding authority shall act upon the demand as provided in this section.

"(*d*) If, within seventy days after the subcontractor has substantially completed the subcontract work, the subcontractor has not received from the general contractor the balance due under the subcontract including any amount due for extra labor and materials furnished to the general contractor, less any amount retained by the awarding authority as the estimated cost of completing the incomplete and unsatisfactory items of work, the subcontractor may demand direct payment of that balance from the awarding authority. The demand shall be by a sworn statement delivered to or sent by certified mail to the awarding authority, and a copy shall be delivered to or sent by certified mail to the general contractor at the same time. The demand shall contain a detailed breakdown of the balance due under the subcontract and also a statement of the status of completion of the subcontract work. Any demand made after substantial completion of the subcontract work shall be valid even if delivered or mailed prior to the seventieth day after the subcontractor has substantially completed the subcontract work. Within ten days after the subcontractor has delivered or so mailed the demand to the awarding authority and delivered or so mailed a copy to the general contractor, the general contractor may reply to the demand. The reply shall be by a sworn statement delivered to or sent by certified mail to the awarding authority and a copy shall be delivered to or sent by certified mail to the subcontractor at the same time. The reply shall contain a detailed breakdown of the balance due under the subcontract including any amount due for extra labor and materials furnished to the general contractor and of the amount due for each claim made by the general contractor against the subcontractor.

"(*e*) Within fifteen days after receipt of the demand by the awarding authority, but in no event prior to the seventieth day after substantial completion of the subcontract work, the awarding authority shall make direct payment to the subcontractor of the balance due under the subcontract including any amount due for extra labor and materials furnished to the general contractor, less any amount (*i*) retained by the awarding authority as the estimated cost of completing the incomplete or unsatisfactory items of work, (*ii*) specified in any court proceedings barring such payment, or (*iii*) disputed by the general contractor in the sworn reply; provided that the awarding authority shall not deduct from a direct payment any amount as provided in part (*iii*) if the reply is not sworn to, or for which the sworn reply does not contain the detailed breakdown required by subparagraph (*d*). The awarding authority shall make further direct payments to the subcontractor forthwith after the removal of the basis for deductions from direct payments made as provided in parts (*i*) and (*ii*) of this subparagraph.

"(*f*) The awarding authority shall forthwith deposit the amount deducted from a direct payment as provided in part (*iii*) of subparagraph (*e*) in an interest-bearing joint account in the names of the general contractor and the subcontractor in a bank in Massachusetts selected by the awarding authority or agreed upon by the general contractor and the subcontractor and shall notify the general contractor and the subcontractor of the date of the deposit and the bank receiving the deposit. The bank shall pay the amount in the account, including accrued interest, as provided in an agreement between the general contractor and the subcontractor or as determined by decree of a court of competent jurisdiction.

"(*g*) All direct payments and all deductions from demands for direct payments deposited in an interest-bearing account or accounts in a bank pursuant to subparagraph (*f*) shall be made out of amounts payable to the general contractor at the time of receipt of a demand for direct payment from a subcontractor and out of amounts which later become payable to the general contractor and in the order of receipt of such demands from subcontractors. All direct payments shall discharge the obligation of the awarding authority to the general contractor to the extent of such payment.

"(*h*) The awarding authority shall deduct from payments to a general contractor amounts which, together with the deposits in interest-bearing accounts pursuant to subparagraph (*f*), are sufficient to satisfy all unpaid balances of demands for direct payment received from subcontractors. All such amounts shall be earmarked for such direct payments, and the subcontractors shall have a right in such deductions prior to any claims against such amounts by creditors of the general contractor.

"(*i*) If the subcontractor does not receive payment as provided in subparagraph (*a*) or if the general contractor does not submit a periodic estimate for the value of the labor or materials performed or furnished by the subcontractor and the subcontractor does not receive payment for same when due less the deductions provided for in subparagraph (*a*), the subcontractor may demand direct payment by following the procedure in subparagraph (*d*) and the general contractor may file a sworn reply as provided in that same subparagraph. A demand made after the first day of the month following that for which the subcontractor performed or furnished the labor and materials for which the subcontractor seeks payment shall be valid even if delivered or mailed prior to the time payment was due on a periodic estimate from the general contractor. Thereafter the awarding authority shall proceed as provided in subparagraph (*e*), (*f*), (*g*), and (*h*)."

Chapter 30, Section 39G, of the General Laws, as amended, reads as follows:

Upon substantial completion of the work required by a contract with the Commonwealth, or any agency or political subdivision thereof, for the construction, reconstruction, alteration, remodeling, repair or improvement of public ways, including bridges and other highway structures, sewers and water mains, airports and other public works, the contractor shall present in writing to the awarding authority its certification that the work has been substantially completed. Within twenty-one days thereafter, the awarding authority shall present to the contractor either a written declaration that the work has been substantially completed or an itemized list of incomplete or unsatisfactory work items required by the contract sufficient to demonstrate that the work has not been substantially completed. The awarding authority may include with such list a notice setting forth a reasonable time, which shall not in any event be prior to the contract completion date, within which the contractor must achieve substantial completion of the work. In the event that the awarding authority fails to respond, by presentation of a written declaration or itemized list as aforesaid, to the contractor's certification within the twenty-one day period, the contractor's certification shall take effect as the awarding authority's declaration that the work has been substantially completed.

Within sixty-five days after the effective date of a declaration of a substantial completion, the awarding authority shall prepare and forthwith send to the contractor for acceptance a substantial completion estimate for the quantity and price of the work done and all but one percent retainage on that work, including the quantity, price and all but 10% retainage for the undisputed part of each work item and extra work item in dispute but excluding the disputed part thereof, less the estimate cost of completing all incomplete and unsatisfactory work items and less the total periodic payments made to date for the work. The awarding authority also shall deduct from the substantial completion estimate an amount equal to the sum of all demands for direct payment filed by subcontractors and not yet paid to subcontractors or deposited in joint accounts pursuant to section thirty-nine F, but no contract subject to said section thirty-nine F shall contain any other provision authorizing the awarding authority to deduct any amount by virtue of claims asserted against the contract by subcontractors, material suppliers or others.

If the awarding authority fails to prepare and send to the contractor any substantial completion estimate required by this section on or before the date hereinabove set forth, the awarding authority shall pay to the contractor interest on the amount which would have been due to the contractor pursuant to such substantial completion estimate at the rate of three percentage points above the rediscount rate then charged by the Federal Reserve Bank of Boston from such date to the date on which the awarding authority sends that substantial completion estimate to the contractor for acceptance or to the date of payment therefor, whichever occurs first. The awarding authority shall include the amount of such interest in the substantial completion estimate.

Within fifteen days after the effective date of the declaration of substantial completion, the awarding authority shall send to the contractor by certified mail, return receipt requested, a complete list of all incomplete or unsatisfactory work items, and, unless delayed by causes beyond his control, the contractor shall complete all such work items within forty-five days after the receipt of such list or before the then contract completion date,

whichever is later. If the contractor fails to complete such work within such time, the awarding authority may, subsequent to seven days' written notice to the contractor by certified mail, return receipt requested, terminate the contract and complete the incomplete or unsatisfactory work items and charge the cost of same to the contractor.

Within thirty days after receipt by the awarding authority of a notice from the contractor stating that all of the work required by the contract has been completed, the awarding authority shall prepare and forthwith send to the contractor for acceptance a final estimate for the quantity and price of the work done and all retainage on that work less all payments made to date, unless the awarding authority's inspection shows that work items required by the contract remain incomplete or unsatisfactory, or that documentation required by the contract has not been completed. If the awarding authority fails to prepare and send to the contractor the final estimate within thirty days after receipt of notice of completion, the awarding authority shall pay to the contractor interest on the amount which would have been due to the contractor pursuant to such final estimate at the rate hereinabove provided from the thirtieth day after such completion until the date on which the awarding authority sends the final estimate to the contractor for acceptance or the date of payment therefor, whichever occurs first, provided that the awarding authority's inspection shows that no work items required by the contract remain incomplete or unsatisfactory. Interest shall not be paid hereunder on amounts for which interest is required to be paid in connection with the substantial completion estimate as hereinabove provided. The awarding authority shall include the amount of the interest required to be paid hereunder in the final estimate.

The awarding authority shall pay the amount due pursuant to any periodic, substantial completion or final estimate within thirty-five days after receipt of written acceptance for such estimate from the contractor and shall pay interest on the amount due pursuant to such estimate at the rate hereinabove provided from that thirty-fifth day to the date of payment. In the case of periodic payments, the contracting authority may deduct from its payment a retention based on its estimate of the fair value of its claims against the contractor, a retention for direct payments to subcontractors based on demands for same in accordance with the provisions of section thirty-nine F, and a retention to secure satisfactory performance of the contractual work not exceeding five per cent of the approved amount of any periodic payment, and the same right to retention shall apply to bonded subcontractors entitled to direct payment under section thirty-nine F of chapter thirty; provided, that a five per cent value of all items that are planted in the ground shall be deducted from the periodic payments until final acceptance.

No periodic, substantial completion or final estimate or acceptance or payment thereof shall bar a contractor from reserving all rights to dispute the quantity and amount of, or the failure of the awarding authority to approve a quantity and amount of, all or part of any work item or extra work item.

Substantial completion, for the purposes of this section, shall mean either that the work required by the contract has been completed except for work having a contract price of less than one per cent of the then adjusted total contract price, or substantially all of the work has been completed and opened to public use except for minor incomplete or unsatisfactory work items that do not materially impair the usefulness of the work required by the contract.

7.16 Claims of Contractor for Compensation.

No person or corporation, other than the signer of the Contract as Contractor, now has any interest hereunder, and no claim shall be made or be valid; and neither Party of the First Part nor any member, agent or employee thereof, shall be liable for, or be held to pay, any money except as provided in Subsections 4.02, 4.03, 4.04, 4.06 and 9.02 of these Specifications and Clause 3 of the Contract.

All claims of the Contractor for compensation other than as provided for in the Contract on account of any act of omission or commission by the Party of the First Part or its agents must be made in writing to the Engineer within one week after the beginning of any work or the sustaining of any damage on account of such act, such written statement to contain a description of the nature of the work performed or damage sustained; and the Contractor shall, on or before the 15th day of the month succeeding that in which such work is performed or damage sustained, file with the Engineer an itemized statement of the details and amount of such work or damage and unless such statement shall be made as required, his claim for compensation shall be forfeited and invalidated, and he shall not be entitled to payment on account of any such work or damage. Such notice by the Contractor and the keeping of costs by the Engineer shall not in any way be construed as providing the validity of the claim. The provisions of this paragraph shall not apply to changes in quantities as provided under Subsection 4.06 or to Extra Work ordered by the Engineer in writing.

On the basis of information provided in writing by his own employees, servants, or agents the Contractor will be required to certify, in writing, that the work for which he is claiming payment, other than as provided for in the Contract, is work actually performed, and the costs as shown are the amounts legally due for performing such work for which payment is claimed.

The Engineer shall determine all questions as to the amount and value of such work, and the fact and extent of such damage and shall so notify the Contractor in writing of his determination. Such determination of the Engineer may be appealed to the Board of Contract Appeals in accordance with General Law, Chapter 16, Section 5b, as amended.

The appeal shall set forth the contract number, city or town project is in, the name and address of the Contractor, the amount of the claim (and breakdown of how amount was computed), a clear concise statement of the specific determination from which appeal is taken, including the reasons for appealing the determination and shall be signed by the Contractor.

The Commission Secretary shall record the date and time any such appeal is received, and shall keep the appeal on record. He shall forward a copy of the appeal to the Hearing Examiner who shall set the matter down for hearing in accordance with rules adopted by the Commission.

The acceptance by the Contractor of the final payment made under the provisions of Subsection 9.05 shall operate as and shall be a release to the Party of the First Part and every member, agent and employee thereof, from all claim and liability to the Contractor for anything done or furnished for, or relating to, the work, or for any act or neglect of the Party of the First Part or of any person relating to or affecting the work, except the claim against the Party of the First Part for the remainder, if any there be, of the amounts kept or retained as provided in Subsection 7.15. For claims for extensions of time see Subsection 8.10.

7.17 Traffic Accommodation.

Any portion of the work which is in an acceptable condition for travel may be opened for traffic as directed in writing by the Engineer, but such opening for traffic shall not be construed as an acceptance of the work or part thereof, nor shall it act as a waiver of any of the provisions of these specifications or of the Contract; provided, however, that on such portions of the project as are opened for use of traffic, the Contractor shall not be required to assume any expense entailed in maintaining the roadway for traffic. The Party of the First Part will be responsible for maintenance and any damage to the work caused solely by traffic on any portion of the project which has been opened to public travel as stipulated above, and it may order the Contractor to repair or replace such damage, whereupon the Contractor shall make such repairs at contract unit prices so far as the same are applicable, or as Extra Work under the provisions of Subsection 4.03 if there are no applicable items in the Contract. Any damage to the highway not attributable to traffic which might occur on such section, shall be repaired by the Contractor at his expense.

No hauling or other traffic shall be permitted over any portions of the work unless so authorized by the Engineer.

If the Contractor is dilatory in completing shoulders, drainage structures or other features of the work, the Engineer may order all or a portion of the project open to traffic, but in such event the Contractor shall not be relieved of his liability and responsibility during the period the work is so opened prior to final acceptance. The Contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic.

Where the new construction coincides with the present traveled way, the Engineer may order the installation of various items of work for safety and convenience of the public due to the highway being open to traffic. The Party of the First Part will be responsible for damage to the following items of work caused solely by traffic on any portion of the project which is open to public travel and on which these items of work have been ordered to be installed and partial acceptance made thereof by the Engineer under the terms and conditions started below.

1. Guard Rail
2. Metal Bridge Railing
3. Traffic Signal Systems
4. Highway Lighting
5. Traffic Attenuators
6. Traffic Signs

If the person or persons causing the damage has been identified, the Contractor shall be responsible for recovering the cost of such repair or replacement from that person or their insurance company. No additional unit price or extra work payment will be made by the Party of the First Part unless the Contractor has been unable to recover the full repair of replacement cost from said person or their insurance company. The Party of the First Part may order the Contractor to repair or replace such damage, whereupon the Contractor shall make such repairs at contract unit prices so far as the same are applicable or as Extra Work under the provisions of Subsection 4.03 if there are no applicable items of work in the Contract. Any damage not attributable to traffic which might occur on such traveled way shall be repaired by the Contractor at his own expense.

7.18 Contractor's Responsibility for the Work.

Until written acceptance of the physical work by the Chief Engineer, the Contractor shall assume full charge and care thereof and he shall take every necessary precaution against injury or damage to the work by action of the elements, or from any cause whatever, whether arising from the execution or the non-execution of the Contract, and especially when blasting is to be done.

The Contractor shall bear all losses resulting to him on account of the amount or the character of the work or because the nature of the land in or on which the work is done is different from what was estimated or expected, or on account of the weather elements or other causes (except as stated in Subsection 4.04, Changed Conditions).

The Contractor shall rebuild, repair, restore and make good all injuries or damages to any portion of the work occasioned by any of the above causes before the completion and written acceptance of the physical work, and shall bear the expense thereof, except damage to the work due to war, whether or not declared, civil war, insurrection, rebellion or revolution, or to any act or condition incident to any of the foregoing, to "Acts of God" (limited to hurricane, tornado, cyclone and earthquake as classified by the United States Weather Bureau for the particular locality and for the particular season of the year, and in addition thereto, damages resulting directly from flooding from any of the aforementioned "Acts of God"). The repair of such damages shall be done by the Contractor and paid for at the respective contract unit prices for the quantity and items of work involved. In any case in which the estimate for replacing such work or repairing such damage caused by war, whether or not declared, civil war, insurrection, rebellion or revolution, or to any act or condition incident to the foregoing, or an "Act of God" combined with any previously authorized Extra Work results in a change of such magnitude as to be incompatible with competitive bid status, the Department reserves the right to terminate the Contract and to call for new bids and award a new Contract for such work. In the event any Contract is terminated for such reason the Department shall pay the Contractor such sum as may be due for work performed up to the date of the "Act of God", or of damage directly due to war, whether or not declared, civil war, insurrection, rebellion or revolution, or to any act or condition incident to any of the foregoing and shall also take over and pay for any material stored at site of the work provided said material was intended to be and could have been incorporated into the work; the Department shall also take over and pay for any material which was being especially fabricated for incorporation into the work, provided, however, that as a condition precedent to the Department's liability for such material, the Contractor is legally liable therefor and the material was intended to be and could have incorporated in the work.

Issuance of an estimate on any part of the work done shall not be construed as final acceptance of any work completed up to that time.

Should the Contractor fail to take prompt action whenever conditions make it necessary, the Party of the First Part shall make emergency repairs or cause the same to be made, with the stipulation that the costs for such repairs shall be charged against the Contractor and deducted from moneys due him.

In case of suspension of work from any cause whatsoever, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his expense. During such period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under his Contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

7.19 Personal Liability of Public Officials.

In carrying out any of the provisions of these specifications, or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Commissioner, Engineer, or their authorized representatives, either personally or as officials of the Commonwealth, it being understood that in all such matters they act solely as agents and representatives of the Commonwealth.

7.20 No Waiver of Legal Rights.

The Party of the First Part shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the physical completion and final acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing that any such measurement, estimate or certificate is untrue or is incorrectly made, nor that the work or materials do not in fact conform to the Contract. The Department shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or his sureties, or both, such damage as it may sustain by reason of his failure

to comply with the terms of the Contract. Neither the acceptance by the Department, or any representative of the Department, nor any payment for any acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Department, shall operate a s a waiver of any portion of the Contract or of any power herein reserved, or of any right to damages. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach. Any remedy provided in the Contract shall be taken and construed as cumulative, that is, in addition to each and every other remedy herein provided; and the Party of the First Part shall also be entitled as of right to a writ of injunction against any breach of the provisions of the Contract.

7.21 Preference in Employment of Labor.

In the employment of mechanics, teamsters, chauffeurs and laborers in the construction of public works by the Commonwealth, or by a county, town or district, or by persons contracting or subcontracting for such work, preference shall first be given to citizens of the Commonwealth who have been residents of the Commonwealth for at least six months at the commencement of their employment and who are veterans as defined in General Laws, Chapter 4, Section 7, Clause 43, as amended and who are qualified to perform the work to which the employment relates; and secondly to citizens of the Commonwealth, generally who have been residents of the Commonwealth for at least six months at the commencement of their employment, and if they cannot be obtained in sufficient numbers, then to citizens of the United States, and every Contract for such work shall contain a provision to this effect. Each county, town or district in the construction of public works, or persons contracting or subcontracting for such works shall give preference to veterans and citizens who are residents of such county, town or district. The Contractor's attention is hereby directed to said Section 26 of Chapter 149 of the General Laws, as amended.

The requirements in the above paragraph do not apply to any project or part thereof, financed in whole or in part with Federal Funds.

7.22 Labor, Lodging, Board, Maximum Hours of Employment, Weekly Payment, Keeping of Payroll Records.

Every employee in public work shall lodge, board and trade where and with whom he elects; and no person or his agents or employees under Contract with the Commonwealth, a county, city or town, or with a department, board, commission or officer acting therefor, for the doing of public work, shall directly or indirectly require as a condition of employment therein, that the employee shall lodge, board or trade at a particular place or with a particular person (Chapter 149, Section 25 of the General Laws).

No laborer, workman, mechanic, foreman or inspector working within this Commonwealth, in the employ of the Contractor, Subcontractor or other person doing or contracting to do the whole or a part of the work contemplated by this Contract, shall be required or permitted to work more than eight hours in any one day or more than 48 hours in any one week, or more than six days in any one week, except in cases of emergency, or in case any town subject to Section 31 of Chapter 149 of the General Laws is a party to such a Contract, more than eight hours in any one day, except as aforesaid. The Department or the Contractor or any Subcontractor may employ laborers, workmen, mechanics, foreman and inspectors for more than eight hours in any one day in the work to be done or under Contract when, in the opinion of the Commissioner of Labor and Industries, public necessity so requires. (Chapter 149, Section 34 of the General Laws, as amended).

Attention of Bidders is called to Section 148 of Chapter 149 of the General Laws and amendments thereof requiring the weekly payment of employees.

Upon request of the Engineer or the Massachusetts Department of Labor and Industries, the Contractor shall furnish certified copies of any or all payrolls for the Contract, showing the name, address, and occupational classification of each employee on said works, and the hours worked by, and the wages paid to each such employee. Such payroll shall also include the rates paid for rented trucks or rental equipment of any kind used on the work. This requirement shall also apply to the work or any Subcontractor, having a Subcontract for any of the work performed on the project. Such records shall be kept in such manner as the Commissioner of Labor and Industries shall prescribe, and shall be open to inspection by the Engineer or any authorized representative of the Department of labor and Industries at any reasonable time and as often as may be necessary.

In the case the work covered by this Contract is financed from Federal Funds, the above provisions relative to the hours of employment shall be subject to such revision and amendment as are required by the Rules and Regulations controlling the expenditures of such Federal Funds.

7.23 Archeological and Paleontological Discoveries.

The Contractor's attention is directed to the United States Department of Transportation, Federal Highway Administration, Federal Aid Highway Program Manual, Volume 7, Chapter 7, Section 4, subject "Archeological and Paleontological Salvage", incorporating Policy and Procedure Memorandum 20-7, dated

March 31, 1971, and to the Commonwealth of Massachusetts, Acts of 1973, Chapter 1155. In compliance with these procedures and legislation, the contractor shall exercise special care during his operations to avoid injury to underground prehistoric and historic archeological remains or paleontological remains. Should any archeological or paleontological remains be encountered during any phase of construction, the contractor shall immediately suspend all work in the area and shall notify the Engineer. The Engineer shall immediately notify the State Archeologist and the Massachusetts Historical Commission. All Construction work in that area will be temporarily delayed while the State Archeologist and Representatives of Massachusetts Historical Commission inspect the site to determine the importance of the discovery. Areas of prehistorical, historical, or paleontological significance shall be carefully protected in accordance with Section 7.18 and shall not be disturbed by the Contractor until so directed by the Engineer.

SECTION 8.00

PROSECUTION AND PROGRESS

8.01 Subletting or Assignment of Contract.

The Contractor shall not sublet, sell, transfer, assign, or otherwise dispose of the Contract or any portion thereof, or of his right, title, or interest therein, without written consent of the Engineer. In case such consent is given, the Contractor will be permitted to sublet a portion thereof, but shall perform with his own organization, work amounting to not less than 50 percent of the original total Contract price, except that any items designated in the Contract as "specialty items" may be performed by Subcontract and the cost of any such specialty items so performed by Subcontracts may be deducted from the total cost computing the amount of work required to be performed by the Contractor with his own organization. No Subcontractors, or transfer of Contract, shall in any case release the Contractor of his liability under the Contract and Bonds.

The Contractor shall notify the Engineer, as soon as practicable after execution of the Contract, the name and address of each Subcontractor he intends to employ, the portion of the work which the Subcontractor is to do, and such other information the Engineer may require in order to ascertain whether the Subcontractor is reliable and able to perform the work.

The Contractor shall direct the attention of his Subcontractors to the requirements of:

(1) Subsection 7.05 regarding insurances, and also the Minimum Wage Rates and Health and Welfare and Pensions Fund Contributions as determined by the Commission of Labor and Industries of the Commonwealth and also to the provisions of Subsections 7.21 and 7.22, and

(2) Chapter 30, General Laws, Section 39L requires (1) that the Commonwealth and every county, city, town, district, board, commission, shall not enter into a Contract for such work with, and shall not approve as a Subcontractor furnishing labor and materials for a part of any such work; a foreign corporation which has not filed with the Department a certificate of the State Secretary stating that such corporation has compiled with Sections 3 and 5 of Chapter 181 and the date of such compliance. Chapter 181, Section 3 requires foreign corporations to appoint the Secretary of the Commonwealth as an attorney for service of process, and Section 5, Chapter 181 requires foreign corporations to file certain documents with the Secretary of State which will permit them to do business in Massachusetts.

He shall also direct the attention of his Subcontractors and of all suppliers of material to the requirements of Subsection 5.09 regarding facilities for the Engineer's inspectors.

8.02 Schedule of Operations.

The Contractor shall submit, to and for the comments of the Engineer, a schedule of operations within ten days after the mailing of the executed Contract to the Contractor. The schedule shall show the proposed methods of construction and sequence of work and the time the Contractor proposes to complete the various items of work within the time specified in the Contract.

If the Contractor's operations are materially affected by changes in the plans or in the quantity of the work, or if he has failed to comply with the submitted and reviewed schedule, the Contractor shall submit a revised schedule if requested by the Engineer within seven days after the date of the Engineer's request. This revised schedule shall show how the Contractor proposes to prosecute the balance of the work, so as to complete the work within the time specified in the Contract.

8.03 Prosecution of Work.

The Contractor shall commence work within 15 days after the mailing of the executed Contract to the Contractor unless otherwise ordered in writing by the Engineer, and he shall thereafter prosecute the work at such places and in such order as the Engineer may from time to time prescribe.

Should the prosecution of the work for any reason be discontinued, the Contractor shall notify the Engineer at least 24 hours in advance of resuming operations.

8.04 Removal or Demolition of Buildings and Land Takings.

When the removal or demolition of buildings within highway location is done under other and separate Contracts the provisions of Subsection 5.06 shall apply and it is expressly agreed between the parties that the Party of the First Part shall not be held liable for any expense to the Contractor on account of any delay or interference with his work due to removal or demolition of the buildings or on account of any failure to remove or demolish any building or because of failure to make necessary land takings, and it is further expressly agreed that no allowance of any kind will be made except as provided in Subsections 8.05 or 8.10.

8.05 Claim for Delay or Suspension of the Work.

The Contractor hereby agrees that he shall have no claim for damages of any kind on account of any delay in commencement of the work or any delay or suspension of any portion thereof, except as hereinafter provided.

Provided, however, that if the Commission in their judgment shall determine that the performance of all or any major portion of the work is suspended, delayed, or interrupted for an unreasonable period of time by an act of the Department in the administration of the Contract, or by the Department's failure to act as required by the Contract within the time specified in the Contract (or if no time is specified, within a reasonable time) and without the fault or negligence of the Contractor, an adjustment shall be made by the Department for any increase in the actual cost of performance of the Contract (excluding profit and overhead) necessarily caused by the period of such suspension, delay or interruption. No adjustment shall be made if the performance by the Contractor would have been prevented by other causes even if the work had not been so suspended, delayed, or interrupted by the department.

No claims shall be allowed under this Subsection for the Department's failure to act as required by the Contract within the time specified in the Contract (or if no time is specified, within a reasonable time) for any cost incurred more than two weeks before the Contractor shall have notified the Department in writing of his claim due to the Department's failure to act.

The contractor shall submit in writing not later than 30 days after the termination of such suspension, delay or interruption the amount of the claim and breakdown of how the amount was computed in accordance with Subsection 9.03B except no allowance for overhead and profit shall be allowed.

Any dispute concerning whether the delay or suspension is unreasonable or any other question of fact arising under this paragraph shall be determined by the Commission, and such determination and decision, in case any question shall arise, shall be a condition precedent to the right of the Contractor to receive any money hereunder.

The Contractor further agrees that the sole allowance for any such delay or suspension, other than as provided above, is an extension of time as provided in Subsection 8.10.

8.06 Limitations of Operations.

The Contractor shall conduct the work at all times in such a manner and in such sequence as will assure the least interference with traffic and abutters. He shall have due regard to the location of detours and to the provisions for handling traffic. He shall not open up work to the prejudice or detriment of work already started.

8.07 Character of Workmen, Methods and Equipment.

The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by these specifications.

All workmen shall have sufficient skill and experience to perform properly the work assigned to them. Workmen engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person employed by the Contractor or by any Subcontractor who, in the Engineer's judgment, does not perform his work in a proper and skilled manner or is intemperate or disorderly or otherwise unsatisfactory or not employed in accordance with the provisions of Subsection 7.21, shall at the written request of the Engineer, be removed forthwith by the Contractor or Subcontractor employing such person, and shall not be employed again in any portion of the work without the approval of the Engineer.

Should the Contractor fail to take the necessary action to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until such orders are complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the Contract, the Contractor is free to use any methods or equipment that he demonstrates to the satisfaction of the Engineer which will accomplish the contract work in conformity with the requirements of the Contract.

When the Contract specifies the methods and equipment by which the construction be performed, such methods and equipment shall be used unless others are authorized by the Engineer, in writing. If the Contractor desires to use a method or type of equipment other than that specified in the Contract, he may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it shall be in writing and it will be on the condition that the Contractor will be fully responsible for producing construction work in conformity with contract requirements. If after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No changes will be made in basis of payment for the construction items involved nor in contract time as a result of authorizing a change in methods or equipment under these provisions.

8.08 Preservation of Roadside Growth.

In general, the Contractor shall take special precautions at all times to protect and preserve natural surroundings and roadside growth either within or adjacent to the location from damage or injury due to his operations. The Contractor shall not, except by written permission of the Engineer, remove, destroy, or trim such roadside trees or shrubs.

Any trees or landscape features carelessly scarred or damaged by the Contractor's operations shall be removed and replaced or neatly trimmed and restored as nearly as possible to the original condition as required by the Engineer. In general the Contractor shall be responsible for all damage to roadside growth due to his operations and shall, without compensation, satisfactorily repair or replace all such damage.

All scars on trees shall be painted as soon as possible with an approved tree paint.

8.09 Delay and Suspension of Work.

The Engineer shall have the authority to delay the commencement of the work and delay or suspend any portion thereof; for such period or periods as he may deem necessary because of conditions beyond the control of the Commonwealth, or the Contractor; or beyond the control of the Commonwealth and the Contractor; for the failure of the Contractor to correct conditions unsafe for the general public; for failure to carry out provisions of the Contract; for failure to carry out orders; for causes and conditions considered unsuitable for the prosecution of the work; for acts of third persons not a party to the Contract; or for any other cause, condition, or reason deemed to be in the public interest.

Upon receipt of written order of the Engineer, the Contractor shall immediately delay the commencement of the work or delay or suspend any portion thereof in accordance with said order. No work shall be suspended or delayed without the prior written approval or order of the Engineer. The work shall be resumed when conditions so warrant or deficiencies have been corrected and the conditions of the Contract satisfied as ordered or approved in writing by the Engineer. The Contractor's attention is also directed to the requirements of Subsections 7.09 and 7.18 which shall govern during any period of temporary or partial suspension of work.

8.10 Determination and Extension of Contract Time for Completion.

The maximum time limit for the satisfactory completion of the work set forth in the Proposal is based upon the requirements of public convenience and the assumption that the Contractor will prosecute the work efficiently and with the least possible delay, in accordance with the maximum allowable working time per week as specified herein.

It is an essential part of this Contract that the Contractor shall perform fully, entirely, and in an acceptable manner, the work required within the time stated in this Contract, except that the contract time for completion shall be adjusted as follows:

A. If the Contractor does not receive the Notice to Proceed for a Federally Aided project within 70 days of bid opening (or for a Non-Federally Aided project, within 55 days of bid opening), it shall be entitled to an extension of time equivalent to the number of days beyond 70 (or 55) that it takes for the Contractor to receive the Notice to Proceed. Any such extension of time shall be reduced by the number of days beyond 14 days from the date of receipt of the Notice of Award that the Contractor takes to return the executed Contract and the required surety.

B. In case the commencing of the work is delayed or any part thereof is delayed or suspended by the Party of the First Part (except for unsuitable weather, winter months, or reasons caused by the fault or neglect of the Contractor), the Contractor will be granted an extension of time in which to complete work or any portion of the work required under the Contract equivalent o the duration of the delay less a reasonable period of time within which he could have done necessary preliminary work.

C. If satisfactory completion of the work shall require performance of work in greater quantities than those set forth in the Proposal, the time allowed for performance shall be increased in the same ratio as the total final estimate value of the contract items bears to their total bid value.

D. When delay occurs due to reasonable causes beyond the control and without the fault or negligence of the Contractor, including but not restricted to "Acts of God", to war, whether or not declared, civil war, insurrection, rebellion or revolution, or to any act or condition incident to any of the foregoing, acts of the Government, acts of the State or any political subdivision thereof, acts of other contracting parties over whose acts the Contractor has no control, fires, floods, epidemics, abnormal tides (not including Spring tides), severe coastal storms accompanied by high winds or abnormal tides, freezing of streams and harbors, abnormal time of Winter freezing or Spring thawing, interference from recreational boat traffic, use of beaches and recreational facilities for recreational purposes during the Summer season, abnormal ship docking and berthing, unanticipated use of wharves and storage sheds, strikes except those caused by improper acts or omissions of the Contractor, extraordinary delays in delivery of materials caused by strikes, lockouts, wrecks, freight embargoes, the time for completion of work shall be extended in whatever amount is determined by the Engineer to be equitable.

An "Act of God" as used in this article is construed to mean an earthquake, flood, cyclone, or other cataclysmic phenomenon of nature beyond the power of the Contractor to foresee or make preparation in defense of. A rain, windstorm, or other natural phenomenon of normal intensity, based on United States Weather Bureau reports, for the particular locality and for the particular season of the year in which the work is being prosecuted, shall not be construed as an "Act of God" and no extension of time will be granted for the delays resulting therefrom.

Within the scope of acts of the Government, consideration will be given to properly documented evidence that the Contractor has been delayed in obtaining any material or class of labor because of any assignment or preference ratings by the Federal Government or its agencies to War, Navy or other defense Contracts.

E. In case the work is delayed by Public Service Corporations or Municipal Corporations see Subsection 5.05.

F. Each Extra Work Order as issued will include a statement of additional time, if any, that is agreed upon by the Contractor and the Engineer as required for the completion of this Contract by reason of this Extra Work Order, and no other time allowance on account of the performance of the work covered by such Extra Work Order will be allowed.

No extension of time will be granted for any delay or any suspension of the work due to the fault of the Contractor, nor if a request for an extension of time on account of delay due to any of the aforesaid causes is not filed within 15 days of the date of the commencement of the delay nor if the request is based on any claim that the contract period as originally established was inadequate.

If the approved extended date of completion falls within the period from December 1st to March 15th, due to reasons above then the Contractor will be allowed the same number of days beyond December 1st, extended after March 15th. The contract period has been carefully considered and has been established for reasons of importance to the Party of the First Part. This time limit will be enforced and any prospective Bidder who is not willing to accept this Contract with the intention of complying with the time limit is cautioned not to submit a bid.

The probable slowdown or curtailment of work during inclement weather and winter months has been taken into consideration in determining the total time required to complete the project, hence no extension of time will be allowed due to this reason.

8.11 Failure to Complete Work on Time.

On or before the date stated in the proposal for completion or the date to which the time of completion shall have been extended under the provisions of Subsection 8.10 the whole work shall have been performed in accordance with the terms of the Contract. The time in which the various portions and the whole of the Contract are to be performed and the work is to be completed is an essential part of the Contract.

In case the work embraced in the Contract shall not have been physically completed by the time stipulated therein (according to the foregoing requirements) the Contractor shall pay to the party of the First Part a designated sum per day for the entire period of overrun in accordance with the Schedule of Deductions listed in the Contract. In the event the Contract has been substantially completed and the project opened for traffic as directed in writing by the Engineer, but physical completion of the work is subject to delay because of minor uncompleted items which do not impair the usefulness of the project, the designated sum per day shall be 1/2 the charges shown. In addition to the daily charge, the Contractor shall pay without reimbursement the entire cost of all traffic officers, railroad flagmen and inspectors the Engineer or the Chief Engineer of the railroad determines to be necessary during the period of overrun of time.

In the event the physical work embraced in the Contract has been completed and accepted in writing by the Chief Engineer but there remains to be submitted to the Department by the Contractor any reports or other documents in accordance with the provisions of the Contract, the Contract shall not be considered satisfactorily completed within the meaning of Section 39G of Chapter 30 of the General Laws until the receipt of such reports or documents by the Department, but the designated sum per day during this interval shall be zero.

Whatever sum of money may become due and payable to the Party of the First Part by the Contractor under this Subsection may be retained out of money belonging to the Contractor in the hands and possession of the Party of the First Part. It is agreed that this Subsection shall be construed and treated by the parties to the Contract not as imposing a penalty upon said Contractor for failing fully to complete said work as agreed on or before the time specified in the Proposal, but as liquidated damages to compensate said Party of the First Part for all additional costs incurred by said Party because of the failure of the Contractor fully to complete said work on or before the date of completion specified in the Proposal.

Permitting the Contractor to continue and finish the work or any part of it after the time fixed for its completion, or after the date to which the time for completion may have been extended, shall in nowise operate as a waiver on the party of the Party of the First Part of any of its rights under the Contract.

8.12 Default Termination.

If the Contractor shall be adjudged a bankrupt, or if he shall make a general assignment for the benefit of his creditors, or if a receiver of his property shall be appointed, or if the work to be done under the Contract shall be abandoned, or if the Contract or any part thereof shall be sublet without the previous written consent of the Party of the First Part, or if the Contract or any claim thereunder shall be assigned by the Contractor otherwise than as herein specified, or if at any time in the Engineer's judgment and he so certifies in writing to the Party of the First Part that the work, or any part thereof, is unnecessarily or unreasonably delayed, or that the Contractor has violated any of the provisions of the Contract, the Party of the First Part may notify the Contractor to discontinue all work, or any part thereof. Such notice shall be given to the Contractor in writing and thereupon the Contractor shall discontinue such work or such part thereof, as the Party of the First Part may designate, and the Party of the First Part shall require the surety or sureties to complete the Contract.

If the Engineer shall certify that the rate of progress is not satisfactory, the Party of the First Part may instead of notifying the Contractor to discontinue all work or any part thereof, notify him from time to time to increase the force, equipment and plant, or any of them, employed on the whole or any part of the work, stating the amount of increase required to insure the proper completion of the work. The Contractor shall provide and maintain, at no additional cost to the Department, any lights necessary to protect the work or the traveling public, for the safety of his construction forces and to insure the proper construction, inspection and prosecution of the work (See Subsections 7.09 and 7.10). Unless he shall, within five days after any such notice, increase his force, equipment and plant to the extent required therein, and maintain and employ the same from day to day until the completion of the work or such part thereof or until the conditions as to the rate of progress shall, in the Engineer's judgment, be fulfilled, the Party of the First Part may employ and direct the labors of such additional force, equipment and plant as may, in the Engineer's judgment, be necessary to insure the completion of the work or such part thereof within the time specified, or at the earliest possible date thereafter, and charge the expense thereof to the Contractor. Neither the notice from the Party of the First Part to the Contractor, to increase his force, equipment or plant, nor the employment of additional force, equipment or play by the Party of the First Part shall be held to prevent a subsequent notice from the Party of the First Part to him to discontinue work under the provisions of the preceding portion of this article.

All expenses charged under this article shall be deducted and paid by the Party of the First Part out of any moneys then due or to become due the Contractor under the Contract, or any part thereof, and in such accounting the Party of the First Part shall not be held to obtain the lowest figures for the work of completing the Contract or any part thereof, or for insuring its proper completion, but all sums actually paid therefor shall be charged to the Contractor. In case the expenses so charged are less than the sum which would have been payable under the Contract if the same had been completed by the Contractor, the Contractor shall be entitled to receive the difference; and in case such expenses shall exceed the said sum, the Contractor shall pay the amount of the excess to the Party of the First Part. upon completion of the work without further demand being made therefor.

8.13 Convenience Termination.

If the Party of the First Part determines that it is in the public interest to do so, it may notify the Contractor to discontinue all work, or any part thereof. Such notice shall be given to the Contractor in writing and thereupon the Contractor shall discontinue such work, or such part thereof, as the Party of the First Part may designate.

If the Party of the First Part notifies the Contractor to discontinue all work, or any part thereof, the Party of the First Part shall pay and the Contractor shall accept, as full payment for all work done and materials provided, the following sums:

A. For all completed items of work for which there are unit prices provided in the contract.

The original contract unit prices.

B. For all work on partially completed items.

A sum agreed to by the Contractor and the Party of the First Part or:

(1). The actual costs for direct labor, materials (less salvage value, if any) and use of equipment, plus 10% of this total for overhead; and (2) the actual cost for Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits, Social Security deductions, and Employment Security Benefits; and (3) 10 percent of the total of (1) and (2) for profit and; (4) the estimated proportionate cost of surety bonds; and (5) the actual cost to the Contractor for work performed by a Subcontractor, plus 10 percent of such cost. No allowance shall be made for general superintendence and the use of small tools and manual equipment.

C. For costs of settlement as:

Reasonable and necessary accounting, legal, clerical and other costs of work discontinuance; and reasonable and necessary storage, transportation and other costs incurred for the preservation, protection or disposition of the discontinued work.

When requested by the Engineer, the Contractor shall furnish itemized statements of the cost of the work performed and shall give the Engineer access to all accounts, bills and vouchers, relating thereto and unless the Contractor, when requested, shall furnish such itemized statements and access to all accounts, bills and vouchers, he shall not be entitled to payment for the work for which such information is sought by the Engineer.

The Contractor shall not be paid and the Contractor shall not have any claim for loss of anticipated profits, for loss of expected reimbursement or for any increased expenses resulting directly or indirectly from the discontinuance of any or all work or from unbalanced allocation, among the contract items, of overhead expense on the part of the bidder and subsequent loss of expected reimbursement therefor or for any other cause.

The Contractor shall incorporate the provisions of this section as provisions in its contracts with each of its subcontractors.

The authority of the Party of the First Part under this section shall be in addition to the authority of the Engineer under other sections of these specifications.

SECTION 9.00

MEASUREMENT AND PAYMENT

9.01 Measurement of Quantities.

The quantities of the various items of work performed shall be determined for purposes of payment by the Engineer and by the Contractor for purposes of the certification(s) of work performed that are generally required by law and specifically by the provisions hereof.

Upon the completion of the work and before final payment is made the Engineer will make final measurement to determine the quantities of the various items of work performed, as the basis for final settlement. All measurements shall be made according to the United States standard units of measurement.

The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the Contracts shall be selected by the Engineer.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of nine square feet or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the plans or ordered in writing by the Engineer.

Structures will be measured according to neat lines shown on the plans or as altered to fit field conditions.

All items which are measured by the linear foot, such as pipe, culverts, guardrail, underdrains, etc., will be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the plans.

In computing volumes of excavation the average end area method or other methods acceptable to the Engineer will be used.

When the term "gage" refers to the measurement of wire, it will mean the wire gage specified in the AASHTO Designation M32.

All materials which are specified for measurement by weight shall be weighed on standard scales furnished by and at the expense of the Contractor. Such scales shall be sealed at the expense of the Contractor as often as is necessary to insure their accuracy. A sworn weigher to be compensated by the Contractor shall weigh all materials required to be weighed as above provided. The weighing of such materials may be witnessed by the Engineer. If materials are shipped by rail or trucks, the car weights or quarry weights may be accepted, but scales shall be used as above, if so directed. Weight slips shall be provided for each shipment of material weighed. Each weight slip shall be signed by the sworn weigher. The weight slips shall be countersigned on delivery by the Engineer and no weight slip not so countersigned shall be included for payment under the Contract.

When requested by the Contractor and approved by the Engineer in writing, material specified to be measured by the cubic yard may be weighed and such weights will be converted to cubic yards for payment purposes. Factors for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before such method of measurement of pay quantity is used.

The term "lump sum" when used as a unit of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weight or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

9.02 Scope of Payments.

The Party of the First Part will pay and the Contractor shall receive and accept the compensation as herein provided, in full payment for furnishing all materials, labor, tools and equipment and for performing all work contemplated and embraced under the Contract, also for all loss or damage arising out of the nature of the work, or from the action of the elements (except as specified in Subsection 7.18), or from any unforeseen difficulties or obstructions which may arise or be encountered during the prosecution of the work (except as set forth in Subsection 4.04) until its final approval by the Party of the First Part, and for all risks of every description connected with the prosecution of the work, also for all expenses incurred by or in consequence of the suspension or discontinuance of the said prosecution of the work as herein specified, and for any infringement of patent, trademark or copyright, and for completing the work in an acceptable manner according to the plans and specifications.

The payment of any current estimate, or any retained percentage shall in no way constitute an acknowledgement of the acceptance of the work or in no way or degree prejudice or affect the obligation of the Contractor, at his own cost and expense, to repair, correct, renew or replace any defects and imperfections in the construction of, or in the strength of, or quality of materials used in or about the construction of the work under Contract and its appurtenances, as well as all damages due or attributable to such defects: which defects, imperfections or damages shall have been discovered on or before the final inspection and acceptance of the work.

The Engineer shall be the sole judge of such defects, imperfections, or damages and the Contractor shall be liable to the Party of the First Part for failure to correct the same as provided herein, (Also see Subsection 7.20).

9.03 Payment for Extra Work.

A. Payment for work for which there is a unit price provided for in the Contract.

Where the Contract contains a unit price for work and the Engineer orders Extra Work for work of the same kind as other work contained in the Contract and is performed under similar physical conditions, the Contractor shall accept full and final payment at the Contract unit prices for the accepted quantities of Extra Work done.

No allowance will be made for any increased expenses or any damages whatsoever.

B. Payment for work or materials for which no price is contained in the Contract.

If the Engineer directs, the Contractor shall submit promptly in writing to the Engineer an offer to do the required work on a lump sum or unit price basis, as specified by the Engineer. The stated price, either lump sum or unit price, shall be divided so as to show that it is the sum of: (1) and the estimated cost of direct labor, materials, and the use of equipment, plus 10 percent of this total for overhead: (2) plus the actual cost of Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits, Social Security deductions, Employment Security Benefits, and such additional fringe benefits which the Contractor is required to pay as a result of Union Labor Agreements and/or is required by authorized governmental agencies: (3) plus 10 percent of the total of (1) and (2); (4) plus the estimated proportionate cost of surety bonds.

Unless an agreed lump sum and/or unit price is obtained from above and is so stated in the Extra Work Order the Contractor shall accept as full payment for work or materials for which no price agreement is contained in the Contract an amount equal to the following: (1) the actual cost for direct labor, material (less value of salvage, if any) and use of equipment, plus 10 percent of this total for overhead: (2) plus actual cost of Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits. Social Security deductions, and Employment Security Benefits: (3) plus 10 percent of the total of (1) and (2); (4) plus the estimated proportionate cost of surety bonds. For work performed by a Subcontractor, the Contractor shall accept as full payment therefor an amount equal to the cost to the Contractor of such work as determined by the Engineer, plus 10 percent of such cost.

No allowance shall be made for general superintendence and the use of small tools and manual equipment.

The Contractor shall, when requested by the Engineer, furnish itemized statements of the cost of the work ordered and give the Engineer access to all accounts, bills and vouchers relating thereto, and unless the Contractor shall furnish such itemized statements, access to all accounts, bills and vouchers, he shall not be entitled to payment for any items of extra work for which such information is sought by the Engineer.

C. Equipment Rates

In the event there arises the need for determination of costs of use of equipment as part of "actual costs" or "cost of performance" or damages" under Subsections 4.04, 7.16, 8.05, 9.02 and/or 9.03, or under Chapter 30 of the Massachusetts General Laws, such costs for use of equipment shall be established in accordance with the following:

(1) "Construction equipment" as used herein means equipment in sound workable condition, either owned or controlled by the Contractor or the Subcontractor at any tier, or obtained from a commercial rental source, and furnished for use under the contract.

(2) Allowable hourly ownership and operating costs for contractor-owned or subcontractor-owned equipment shall be determined as follows:

(a) Actual cost data from the Contractor's accounting and operating records shall be used whenever such data can be determined for hourly ownership and operating costs for each piece of equipment, or groups of similar serial or series equipment. Actual costs shall be limited to booked costs of the annual accounting period or periods during which the equipment was utilized on the Contract, and will not include estimated costs not recorded and identifiable in the Contractor's formal accounting records. The Contractor shall afford Department auditors full access to all accounting, equipment usage, and other records necessary for development or confirmation of actual hourly cost rates for each piece of equipment, or groups of similar serial or series equipment. The Contractor's refusal to give such full access shall invalidate any request or claim for payment of the equipment costs. When costs cannot be determined from the Contractor's records, hourly equipment cost rates may be determined under (b) and (c) below.

(b) When the Department ascertains that it is not practicable to determine actual equipment cost rates or elements thereof from the Contractor's records, hourly equipment cost rates or elements shall be determined by the use of rate schedules or the formula contained in *Construction Equipment Ownership and Operating Expense Schedule*, Region 1, published by the U.S. Army Corps of Engineers; said publication is

incorporated herein by reference. The Contractor shall provide to the Department, in a format prescribed by the Department, sufficient descriptive and operating data for each piece of equipment so that the cost rates or elements may be determined from the aforementioned schedule or formula. Depreciation costs shall be based on the actual purchase price for each equipment item. Where appropriate, hourly cost rates may be comprised partly of actual booked cost elements (such as depreciation) determinable under (a), and partly of other cost elements not determinable as a practical matter under (a), but determined under (b).

(c) The Department will consider as an alternative to (b) appropriate rates for Contractor owned equipment developed from the "Rental Rate Blue Book" (Volume 1) published by Dataquest, Inc., provided that (1) Hourly rates shall be developed by dividing monthly rates by 176 hours per month (the "weekly," "hourly" and "daily" rates listed in the "Blue Book" will not be used); (2) Rates shall in all cases be adjusted by application of Rate Adjustment Tables (machine age adjustment) plus adjustment to eliminate Equipment Overhead plus Regional Adjustments; and (3) Rates shall be further reduced by 20% to eliminate duplicate and excessive costs, except that the rates shall instead be reduced by 75% to determine standby rates. The number of hours to be paid for shall be the numbers of hours that the equipment is actually used on a specific force account activity. The "current revisions" to the Blue Book will be used in establishing rates. The "current revision" applicable to specific force account work will be the "current revision" as of athe first day of work performed on that force account work and that rate will apply throughout the period the force account work is being performed. In all cases, the Department reserves the right to utilize, in preference to Blue Book rates, equipment cost rates based upon actual costs per accounting records, or the U.S. Army Corps of Engineers guide, or hybrid rates as described above.

(d) In those cases where a 10 percent additive for overhead is to be superimposed on the equipment costs as provided in Subsections 4.04, and 9.03B, equipment cost rates determined under (a), (b) and (c) shall exclude any overhead costs such as equipment insurance, licenses, or taxes. The 10 percent additive shall compensate the Contractor for all overhead costs, including equipment overhead, general superintendence, small tools, manual equipment, field overhead, and central office overhead. Where the 10 percent overhead additive is not applicable, overhead items clearly related to equipment, (equipment insurance, licenses, taxes), shall be includable in the equipment rates; provided, however, that such costs shall be identified and eliminated from any other direct or indirect costs or damages payable by the Department under the Contract. No element of profit shall be allowable in equipment cost rates for Contractor-owned equipment; it being understood that a 10 percent profit additive will be superimposed upon equipment costs when called for by the Contract.

(3) Reasonable hourly costs of renting equipment are allowable subject to Contractor production of auditable records supporting actual costs incurred, provided further that:

(a) Costs such as fuel, lubricants, and minor or running repairs incident to operating such rented equipment that are not included in the rental rate are allowable.

(b) Costs incident to major repair and overhaul of rental equipment are not allowed.

(c) Charges for equipment leased or rented from any division, subsidiary organization under common control, or business under common ownership, ordinarily will be reimbursable to the extent that they do not exceed the actual costs of ownership and operating costs determined as in (2), above. Rental cost of equipment leased or rented from any division, subsidiary, affiliate of the Contractor under common control, or business under common ownership, that has an established practice of renting out the same or similar equipment to unaffiliated parties, shall be allowed at rates higher than actual ownership and operating costs, provided that the Contractor furnishes the Department adequate documentation, including the rental and usage records for the same or similar equipment items, demonstrating a reasonable likelihood that the equipment would have been rented out if not used on this Contract, and that the rental rates charged are consistent with rates charged to unaffiliated parties and going market rates. Rental costs under a sale and leaseback arrangement will be allowable only up to the amount the Contractor would be allowed if the Contractor retained title.

(4) Equipment cost rates determined in (2) and (3) shall be exclusive of labor cost of equipment operators. Such costs shall be reimbursable subject to Contractor production of auditable payroll and other records sufficient for determination of hours, pay rates, and reimbursable fringe costs as defined in Subsection 4.04 and above.

(5) Except in cases of unit price or lump sum extra work orders approved by the Department before the work is done, actual reimbursable hours of equipment usage and operator time must be adequately documented by the Department force account records or Contractor field and office records maintained during performance of the work in a manner acceptable to the Department. Failure of the Contractor to so maintain time records which adequately segregate added equipment hours caused by extra work required by the Department, or caused by other Department actions cited in the Contractor's claim for damages, from other equipment time worked

on the Contract, when maintenance of such records would have been feasible, shall constitute a cardinal omission of the Contractor, invalidating any claim for equipment cost reimbursement.

The above provisions constitute an advanced agreement made in general conformance with intent of Federal Acquisition Regulation 31.05, paragraph (d)(1), said intent being to maximize clarity of understanding and minimize possible disputes with respect to determination of reimbursable actual equipment costs under this Contract.

9.04 Partial Payments.

The Engineer shall biweekly make an estimate of the total amount of the work done from one estimate to the next. The Department's Computer Section will process the estimated value from the Engineer's report. The Party of the First Part shall retain a portion of such estimated value, but not to exceed $500,000 on any one Contract as part security for the fulfillment of the Contract by the Contractor, and shall also retain from said estimates an amount sufficient to cover claims which it may have against the Contractor and claims filed pursuant to Chapter 149, Section 29 and Chapter 30, Section 39A and F. The Party of the First Part shall pay-biweekly to the Contractor while carrying on the work the balance not retained as hereinbefore provided. No such estimates or payment shall be required to be made when, in the Engineer's judgment, the work is not proceeding in accordance with the provisions of the Contract, or when in his judgment the total value of the work done since the last estimate amounts to less than $1,000.00.

There will be a retainage of ten (10%) percent of the value of all planting items. For all other items of work there will be no retainage for the first fifty (50%) percent of the bid price as determined by the Engineer. For the second fifty (50%) percent of the bid price there will be a retainage of five (5%) of the value of all items of work excluding planting items.

Whenever the work is substantially complete, the Party of the First Part may, if it considers the amount retained to be in excess of the amount adequate for the protection of the Commonwealth and is required by statute, at its discretion, release to the Contractor all or a portion of such excess amount, and may cause the Contractor to be paid, temporarily or permanently, from time to time such portion of the reserve as it deems prudent.

Upon presentation by the Contractor of certified copies of paid invoices, the Party of the First Part may include in the estimate, advance payments for acceptable reinforcing steel, structural steel, stone, piles, culvert pipe or other non-perishable materials purchased expressly for the work and delivered on the work or in approved storage places at the site, but which materials are not considered as erected or complete in place under the items of the Contract, and for which partial payment as specified above would not be made until such materials and items were erected or complete in place.

If it is impossible due to lack of area on the site or other valid reason, the Contractor may request in writing permission from the Engineer to store materials off the site and still have the materials paid as material on hand and the Engineer may approve payment. This request will state the reason for the request, location of proposed storage site, methods that will be employed to insure that materials is properly protected and the material will be used on the particular project, and any other information as may be deemed necessary in order to evaluate the request. No advance payment for material stored off the site will be made until written approval of the Engineer has been obtained. The amount to be included in the estimate will be determined by the Engineer up to a maximum of 100% of the value of the materials as shown by the certified copies of paid invoices. Payment will not be approved when the invoice value of such materials as determined by the Engineer, amounts to less than $1000.

Deductions at rates and in amounts which are equal to the payments will be made from estimates as the materials are incorporated in the work.

Payment for the materials, as aforesaid, shall not in itself constitute acceptance and any materials which do not conform to the specifications for same shall be rejected in accordance with the stipulation of Subsection 6.04.

For any item for which the payment is made on a lump sum basis, (except lump sum Bridge Structures) and for which payment may be allowed if the Contractor requests partial payment on such an item, the Contractor shall submit for approval by the Engineer, a schedule of the quantities and unit prices for the major components of the item. Each component part shall be considered as including all its concomitance so that the total cost listed for the components is the contract cost for the item. The approval of the schedule by the Engineer shall not be considered as a guarantee to the Contractor that the quantities shown on the schedule are the approximate quantities actually included in the lump sum item.

The schedule is only for the purpose of estimating partial payments, and it shall not affect the contract terms in any way.

The Contractor will be required to certify, in writing, that the work for which he is being paid on the estimate in question has in fact been done.

9.05 Final Acceptance and Final Payment.

When in the opinion of the Chief Engineer the Contract has been satisfactorily completed and final acceptance has been voted by the Board of Commissioners, the Department Secretary shall inform the Contractor in writing of the date of such acceptance, upon which date the Contractor's responsibility shall cease except as provided in his bond and as provided in Subsection 7.20.

The Engineer shall, as soon as practicable after the physical completion of the Contract, make a final estimate of the amount of work done thereunder and the value of such work. Within 65 days from and after the date the work has been accepted by the Board, the Party of the First shall forward to the Contractor a copy of the final estimate or semifinal estimate as stipulated in Chapter 30, Section 39G of the General laws, as amended together with an agreement form for his acceptance. After such acceptance has been filed with the Supervisor of Fiscal Management of the Department payments of the entire sum will be made, so found to be due thereunder after deducting therefrom all previous payments and all amounts to be kept and all amounts to be retained under the provisions of the Contract. All prior partial estimates and payments shall be subject to correction in the final estimate and payment. If within six months from the date the final estimate is forwarded to the Contractor, the Contractor has not filed a valid (as determined by the Engineer) written reason(s) for not accepting the final estimate, the final estimate will be considered acceptable to the Contractor and payment of the final estimate made.

The acceptance by the Contractor of the final payment shall operate as and shall be a release to the Party of the First Part and every member, agent and employee thereof, from all claims by the Contractor for anything done or furnished for, or relating to the work or for any act or neglect of the Party of the First Part or of any person relating to or affecting the work, except the claim against the Party of the First Part for the remainder if any there be, of the amounts kept or retained as provided in Subsection 7.15.

DIVISION II
CONSTRUCTION DETAILS

SECTION 1.00 — EARTHWORK, GRADING, DEMOLITION, RODENT CONTROL AND BORINGS
SECTION 2.00 — DRAINAGE
SECTION 3.00 — WATER SYSTEMS
SECTION 4.00 — SUB-BASE, BASE COURSES, SHOULDERS, PAVEMENTS AND BERMS
SECTION 5.00 — CURB AND EDGING
SECTION 6.00 — HIGHWAY GUARD, FENCES AND WALLS
SECTION 7.00 — INCIDENTAL WORK
SECTION 8.00 — TRAFFIC CONTROL DEVICES
SECTION 9.00 — STRUCTURES

SECTION 100
EARTHWORK, GRADING, DEMOLITION, RODENT CONTROL AND BORINGS

SECTION 101
CLEARING AND GRUBBING

DESCRIPTION

101.20 General.

This work shall consist of clearing, grubbing, cutting, removal and disposal of all vegetation and debris from areas either within or outside of the Right-of-Way as shown on the plans or designated by the Engineer. The work shall also include the preservation from injury or defacement of all vegetation and objects designated by the Engineer to remain.

CONSTRUCTION METHODS

101.60 General.

The burning of trees, brush, stumps, etc., will not be permitted. The Contractor shall provide other satisfactory methods of disposal without additional compensation.

The Contractor shall obtain written permission of the Engineer for use of storage areas within the Right-of-Way requiring clearing and grubbing or selective clearing and thinning. Any clearing for the Contractor's convenience shall be done at his own expense. All such areas shall be restored to a condition acceptable to the Engineer including necessary mulching, seeding, and planting without additional compensation.

The Engineer shall be provided with notarized copies of agreements between the Contractor and owners of land used as disposal or storage areas.

When fencing is installed outside normal clearing areas, every reasonable effort shall be made to preserve trees or shrubs whose removal is not essential to the installation of the fencing.

Acceptable material obtained on the project may be used to produce wood chip mulch. The Contractor shall use an approved chipper and ¼ inch knife setting as described under Subsection M6.04.3. Wood Chip Mulch. Material obtained from Elm trees shall not be accepted for use.

Wood chips produced on the project from clearing and grubbing shall be stockpiled within the location and used where and as directed.

Except for materials used for making wood chip mulch, the Contractor shall make all arrangements and negotiations necessary for the satisfactory disposal of trees, shrubs, stumps, roots, dead wood and other litter, in areas outside the Right-of-Way and in such manner that no condition or accumulation of material shall be permitted to disfigure or mar the finished landscape.

101.61 Clearing and Grubbing.

The stumps of all trees, brush and major roots shall be grubbed and removed in all excavation areas and under all embankments where the original ground level is within 3½ feet of the subgrade or slope of embankments.

All trees, stumps, and brush shall be cut off within 6 inches of the ground in embankment areas where the original ground level is more than 3½ feet below the subgrade or slope of embankments.

Trees and shrubs that are specifically designated by the Engineer not to be cut, removed, destroyed or trimmed shall be saved from harm and injury.

All damage done to trees by the Contractor's operation and all branches of trees extending within the roadway shall be trimmed and painted where cut as directed to provide a 20-foot minimum vertical clearance including selective trimming of such trees as directed.

101.62 Selective Clearing and Thinning.

A. General.

The work under this item shall consist of the removal of hazardous growth and dead, dying or diseased plant material; the removal of groups and individual plants which interfere with the growth of more desirable types of trees and the clearing away of lesser growth that may obscure outstanding trees, tree groups, or scenic views. Any part of tree trunks or base of plant material located on the Location Lines shall be considered within the State Highway Limits.

Densely wooded areas shall be thinned to provide space for healthy growth by eliminating thinner, weaker trees and the reduction of number of varieties.

The Contractor's attention is called to the requirements for work under this item. The desired appearance to be attained in certain areas of heavy growth may require three or more operations. First, the obvious dead, dying and diseased trees and undergrowth shall be cut and cleared out of the area. This work includes removal of any previously fallen trees, branches, uprooted stumps and other debris as directed. Next, the area is to be thinned out, as directed, by removing the less desirable trees and brush which interfere with the growth of the better plant material. Finally, clear out lesser growth which may obscure outstanding trees, tree groups or scenic views.

Tree up-branching and shaping under this item will be restricted to trees which have limbs and branches restricting sight distance, extending over roadways, shoulders, turn outs, etc. Up-branching or trimming will be required to produce a 20-foot minimum vertical clearance over all locations described hereinbefore, and the removal of limbs and branches involved in this operation shall be accomplished as outlined hereafter.

B. Prosecution of Work

(Supplementing Subsection 8.03). Quality of work must conform with accepted tree trimming practices.

All trimming and pruning shall conform to recognized tree surgery practices, and particular note should be made that painting with an approved tree dressing or paint, will be required on all cuts 2 inches or over in diameter.

The dressing or paint shall be applied no later than two days after the cuts are made.

Recognized tree surgery practices include among many others, the fact that all limbs and branches which require removal and all stubs regardless of age must be cut flush either to a union with the next larger sound limb or branch or flush to the trunk of the tree.

The cutting shall be performed by experienced woodsmen. Trained tree climbers are required for pruning of tall growth. Care shall be exercised by the Contractor to prevent injury to trees and shrubs designed to be preserved. Any injury to limbs, bark or roots of such plants shall be repaired by the Contractor, as directed, or the plants replaced without additional compensation for such repair or replacement.

C. Cutting and Treatment of Stumps and Stubble.

Standing trees, undesirable brush and existing stumps to be removed shall be cut flush with the ground and a 2'' tolerance permitted and the resulting stumps or stubble then brushed or sprayed with a chemical spray material conforming to the requirements of M9.02.0 of Division III, Materials.

Application shall be by brush or spray so as to give complete coverage and wetting to the point of runoff.

This application shall be completed within two days after the cutting.

As the specified chemical herbicide is harmful to desirable roadside growth, the Contractor shall apply the chemical in such a manner that damage will not occur either from the direct spray or from drift of the chemical to any desirable growth.

The Contractor shall use all necessary precautions to prevent injury to crops or damage to other desirable growth on private abutting property, as well as to those within the Right-of-Way, and shall assume full responsibility for any damage.

D. Disposal of Cuttings.

The Contractor may dispose of cut material by processing into a wood chip mulch as described in Subsection M6.04.3 and spreading uniformly throughout the cleared and thinned areas as directed by the Engineer.

101.63. Disposal of Trees.

All trees to be cleared shall become the property of the Contractor, and the satisfactory disposal of the wood in such trees outside the Right-of-Way shall become his responsibility.

The trees, including cuttings and slash shall be disposed after cutting as soon as practicable and in such a manner as not to detract from the appearance of the roadside.

If the existing ground in the area is disturbed by any of the work or equipment, the Contractor shall rough-grade and loam and seed if necessary the disturbed areas, if so directed, without additional compensation.

101.64. Disposal of Stumps and Brush.

After removal, all stumps including the major root system shall be disposed by the Contractor at his own responsibility outside the layout where the material will not cause obstructions to streams and will not detract from the appearance of the roadside.

101.65. Disposal of Dutch Elm Diseased Wood.

Dutch Elm diseased wood shall be disposed of in accordance with the provisions of General Law, Chapter 87, Section 5 and Chapter 132, Sections 8 and 11, as amended; and in accordance with any additional local regulations.

Where the work includes the removal of elm trees or the limbs of elm trees, such trees or limbs thereof shall be disposed of immediately after cutting or removal and in such a manner as to prevent the spread of Dutch Elm disease. This shall be accomplished by covering them with earth to a depth of at least 6 inches in areas outside the highway location where the Contractor has arranged for disposal.

Where the work includes the removal and disposal of stumps of elm trees, such stumps shall be completely disposed of immediately after cutting in the manner specified above.

COMPENSATION

101.80 Method of Measurement.

Clearing and grubbing shall be measured by the horizontal plane area and will be the number of acres within the limiting stations of the project and/or as designated by the Engineer and the outside limits of measurement shall extend to a point 5 feet beyond the top or bottoms of slopes, excluding existing roadway and shoulder surfaces, streams or bodies of water.

Areas outside of the limits specified above, when cleared and grubbed in connection with the construction of fences shall be computed on the basis of a ten foot width multiplied by the total length of fencing installed, and when done in connection with excavating ditches or trenches the width shall be limited to 5 feet beyond the outer edges of the excavation.

Measurement of selective clearing and thinning will be based on the actual number of acres which receive the required attention. Approximate locations will be shown on the plans or detail sheets and as designated in the field by the Engineer.

Only such trees as have a shortest diameter of at least 9 inches and less than 24 inches shall be included in the item of Trees Removed (Diameter Under 24 Inches). Only such trees as have a shortest diameter of 24 inches or more shall be included in the item of Trees Removed (Diameter 24 Inches and Over).

The item of Stumps Removed shall include the removal and satisfactory disposal of all tree stumps which remain in their original position and measure 9 inches or more in shortest diameter at the cutoff point, where the trees have been previously removed by others. A stump shall not be construed as a tree under these specifications unless the trunk extends over 6 feet above the average ground.

Trees or stumps to be removed which have the shortest diameter specified for payment will be measured in place by the following procedure:

Where the tree consists of a single trunk extending more than a 3 foot vertical height above the average natural ground line, the shortest diameter shall be measured at the 3 foot level above the average elevation of the original ground.

Any tree whose main trunk separates into multiple trunks or which has limbs or branches growing out from the main trunk below the 3 foot level defined hereinbefore shall have its shortest diameter measured at the lowest point on the main trunk where multiple growth or branching out begins.

The shortest diameter of a stump shall be measured at the cutoff except that where multiple growth begins below cutoff, the shortest diameter shall be measured at the main trunk where multiple growth begins.

Measurement for payment under the respective items shall be such that any individual growth to be classed as a tree stump shall be measured in a manner to limit payment to one single tree or stump at each particular location of the individual growth. When multiple trunks with a common root system are separated at ground level each separate trunk shall be considered as an individual growth under these specifications.

The quantity of trees or stumps to be paid for will be the number actually removed by the Contractor in the completed and accepted work as determined by count.

Wood chip mulch produced from Clearing and Grubbing will be measured by the cubic yard (truck load measure) at time of spreading.

101.81 Basis of Payment.

Clearing and Grubbing and Selective Clearing and Thinning will be paid for at the contract unit price per acre.

When Clearing and Grubbing is not included in the Proposal as a payment item, payment for any such work will be included in the items of Earth Excavation or Borrow except as herein provided for the removal of trees and stumps.

The removal of trees, including the stumps thereof and required spray material will be paid for at the contract unit price each for the particular kind of work involved, as defined hereinbefore when a quantity is given in the Proposal under their respective items, otherwise this work will be paid for at the contract unit price for excavation or at the contract unit price per acre of Clearing and Grubbing or Selected Clearing and Thinning, whichever is applicable. The contract unit price shall include the cost of all arrangements and methods required to protect from harm all existing overhead or underground installations. The contract unit price for the respective items shall not include any trees or stumps removed from the area paid for under the item of Clearing and Grubbing or Selected Clearing and Thinning.

No payment shall be allowed for preparation and spreading of wood chip mulch used from areas included under Selective Clearing and Thinning. Wood chip mulch directed to be produced from Clearing and Grubbing shall be paid for complete in place at the contract unit price.

Only such trees or stumps as have a shortest diameter of 9 inches and over, measured as stipulated in Subsection 101.80 shall be included for payment.

101.82 Payment Items.

101.	Clearing and Grubbing	Acre
102.	Selective Clearing and Thinning	Acre
103.	Tree Removed (Diameter Under 24 Inches)	Each
104.	Tree Removed (Diameter 24 Inches and Over)	Each
105.	Stump Removed	Each
767.4	Wood Chip Mulch	Cubic Yard

SECTION 112
DEMOLITION OF BUILDINGS, STRUCTURES AND BRIDGES

DESCRIPTION

112.20 General.

The work to be done consists of demolishing completely such buildings and structures as are listed in the Proposal.

Said demolishing of the buildings shall be done on the site. Buildings as such shall not be removed intact from the site by the Contractor nor shall they be sold to others for such removal.

"Buildings" or "Structures" shall be considered interchangeable terms within the scope of these Specifications.

The Contractor shall not proceed with the demolition of any building or structure unless and until he receives written approval.

Structures which must be removed, and which are not listed in the Proposal will be removed by others at the direction of the Department. The Contractor's attention is directed to the relevant provisions of Subsections 8.04, 8.08 and 9.05 wherein it is stipulated that he shall have no claim for damages for any delay in the prosecution of the work under any of these items, or for the omission of any one or more of the items scheduled in the Proposal.

The Department may withdraw from the Contract any or all of the structures which are scheduled for

demolishing and for which items are included in the Proposal, and the Contractor shall, in this case, have no redress against the Department for any loss in anticipated profits. The Contractor's attention is further directed to the probability that delay may be encountered in the prosecution of demolition or removal work and that as stipulated in said Subsections 8.04 and 8.05 he shall have no claim for damages for any delay in the prosecution of work hereunder, except as provided.

The Contractor shall be solely responsible for making all necessary arrangements and for performing any necessary work to the satisfaction of the Utility Companies and Municipal Departments involved in connection with the discontinuance or interruption of all public utilities or services, such as gas, water, sewer, electricity, and telephone, which will be affected by the work to be done under the Removal items specified in the Proposal.

CONSTRUCTION METHODS

112.60 Demolition of Buildings and Structures.

Each item for demolition includes the demolition of the building or buildings as identified, and described under the particular item listed in the Proposal, and the satisfactory disposal of the buildings and all contents therein. Basements shall be completely cleaned of all unsuitable materials and debris, all partition walls, and supports for the appurtenances to the buildings.

The foundation walls of the structures shall be broken down to a depth of not less than one foot below the existing ground level.

Cellar floors shall be broken into pieces having an area not more than 4 square feet with well defined cracks through the full depth of the floor.

Holes having an area of not less than one square foot shall be made through the floor at intervals of not more than 10 feet lengthwise and crosswise, to provide vertical drainage.

Buildings without basements or cellars having concrete or masonry floors or slabs at ground level, when demolished, shall be removed to the ground floor grade. The floor or slab shall be removed and the area graded as directed.

All fences, debris, etc., on the parcel on which the building that is demolished is located shall be removed and the parcel left in a reasonably neat and safe condition

In case the building to be removed in served by a septic tank or cesspool, or underground fuel tanks, such structure or structures and appurtenant pipes shall be broken down or removed and all resulting cavities satisfactorily filled with selected excavated material placed in one foot layers and thoroughly compacted. If directed, the Contractor shall remove the contents of said structures prior to disturbing them, and the disposal thereof shall conform to the requirements of the local Board of Health. Underground fuel tanks and contents shall become the property of the Contractor and shall be carefully handled and removed and immediately disposed of in compliance with applicable safety and pollution control regulations.

The Department assumes no responsibility for any changes in the condition of the buildings, or for loss of fixtures, or equipment at any time.

All materials resulting from the demolition of the buildings shall become the property of the Contractor and he shall dispose the same outside and away from the site, except all acceptable solid fill shall be used in filling cellar holes before borrow is used. Solid fill shall consist of noncombustible material, such as brick, stone and plaster (but not wood lath) and shall contain no piece larger than one half cubic yard in volume, or greater than 3 feet in dimension. Acceptable materials from removal may be placed no higher than 1 foot below existing grade. All pipes and other conduits encountered and to be abandoned on account of the demolition shall be plugged with brick and mortar. Drainage structures shall be removed completely and the cavity completely filled with selected excavated material or borrow in 18 inch layers and thoroughly compacted.

A minimum depth of at least 1 foot of ordinary borrow shall be used as a cover and shall be reasonably leveled. The areas adjacent to the site of the removal shall be left in a neat and safe condition satisfactory to the Engineer. Upon completion of the work, all cellar holes shall be filled to the grade of adjacent ground in the manner specified hereinabove.

The Contractor shall protect all buildings which adjoin a structure to be demolished and shall leave the same in a permanently safe and satisfactory condition.

In accordance with the provisions of Subsection 7.10, Contractor shall erect suitable fences around unfilled basements and other dangerous locations created by his work, during demolition and prior to filling of cellar holes or cavities. All costs in connection with such fences shall be included in the contract price for the appropriate demolition item.

112.61 Demolition of Bridges.

The Contractor shall not disturb any utility or property carrying water, gas, telephone, electric or similar service across the bridge unless he is permitted to do so by the Engineer.

If the Contractor is directed to make any repairs or to do any maintenance work on the present superstructure or bridge supports during the period it is open for public travel, the Contractor shall do the directed work in accordance with the provisions of Subsection 4.03.

The Contractor shall assume responsibility for the maintenance and safety of the present superstructure or bridge immediately on notice to him that the Engineer has closed the bridge to the public.

Where the bridge to be removed is over a railroad all work of removing the bridge superstructure and bridge supports shall be done at such times and in such manner as will cause the least possible interference with the operation, management, business or traffic of the railroad.

Demolition of Present Superstructure.

All materials in or on the superstructure of the present bridge, its supporting beams and braces, shall be satisfactorily removed. Such material as the present owner desires which are specified in the Special Provisions shall be stacked near the site as directed and convenient for removal by owner. The material that the present owner does not specify shall become the property of the Contractor.

Demolition of Present Bridge.

The work under this item shall include the removal and satisfactory disposal of the entire superstructure, as specified above, and the removal and satisfactory disposal of the substructure to the extent that the slopes in the abutment area will match the slopes of the adjacent embankment. Materials resulting from removal may be used as embankment materials on the project, if approved by the Engineer, without any additional compensation to the Contractor.

Stone, concrete masonry or other support shall be removed so that none of it will come within two feet of the finished slopes or within three feet of the roadway surface, and the remaining space shall then be backfilled.

When the bridge to be removed is over water, all parts of piers or other supports in the water shall be removed to the elevation of the bed of the stream or other body of water or as indicated on the plans or in the Special Provisions.

COMPENSATION

112.80 Method of Measurement.

Ordinary borrow shall be measured as described under Subsection 150.80.

112.81 Basis of Payment.

The work will be paid for at the contract lump sum price under the respective item for the particular building, structure or bridge designated to be demolished as set forth in the Proposal, which price shall include full compensation for all the work prescribed herein, except furnishing and placing ordinary borrow for cover where required.

112.82 Payment Items.

112.	Demolition of Building No. ____ or Structure No. ____	Lump Sum
114.	Demolition of Superstructure of Bridge No. ____	Lump Sum
115.	Demolition of Bridge No. ____ or Structure ____	Lump Sum
150.	Ordinary Borrow	Cubic Yard

SECTION 119
CONTROL OF RODENTS

DESCRIPTION

119.20 General.

The work to be done consists of the control (extermination) of rodents, prior to the demolition of buildings, in dump areas, land fills or other areas so designated by the Engineer.

CONSTRUCTION METHODS

119.60 Control (Extermination).

This work shall consist of two (2) phases as follows:

1. Initial Treatment.

This phase shall start immediately after execution of the Contract and shall be applied in all buildings to be razed and to all other buildings and areas within the limits of construction where, in the Engineer's judgement, rodents have gathered or may gather during the construction period. A toxic material consisting of zinc phosphide pre-packaged acute toxicants or another acute anti-coagulant which has been approved by the Massachusetts Department of Food and Agriculture-Pesticide Board, with a suitable bait shall be used. The treated bait shall be placed in all structures to be demolished so as to attract the greatest possible number of rodents; and in accordance with best practice.

2. Maintenance.

One week (more or less, as directed) after the "Initial Treatment", the Contractor shall start a program of maintenance to rid the structures and adjacent areas within the limits of this Contract of any remaining rodents, their carcasses, and to prevent their migration to other adjacent areas. The toxicant should be an acute anti-coagulant pre-mixed bait and used in accordance with the labeled and regulatory laws.

All visible carcasses of rodents shall be removed and disposed satisfactorily.

The toxic bait shall be renewed semi-monthly or as directed, throughout said maintenance period until the structures have been demolished and the cellar holes have been filled to the extent required.

All extermination operations shall be in accordance with the rules and regulations of the Municipality and State Health Departments.

COMPENSATION

119.81 Basis of Payment.

The work will be paid for at the contract lump sum price.

119.82 Payment Item.

119.	Rodent Control	Lump Sum

SECTION 120
EXCAVATION

DESCRIPTION

120.20 General.

This work shall consist of excavation, disposal or compaction of all materials not being removed under some other item which is encountered within the limits of the Contract in accordance with the specifications and in close conformity with the lines, grades, thicknesses and cross sections shown on the plans or established by the Engineer. All excavation will be classified as "Earth Excavation", "Class A Rock Excavation", "Muck Excavation", "Topsoil Excavated and Stacked", "Bituminous Concrete Excavation by Cold Planer", and "Unclassified Excavation", as hereafter described.

Materials from all classes of excavation which are unsuitable, and any surplus of suitable materials remaining after completing the formation of embankments, shoulders, approaches, widening of roadway or embankment slopes as directed or backfilling, will be known as waste and shall be disposed of by the Contractor outside the Right-of-Way at his responsibility and expense, unless otherwise directed. Waste material shall not be disposed of in the flood channel areas of any stream.

120.21 Earth Excavation.

Earth Excavation shall consist of all excavation not included as Class A Rock Excavation or excavation which is otherwise classified and paid for.

Unless otherwise provided for in the Contract, Earth Excavation shall also include as incidental to the general work the removal and disposal of abandoned junk cars, trash, signs, fences, guardrail, guide posts, bituminous concrete berms and debris of every nature.

120.22 Class A Rock Excavation.

When encountered within the limits of roadway or channel excavation unless otherwise provided for the Proposal.

Class A Rock Excavation shall consist of:

(1) Igneous, metamorphic and sedimentary rock which cannot be excavated without blasting or the use of rippers.

(2) All rock, stone, parts of stone, brick or cement concrete pavement, parts of cemented stone walls or masonry structures measuring one (1) cubic yard or more that require blasting for removal.

120.23 Muck Excavation.

Muck excavation shall consist of the removal and disposal of saturated or unsaturated mixtures of soils and organic matter not suitable for foundation material regardless of moisture content.

120.24 Topsoil Excavated and Stacked.

The work to be done under this item consists of excavating topsoil from certain locations listed on the details sheets and where directed, to the depths shown on the cross sections or as directed, and stacking the topsoil in accordance with the provisions of Subsection 120.65.

120.25 Bituminous Concrete by Cold Planer.

The work to be done under this item consists of removing, by Cold Planer, bituminous concrete in designated areas.

120.26 Unclassified Excavation.

This work shall consist of all excavation not provided for elsewhere in the Contract.

CONSTRUCTION METHODS

120.60 General.

A. Sequence of Operations.

When required, the Contractor shall so prosecute his work that traffic will be maintained over and through the work with a maximum of safety and convenience in accordance with the provisions of Subsection 7.09, "Public Safety and Convenience".

The sequence of all excavation operations, earth or rock, shall be such as to insure the most efficient utilization of excavated materials into embankments (as specified in Section 150) and the use of a minimum amount of borrow. When the plans require excavation in areas in close proximity to existing roads, structures and utilities it shall be the responsibility of the Contractor at his expense to construct suitable drainage ditches or use other satisfactory means and methods to protect and maintain the stability of such roads, and structures located immediately adjacent to but outside the limits of excavation.

The Contractor's attention is directed to the requirements of the Prevention of Water Pollution and Erosion. The Contractor shall prosecute the work as to prevent the ponding of water. Each lift of excavation shall be visibly crowned to allow drainage of surface and rain water.

B. Disposal of Excavated Materials.

All suitable materials obtained from the excavation or from the removal of present structures shall be used either in the formation of embankments, shoulders, slopes, loam or clay hardening, etc., or for backfill under, over, or around structures, pipe culverts or drains and at such other places as directed and the material shall be placed and compacted in a manner conforming to the specifications for the particular type of work required without additional compensation. It shall be the Contractor's responsibility to obtain from the Engineer approval for the use and placing of various materials encountered in excavation.

It shall be the Contractor's responsibility to dispose of material designated as unsuitable and any excavated material which is not required, except as noted in Paragraph C of this subsection, outside of the Right-of-Way in such a manner as not to obstruct streams or otherwise impair the drainage, appearance, safety or efficiency of any structure or any other part of the road.

No materials from the excavation, nor from construction, shall be deposited in flood plains nor within 100 feet of any body of water without compliance under provisions of Chapter 131, Section 40 of the

Massachusetts Wetlands Protection Act. Notification to the Engineer, in writing, will be required wherein such filling has been authorized by the local Conservation Commission.

No excavated material shall be placed outside of and adjacent to the Right-of-Way without the written approval of the Engineer. The Contractor shall certify he has proper releases from property owners within 500 feet of Right-of-Way which is used as disposal areas for unsuitable material.

The Contractor shall construct sod or other adequate retaining banks around perimeters of the disposal areas outside the project to protect existing roads, stream channels, and adjoining properties (including underground water supplies) against the spread of, or contamination by, the excavated material. Stream channels and ditches within and adjacent to the project shall be maintained as at present or as specifically altered by the design of the project.

All waste areas shall be thoroughly stabilized by means of drains, proper grading, mulching, loaming and seeding as required to promote vegetation and to insure the areas will not be subject to erosion.

C. Grading Outside of the Location.

Where directed, earth, loam, or borrow of the kind required shall be used for grading outside of the Right-of-Way and the surface shall be raked, smoothed and rolled. Excavation shall be made as directed on slopes or surfaces outside of and adjoining the location.

When temporary or existing roads are abandoned within the limits of highway work and beyond the limits of the main roadway slopes, their surfaces shall be removed and graded and loamed for a neat and natural appearance for proper drainage of surface water, as directed.

120.61 Earth Excavation.

This work shall be performed in the manner specified in Subsection 120.60 and Subsection 170.60.

120.62 Class A Rock Excavation.

Class A Rock Excavation shall be performed in accordance with the requirements specified in Subsection 120.60, with the following additional requirements:

The Contractor shall prosecute his work so that all rock available for disposal in embankments shall be removed previous to the final embankment formation. Rock shall be partially or completely stripped of overburden, as directed, before removal operations are begun. Loose or shattered fragments of rock which may be a hazard to traffic shall be removed from the slopes.

120.63 Presplitting Rock.

Presplitting shall be required in rock cuts 10 feet or more in vertical height where designed slope is 1 horizontal to 4 vertical or steeper. Rock cuts more than 25 feet in vertical height may be presplit in stages (lifts) at the option of the Contractor, provided that no stage shall be less than 10 feet in depth and further provided that no payment will be made for additional excavated quantities caused by offsetting presplitting holes beyond the specified face in the top on successive stages. Presplitting holes in successive stages shall be offset not more than 2 feet inside of the previously presplit face.

Prior to the blasting of any rock for removal, the Contractor shall presplit the rock along the designated cut face by the method hereinafter described to produce a uniform plane of rupture, so that the resulting face will not be affected by subsequent fragmentation blasting and excavation operations.

The Contractor shall adjust his blasting operations according to the characteristics and structure of the rock formation to obtain the required slope without fracturing the rock beyond the presplit face.

The sequence of operations shall be as follows, unless otherwise directed:

1. Remove all overburden soil within the areas of proposed fragmentation blasting to expose the rock surface.

2. Drill 2½" or 3" normal diameter holes not more than 3 feet on centers along the top of the proposed slope line and at the required inclination, to the full depth of the cut or to a predetermined stage (lift) elevation. Presplit holes shall deviate not more than ½ foot at any point from the plane of specified slope, nor more than 1 foot at any point from a vertical plane through the top of the hole and normal to the plane of slope.

3. Fragmentation blast holes shall be positioned so that no portion of any blast hole shall be within 4 feet of the designated presplit face, unless otherwise permitted by the Engineer.

The plane of presplitting slope as originally drilled shall not be penetrated by subsequent fragmentation blast holes.

4. The Contractor shall inspect and test each hole to determine the possible presence of any obstruction before placing the charge. No loading shall be permitted until the hole is clear of all obstructions. Precautions shall be used in placing the charge to prevent caving-in of material from the wall of the hole.

5. Cartridge explosives prepared and packaged by explosive manufacturing firms and approved by the Engineer shall be used in presplitting holes except, with prior permission of the Engineer, either of the following charges may be used as an alternative provided the results are satisfactory:

(a) Continuous column commercial explosives manufactured especially for presplitting.

(b) Multiple strands of high-strength (175-200 grains of explosive per foot) detonating fuse (Primacord) taped together at 4′ to 6′ intervals.

6. The spacing of the dynamite charge in each hole shall be accomplished by securely taping (or attaching by other approved means) each piece of dynamite to the detonating fuse at the selected intervals or by deck-loading. If the latter method is used, the dynamite must be in intimate contact with the detonating fuse to assure detonation of all charges.

7. All space in each hole not occupied with the explosive charge shall be filled with 3/8″ crushed stone meeting the requirements of Materials Subsection M2.02.6. No other material or type of stemming will be permitted.

8. The detonation of presplit charges shall precede the detonation of adjacent fragmentation charges within the section by a minimum of 25-miliseconds.

120.64 Muck Excavation.

The work of muck excavation shall be performed in accordance with the requirements of Subsection 120.60 with the following additional requirements:

Muck shall be excavated to the estimated widths and depths shown on the plans and/or so as to completely remove the muck. Where a proposed bridge or other structure comes within the limits of muck excavation, that portion of the excavation within the limits of the proposed structure will be paid for as Muck Excavation.

120.65 Topsoil Excavated and Stacked.

This work shall consist of removing topsoil and stacking it where and as directed in accordance with the relevant requirements of Sections 120 and 751.

Such of the topsoil as will be selected, after testing by Department of material obtained from test pits, shall be stacked neatly outside the limits of the proposed slopes within the Right-of-way or such material may be temporarily stacked by the Contractor outside the Right-of-Way for his own convenience, with the approval of the Engineer, in which case the Contractor shall be responsible for all arrangements and negotiations. If the material stacked outside the Right-of-Way is not available when needed for use on the project, the Contractor will furnish at his expense an equal volume of equal material.

If the temporary storage areas outside the Right-of-Way require clearing and grubbing, the Contractor shall do such work without additional compensation.

Storage areas shall be cleared, grubbed and rough graded so that maximum amount of stacked material will be available for reuse.

The Contractor shall take reasonable care to avoid leaving any unsightly condition and to avoid unnecessary damage or injury to natural surroundings and roadside growth. The landscape shall be left in a satisfactory, neat and trim condition upon completion of the work.

120.66 Bituminous Concrete Excavation by Cold Planer.

This work consists of removing bituminous concrete by Cold Planer in designed areas. The Cold Planer must be equipped with an elevating device capable of loading planed material directly into dump trucks while operative. It shall have all necessary safety devices such as reflectors, headlights, taillights, flashing lights, and back up signals so as to operate safely in traffic both day and/or night.

The Cold Planer shall be designed and built for planing flexible pavements and possess the ability to plane cement concrete patches when encountered in bituminous pavement. It shall be self-propelled and have the means for planing without tearing or gouging the underlying surface. Variable lacing patterns shall be provided to permit a rough grooved or smooth surface as directed.

A three inch cut to predetermine grade or any specified lesser depth may be required in one pass. The minimum width of pavement planed in each pass shall be six feet, except in areas to be trimmed and edged. The machine shall be adjustable as to crown and depth and meet the standards set by the Air Quality Act for noise and air pollution.

The milled or planed surface shall conform generally to the grade and cross slope required. The surface shall not be torn, gouged, shoved, broken or excessively grooved. It shall be free of imperfections in workmanship that prevent resurfacing after this operation. Surface texture shall be as specified by the Engineer and excess material shall be removed so that the surface is acceptable to traffic if required.

120.67 Unclassified Excavation.

This work shall consist of the excavation, removal and satisfactory disposal, in accordance with the relevant provisions of Section 120.60 of all materials listed under Section 120 necessary for the construction of the proposed work as shown on the Plans or as directed, except those materials for which payment is specified under other items of the Contract.

COMPENSATION

120.80 Method of Measurement.

All classes of excavation except topsoil will be measured in their original position by the cross section method except where such measurement is impracticable the volume shall be measured by such other methods as the Engineer may determine.

In any case, payments will be made only for excavation to lines and grades as indicated on the plans or as directed.

Pay limits for rock excavation actually removed will be as follows:

1. For side slopes.
   (a) In excavation for side slopes up to a limit of 24 inches beyond and parallel to slope lines either shown on the plans or ordered in writing by the Engineer.
   (b) No allowance will be made for rock excavation beyond these specified lines in side slopes except that if ordinary borrow is required for the work and excess rock excavation is used in embankments such rock will be paid for as ordinary borrow.
2. Rock Excavation in curb and edging trenches not already paid for in previous rock excavation will be paid up to a width of 18 inches, providing rock extends to that width.
3. For area between side slopes.
   (a) in excavation to subgrade an allowance of a depth of 6 inches below subgrade lines.
   (b) In any other rock excavation an allowance of a depth of 6 inches below lines of proposed excavation.

Boulders which are to be included in the item for rock excavation will be measured at the point of removal.

Presplitting of rock will be measured by the square yard of exposed rock face, measured from the top of exposed rock to the bottom of the Class A Rock Excavation at the presplit face, as directed.

Topsoil excavation will be measured in its original position by measuring the surface area of topsoil to be removed and measuring the depth to be removed by test pits prior to removal, or by the cross section method as determined by the Engineer.

Bituminous Concrete Excavation by Cold Planer will be measured by the square yard to the limits shown on the plans or as directed.

120.81 Basis of Payment.

All classes of excavation will be paid for at the contract unit price per yard of the particular type of excavation as defined hereinbefore.

In Contracts where ordinary borrow is required, excavated material taken by the Contractor with the prior written permission of the Engineer, and used on the project for purposes other than for forming embankments will be paid for at the contract price for the purpose of which it is used, in addition to the payment to be made for excavation, provided that any additional filling material made necessary by such use shall be replaced except Bituminous Concrete excavated by Cold Planer.

The amount of borrow to be replaced shall be as follows:

1. If Class A Rock Excavation is used in revetment, the revetment shall be measured in its final position, and this computed quantity shall be divided by 1.20 and the resulting quantity shall be the amount of borrow to be replaced.

2. If Earth Excavation is used for gravel borrow, special borrow, etc., the amount of gravel borrow, special borrow, etc., as computed (including any percentage added to in place measurement) shall be the amount of borrow to be replaced.

Payment shall be made only for the purpose the borrow was used until such time as replacement borrow is supplied, at which time an equal volume of excavation will be paid for.

In Contracts where excavated materials are used as described in the paragraph above and no additional filling material is required, the following will govern:

1. Material such as gravel, sand, special borrow, or impervious soil borrow obtained in excavation and used as gravel, sand borrow, special borrow or impervious soil borrow will be paid for only at the contract price for the purpose used.

2. Topsoil obtained in excavation and stacked for future use on the project will be paid for at the contract unit price for the item of Topsoil Excavated and Stacked (which price will include excavating for test pits required) but if such future use necessitates rehandling and spreading, payment will also be made at the contract unit price for Topsoil Rehandled and Spread.

3. No deduction from the item of Class A Rock Excavation will be made on account of the use of boulders or rock fragments in masonry or in revetment.

Presplitting of rock will be paid for at the contract unit price per square yard of exposed presplit rock face.

Bituminous Concrete Excavation by Cold Planer will be paid for at the contract unit price per square yard.

120.82 Payment Items.

120.	Earth Excavation	Cubic Yard
120.1	Unclassified Excavation	Cubic Yard
121.	Class A Rock Excavation	Cubic Yard
122.	Presplitting Rock	Square Yard
123.	Muck Excavation	Cubic Yard
125.	Topsoil Excavated and Stacked	Cubic Yard
129.	Bituminous Concrete Excavation by Cold Planer	Square Yard

SECTION 140
EXCAVATION FOR STRUCTURES

DESCRIPTION

140.20 General.

Excavation for foundations of bridges, culverts, pipe drains, masonry walls and other structures shall be made to the depth and lines indicated on the plans or established by the Engineer.

140.21 Bridge Excavation.

Bridge excavation shall include excavation required for construction of bridges, culverts having a clear square span of 8 feet or more, end walls and wingwalls that are a part of these structures and major wall structures as designated in the Contract Documents.

The excavation shall include the removal and satisfactory disposal of materials including piles, sheeting and timbers encountered in these constructions.

In areas where unsuitable material is removed and backfilled under Item 123. Muck Excavation, the excavation of the backfill shall be included under bridge excavation.

All other material encountered in the above noted construction, except that classified as Class B Rock Excavation and Muck Excavation as defined in these specifications, will be classified as Earth Excavation.

140.22 Class A Trench Excavation.

Unless otherwise shown on the plans, Class A Trench Excavation shall include the removal and satisfactory disposal of all materials, except Class B Rock Excavation that are encountered in the construction or demolition of masonry culverts and other structures having a clear square span of less than 8 feet, masonry inlets, culvert ends, masonry walls, revetment, test pits, paved waterways, construction of drains for slope or subgrade stabilization and in the construction, widening, straightening or deepening of drainage ditches and water courses in connection with pipes or structures having a clear span of less than 8 feet.

Test pits to locate underground services shall be excavated where directed and will be classed as Class A Trench Excavation. The Contractor shall take special care during this excavation to avoid damage to any underground structures or utilities. When necessary the Contractor shall cooperate with representatives of public service companies in order to avoid damage to their structures by permitting them to erect suitable supports, props, shoring or other means of protection.

140.23 Class B Trench Excavation.

Class B Trench Excavation shall include the removal and satisfactory disposal of all materials, except Class B Rock Excavation, encountered in the construction of drainage and water pipes greater than the 5 foot maximum depth specified in Section 200.

Trench excavation for pipe laying in roadway cuts shall include only that portion of the trench which is below the roadway excavation except where the Engineer orders in writing, that the trench excavation and its backfill shall be completed before the roadway excavation is begun.

140.24 Channel Excavation.

Channel Excavation shall include the removal and satisfactory disposal of all materials other than those classified as Bridge Excavation, Trench Excavation, Muck Excavation or Rock Excavation when encountered in the excavation for streams or rivers or excavation on new locations for same in connection with drainage structures having a clear span of 8 feet or more.

140.25 Class B Rock Excavation.

This item shall include the removal and satisfactory disposal when encountered in the excavation for drainage structures, fences, highway guard, posts, bounds, pipes, ducts, walls, open trenches and bridge structures of:

(A) Boulders measuring 1 cubic yard or more and all solid rock that requires blasting or breaking by hand power tools (such as jackhammers etc.) prior to removal.

(B) Masonry removed from the walls, covers and other portions of existing drainage structures, also plain and reinforced concrete pavements, and masonry removed from bridge substructures.

Removal operations shall be so prosecuted that no damage will be caused to adjacent structures or property.

140.26 Drainage Structures Abandoned or Removed.

The work shall consist of the removal and stacking of iron castings. The plugging of inlets and outlets and the filling of all drainage structures designated to be abandoned and the removal of all masonry and filling the cavity of the drainage structures designated to be removed.

CONSTRUCTION METHODS

140.60 General.

A. Sequence of Operations.

The Contractor shall prosecute his work so as to conform to the requirements of Subsection 120.60A.

B. Disposal of Excavated Materials.

The Contractor shall prosecute his work so as to conform to the requirements of Subsection 120.60B.

C. Cofferdams.

Cofferdams for foundation construction shall be carried to adequate depths and heights, shall be safely designed and as watertight as necessary for the proper performance of the work which must be done inside them. Sheeting shall be driven to a sufficient depth below the proposed foundation grade to permit reasonable change in depth of the proposed foundation to a maximum of 2 feet except where solid rock is encountered. The interior dimensions shall be sufficient for the unobstructed and satisfactory completion of such construction work as pile driving, form building, inspection and pumping. Cofferdams which become tilted or are displaced during the process of building the substructure shall be righted, reset or enlarged as may be necessary to provide the necessary clearances and this shall be at the sole expense of the Contractor. Cofferdams shall be unwatered and the proposed masonry footings placed in the dry.

Cofferdams shall be constructed so as to protect masonry against damage from a sudden rising of water and to prevent damage to the foundation by erosion. No part of the cofferdam shall be left in such a way as to extend into the substructure masonry, without written permission of the Engineer.

Upon request, the Contractor shall submit plans to the Engineer for his information showing his proposed method of cofferdam construction prior to the start of such construction. The furnishing of such plans and

methods shall not serve to relieve the Contractor of any of his responsibility for the safety of the work or the responsibility for the successful completion of the project.

Where the plans indicate construction of a tremie concrete seal below the footing or if in the Engineer's opinion a tremie seal is necessary, he may require the placing of underwater concrete of such dimensions as necessary to safely dewater the foundations and place the footing concrete in the dry.

All tremie concrete seals shall be placed as shown on the plans or as directed by the Engineer.

Before placing the underwater concrete, the inside walls of the cofferdam shall be thoroughly cleaned and the walls made sufficiently tight to reduce the flow or current of water to less than 10 ft. per minute. The elevation of the water inside the cofferdam shall be controlled during the placing and curing of the concrete. Concrete shall not be placed in water having a temperature below 35 °F. No pumping of water shall be permitted while concrete is being placed nor until the concrete has cured a minimum of 24 hours. Once concreting has started the tremie shall not be moved laterally through the deposited concrete. When necessary to move the tremie it shall be lifted out of the concrete and moved to the new position. Unless otherwise directed by the Engineer, spacing of the tremies shall be at the Contractor's option.

After each excavation is completed, the Contractor shall notify the Engineer and no constructions shall be started until the Engineer has approved the depth of the excavation and the character of the foundation material.

Unless otherwise provided, all parts of the cofferdams shall be removed after the completion of the substructure, care being taken not to disturb or otherwise injure the finished masonry.

Sheet piling used in the construction of cofferdams may be left in place at the option of the Contractor, provided it is cut off at an elevation as may be directed by the Engineer, and the cutoff portions are removed from the site.

D. Excavation for Stepped Footings.

Where the footings for bridges are shown stepped, the Contractor shall sheet and shore the existing ground so that adjacent sections of the footings will rest on undisturbed ground according to the pattern shown on the plans. The sheeting shall be strong enough to support the earth along the designated lines, tight enough to restrain the fines in the concrete, and shall be left in place to the extent required to hold the concrete that is to be placed against it. Before the concrete is placed, the sheeting shall be cut so that none of the sheeting will extend into the concrete. Shoring and bracing shall be removed. If rock is encountered, it shall be stepped to the pattern shown and sheeting will not be required.

E. Water Control in Foundation Area.

When concrete for the foundations of a structure is to be placed in the dry, the Contractor shall use such equipment and perform his operations in such a manner that boiling or other disturbances of the ground in the foundation area will be prevented and shall keep the area being excavated dry by such means that will prevent the entering of water through or from the adjacent ground, if such entering water could affect the stability of the foundation material or the adjacent ground or the foundations.

No surface pumping will be allowed. Water shall be controlled by means of properly screened sumps or well points. If sumps are used, they shall be installed at strategic locations but not closer than 5 feet from the nearest edge of the footing.

The contractor shall provide temporary diversion channels, excavations, embankments, sheeting, drains, flumes, well point unwatering systems, pumps, or other effective procedures or structures together with all labor, materials and equipment necessary for unwatering the foundation areas. Such work shall be subject to the approval of the Engineer, but such approval will not relieve Contractor of responsibility for the adequacy of construction, maintenance, operation and safety of the water control system. Upon completion of the work all temporary embankments and structures shall be removed from the site. All temporary excavations shall be backfilled in accordance with the applicable provisions of Section 150 for forming embankments or as directed.

F. Shoring and Bracing of Trenches.

Shoring and bracing of trenches and other excavations shall be in accordance with the requirements of the Department of Labor and Industries Industrial Bulletin No. 12, Section 10, dated April 19, 1967, and subsequent amendments.

G. Excavation.

Trenches for pipes, structural pipes, arches, and pipe arches shall be excavated to the required line and grade and of sufficient width to permit thorough tamping of backfill material under the haunches. Soft or unsuitable material existing below the required bedding grade shall be removed as directed and replaced with sand, gravel, crushed stone or other suitable material and thoroughly compacted. Rock or boulders shall be removed below the bedding grade as specified in Subsection 140.25.

All materials excavated from pipe trenches and subdrain trenches and not used in the backfill of the trench will be used as part of the embankment, when deemed suitable for this purpose by the Engineer, and no deduction will be made from the in-place measurement of the embankment.

If cross pipes, conduits, drains or other unforeseen obstacles are encountered during the excavation, the proposed line and grade of the pipe may be altered, but only as directed by the Engineer.

When pipes, structural pipes, arches and pipe arches are to be installed in new embankments, the Contractor shall first construct and compact the embankment to an elevation at least 2 feet above the proposed flow line.

When culverts, storm drains or sewer pipes are to be installed in roadway areas on traveled ways, the edges of the trench through the pavement shall be cut to a neat line, using an approved pavement breaker or power saw.

140.61 Channel Excavation.

The excavation shall be made and the bank sloped as shown on the plans or as directed.

Unless otherwise directed, the banks outside of the limits of a bridge structure shall be cut to a 2 to 1 slope. Within the limits of the bridge structure, the banks shall be cut to the slope required for revetment.

No waste or surplus excavation shall be left within 5 feet from the edge of the ditch or channel. Any such surplus or waste material shall be spread in a thin, uniform layer. All ditches and channels constructed on the project shall be maintained to the required cross section and shall be kept free from debris until final acceptance.

140.62 Class B Rock Excavation.

If a rock is encountered in a location such that it may be used as a part of a base, footing, wing, or abutment of any structure, it shall not be removed. The surface of all rock or other hard material upon which masonry is to be placed shall be freed from all loose fragments, cleaned and cut to a firm surface. The surface shall be level, stepped or serrated, as directed by the Engineer.

All structures shall be founded on uniform bearing materials. If rock is encountered at portions of the bottom of the foundation for bridges, box culverts, structural plate pipe, structural plate pipe arches and end walls and wingwalls that are a part of these structures, the rock shall be removed to a minimum depth of 1 foot below the bottom of foundation for a depth of fill on the structure up to 25 feet. For fills over 25 feet the depth of excavation shall be increased 1 inch for every additional 2 feet of fill. The excavation shall be backfilled with gravel borrow and compacted. Payment for such excavation will be made under the item for Class B Rock Excavation. Where wingwalls are not integral with the bridge or culvert the overdepth excavation will not be required.

140.63 Drainage Structures Abandoned or Removed.

The present castings shall be carefully removed. They shall be satisfactorily stored and protected until they are required for use or until they are removed from the project by the owners.

Inlets and outlets of structures to be abandoned shall be plugged with brick masonry not less than 8 inches in thickness, conforming to Section 201. Upper portions of the masonry shall be removed to a depth of 3-feet below the finished grade at the location designated by the Engineer, and the structures shall be completely filled with selected excavated material placed in 6 inch layers and thoroughly compacted.

The existing masonry of structures to be removed shall be completely removed.

The cavity shall be completely filled with selected excavated materials placed in 6 inch layers and thoroughly compacted.

COMPENSATION

140.80 Method of Measurement.

All classes of excavation for structures will be measured in their original position by the cross section method except that where such measurement is impracticable the volume shall be measured by such other methods as the Engineer may determine. In calculating excavation for structures the sides of the excavation will be considered vertical.

Bridge Excavation shall be measured as follows:

Unless otherwise shown on the plan the quantity of excavation shall be computed within the following limits:

Horizontally

To vertical planes 12 inches outside of and parallel to the neat lines of masonry bases or footings.

To vertical planes 18 inches outside of and parallel to the inside walls of structural plate pipes and arches (spans 8 feet or more and without masonry footings) at their widest dimensions.

To vertical limits of crushed stone or gravel borrow for bridge foundation as shown on the plans.

Vertically

From the bottom of the earth excavation limits of proposed roadway and/or design slopes carried through the structure location or existing ground surface, whichever is lower, to the bottom of the required excavation as determined by the Engineer.

In areas where unsuitable material is removed and backfilled under Item 123, Muck Excavation, excavation of the backfill will be measured horizontally and vertically as above except the upper limit of excavation shall be two feet above the swamp or two feet above any water that is present, whichever is higher.

Where masonry is ordered removed from existing substructures, only the actual quantity ordered removed shall be measured for payment.

Excavation made outside the lines prescribed for payment will be considered as made for the Contractor's convenience and will not be included for payment under any item of excavation, nor will the refilling of any such area be included under any item of filling material.

Class A Trench Excavation shall be measured as follows:

For masonry culverts (having a clear square span of less than 8 feet), inlets and walls, a width of 1 foot outside the base of the masonry section shown on the plans and to the depth required. Trench excavation for walls in cuts shall include only that portion below the elevation of the subgrade adjacent to the wall. For walls where an embankment is proposed, trench excavation shall be only that portion between the existing ground and the bottom of the foundation. All other Class A Trench Excavation will be measured according to the amount of materials removed to the lines and grades shown on the plans or as directed.

Class B Trench Excavation shall be measured as follows:

For pipe culverts, drains and water pipes the depth of excavation shall be measured from the bottom of the pipe barrel to the bottom of the roadway excavation or existing ground, whichever is lower, as determined above the center line of the pipe, less five (5) feet. The width of excavation shall be three (3) feet greater than the rated inside diameter of the pipe up to a point five (5) feet above the bottom of the pipe barrel and a width above that point equivalent to the base width plus an allowance for 1 to 1 slopes on the sides of the trench for the measured depth described above. The allowance for 1 to 1 slopes will be included regardless of the actual slope excavated or whether sheeting or shoring is used that is not included for payment under Section 950. The sides of the trench excavation will be considered vertical when sheeting is used and paid for separately under Section 950 and the width shall be three (3) feet greater than the inside diameter of the pipe. If necessary to obtain a satisfactory foundation for pipe culverts, drains and water mains, trenches, shall be excavated deeper than normally required for bedding the pipe and such excavation below the barrel of the pipe will be measured for payment under this item. The width of trench shall be three (3) feet greater than the rated inside diameter of the pipe and the depth shall be the actual depth as directed by the Engineer.

Class B Rock Excavation shall be measured as follows:

Pay limit for rock excavation actually removed in all masonry culverts, walls and bridges, will be up to a limit of 1 foot outside of the foundation. This rock excavation in cuts shall include only that portion below the limits of payment of Roadway Earth Excavation or Class A Rock Excavation and in embankment only that portion below the surface of the existing ground.

Pay limit for rock actually excavated in pipe trenches will be made to a width of 2 feet greater than the rated inside diameter of the pipe barrel, providing rock extends to that width. The maximum depth of rock to be paid for shall be equal to the difference in depth between the top of the original rock in the trench and a line 12 inches below the bottom of the outside of the pipe barrel. No part of any rock remaining in the trench shall come within 6 inches of any portion of the pipe. Rock actually excavated in the construction of catch basins, manholes, and leaching basins will be calculated on a basis of 1 foot outside of the outer walls and 6 inches below the bottom of the structure. Rock excavation in subdrain trenches will be measured as specified above for pipe trenches.

Rock excavation in post and bound holes not already paid for in previous rock excavation shall be based on an area 2 feet square multiplied by the depth of rock encountered in the post or bound hole required plus 6 inches.

Rock excavation in channel excavation will be measured as specified in Subsection 120.22.

The unit of measurement for drainage structure abandoned or removed will be each structure abandoned for each structure removed, complete.

140.81 Basis of Payment.

Excavation for structures will be paid for at the contract unit price per cubic yard under the item for the particular type of excavation encountered.

The unit price per cubic yard shall include all backfilling when the materials are obtained from excavation, all clearing and grubbing (except as may be otherwise provided on the plans or in the Specifications), all excavations for the structure formation of embankments, disposal of surplus material, and the furnishing of all equipment, tools, labor and work incidental thereto.

If cofferdams, sheeting, shoring, bracing, unwatering system or other method of control for excavation are not specific items in the Contract, no allowance in addition to the prices bid for any items in the Contract will be made for such controls, or for labor, equipment or materials required. If any change in depth of foundation greater than 2 feet or in other dimensions of the foundation is directed by the Engineer after the controls have been provided, and if such change is greater than can be accommodated by the controls as constructed by the Contractor with the approval of the Engineer, then any changes made as directed by the Engineer will be paid for in accordance with the Contract provisions for Extra Work. Excavation, borrow, concrete or other items of work done within the controlled area will be paid for only at the contract prices for these items unless the operations require different or additional equipment or labor in addition to or different from that required for the original design of the control. If such different or additional equipment or labor is required to perform the operation for the pay unit of an item the additional costs will be paid for under Extra Work. Where salvage of material is involved in the additional work, the value of the salvage shall be deducted from the additional payment.

Backfilling when not obtained from excavation will be paid for at the contract unit price for the kind of material used.

Bridge Excavation will be paid for at the contract unit price per cubic yard under Item 140. Bridge Excavation. Bridge excavation within a cofferdam and included in the Proposal as a separate pay item will be paid under Item 140.1, Bridge Excavation within Cofferdam. All other excavation encountered in the construction of bridges, culverts (spans 8 feet or more) and major wall structures, not otherwise defined in these specifications will be classified and paid for as Earth Excavation.

Class A Trench Excavation will be paid for at the contract unit price per cubic yard of Class A Trench Excavation except that where the depth is greater than 8 feet that excavation below the 8 foot depth will be paid for at a price per cubic yard equal to 1 ½ times the price bid per cubic yard for Class A Trench Excavation with the exception that no addition to unit bid price will be allowed for excavation of open ditches that may exceed 8 feet in depth for excavation required for the construction of revetment regardless of the depth. Test pits exclusively for the purpose of locating existing underground structures and conduits where directed, regardless of depth, will be paid for at 3 times the contract unit price per cubic yard for Class A Trench Excavation.

Class B Trench Excavation will be paid for at the contract unit price per cubic yard for Class B Trench Excavation.

Channel excavation (except rock) will be paid for at the contract unit price per cubic yard of Channel Excavation which price shall include full compensation for all handling, stacking or rehandling or excavated material.

Where channel excavation is made adjacent to a bridge or other structure the limits of pavement for channel excavation begin at the outer limits of payment for excavation for bridge or other structure.

Excavation for the placing of riprap in channel excavation areas where required will be included under the item of Channel Excavation.

Rock excavation (except in channel excavation) will be paid for at the contract unit price per cubic yard of Class B Rock Excavation. Class B Rock excavated within a cofferdam (constructed of lumber, wood or steel sheeting) will be paid for at 3 times the contract unit price per cubic yard of Class B Rock Excavation.

Rock excavation in channel excavation will be paid for at the contract unit price per cubic yard of Class A Rock Excavation.

Drainage structures abandoned will be paid for at the contract unit price each under the item for Drainage Structures Abandoned.

Drainage structures removed will be paid for at the contract unit price each under the item for Drainage Structures Removed.

140.82 Payment Items.

140.	Bridge Excavation	Cubic Yard
140.1	Bridge Excavation Within Cofferdam	Cubic Yard
141.	Class A Trench Excavation	Cubic Yard

142.	Class B Trench Excavation	Cubic Yard
143.	Channel Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard
145.	Drainage Structure Abandoned	Each
146.	Drainage Structure Removed	Each
121.	Class A Rock Excavation	Cubic Yard
999.141	Extra Depth Class A Trench Excavation	Cubic Yard
999.143	Test Pit Excavation	Cubic Yard
999.144	Cofferdam Class B Rock Excavation	Cubic Yard

SECTION 148
DREDGING

DESCRIPTION

148.20 General.

Dredging shall consist of the removal and disposal of all materials within the limits shown on the plan, or as laid out in the field. Materials shall be removed to the depths shown on the plan. All dredged material will be classified as "Material, Dredged and Disposed". "Rock, Removed from Dredged Area and Disposed", and "Ledge, Removed from Dredged Area and Disposed".

The Contractor's attention is directed to the requirements of Section 7.00 concerning Prevention of Water Pollution and Erosion.

148.21 Material, Dredged and Disposed.

Material, Dredged and Disposed, shall consist of all material removed from the dredging area and placed in scows and disposed of where and as directed in the Special Provisions; not included are Rocks, Removed from Dredged Area and Disposed, and Ledge, Removed from Dredged Area and Disposed.

148.22 Material, Dredged and Disposed (Hydraulic Method).

Material, Dredged and Disposed (Hydraulic Method), shall consist of all material removed from the dredging area and disposed of by Hydraulic dredging methods where and as described in the Special Provisions; not included are Rocks, Removed from Dredged Area and Disposed, and Ledge, Removed from Dredged Area and Disposed.

148.23 Rocks, Removed from Dredged Area and Disposed.

Rocks in excess of 1 cubic yard in volume, and less than 5 cubic yards in volume, which are entirely removed from the dredged areas and deposited at a location approved by the Engineer, will be paid for under this item. No compensation will be made for rocks which are lowered so that they are below the depths of the proposed work.

148.24 Ledge, Removed from Dredged Area and Disposed.

Ledge or Rocks (including masonry) in excess of 5 cubic yards in volume encountered within the dredging limits shall be removed and disposed of, upon the direction of the Engineer.

148.25 Mobilization and Demobilization.

Mobilization and Demobilization shall consist of the mobilization of all the Contractor's dredging plant, including tugs, scows, pipe lines, pontoons, and all equipment at the site of the work prepared to commence dredging operations: and upon completion of dredging operations the demobilization and removal of all aforesaid plant and equipment.

CONSTRUCTION METHODS

148.60 General.

The material shall be removed by dredging plant and equipment either by the Hydraulic Method or by placing the material in scows and disposing of it outside of the dredging areas. The method(s) to be used will be specified in the Special Provisions.

If no area for the disposal of material is stated in the Special Provisions, it shall be the Contractor's responsibility for the negotiations necessary to furnish all required areas for disposal of material.

In the dredging and disposal of dredged material, the Contractor will be required to observe all laws of the United States, all requirements of the U.S. Corps of Engineers and all local or state authorities in relation thereto. The Contractor's attention is directed to the fact that material disposal of below mean high water requires a permit from the U.S. Corps of Engineers and a license from the Commonwealth.

The areas shown on the plans, or as laid out in the field, shall be dredged so that they shall have throughout upon completion of the work the specified depths over their whole extent as shown on the plans, with the banks at the sides sloped at an angle of approximately 1 vertical to 3 horizontal, unless otherwise shown on the plan. The Contractor shall make the bottom of the dredged areas as smooth and level as possible to or slightly below the required depths.

The Contractor shall exercise extreme caution in any location in which the dredging operations are in close proximity to structures. The Contractor shall bear full responsibility for damage of any nature to structures caused by dredging beyond the limits shown on the plan or as laid out in the field and such damage shall be satisfactorily remedied at the sole expense of the Contractor.

The Contractor shall conduct his dredging and disposal operations so as to cause a minimum of interference with navigation.

The Contractor shall furnish regularly to inspectors on board the dredge or other craft upon which they are employed, when transportation ashore is impracticable, a suitable room for office and sleeping purposes. The room shall be properly heated, ventilated and lighted and shall have a desk which can be locked, a comfortable bed and chair for each Inspector, and washing conveniences. If such quarters and conveniences are not provided, or the work is so located that transportation ashore can be furnished without interference with the work, the Contractor shall provide the Inspector with transportation to and from such points ashore as the Engineer may from time to time, designate.

If the Contractor maintains on his work an establishment for the subsistence of his own employees, he shall furnish to Inspectors and survey parties when employed on the work, meals of satisfactory quality.

Each Bidder shall state in his Proposal whether the plant he proposed to use on the work has facilities for furnishing the meals and accommodations required.

The entire cost to the Contractor for furnishing, equipping and maintaining the foregoing accommodations, providing transportation ashore, and furnishing meals, shall be included in the price bid for dredging.

COMPENSATION

148.80 Method of Measurement.

The amount of material dredged and disposed of will be determined by preliminary and final cross sections taken by the Engineer in the dredging area. If this method is impracticable, the Engineer will determine the method of measurement.

If the alternate method of measurement is by measuring the dredging materials in the scows in which it is placed for disposal, such actual scow quantities as determined by the measurements shall be divided by 1.15 to compensate for bulking or swelling. The quotient for this division shall then be the quantity to be paid for.

The quantity of materials shown in the Proposal has been computed to the payment limits.

The Engineer may take additional soundings before the work is started, which soundings shall be the preliminary soundings for payment purposes.

Pay limits for material actually dredged and disposed will be as follows:

A. Bottom — Depth up to and including 24 feet below mean low water plus 1 foot below the required depths.

Depths more than 24 feet below mean low water plus 2 feet below the required depths.

B. Side slopes shall be as shown on the plans.

Rocks. Removed from Dredged areas and Disposed will be determined by measurement made by the Engineer.

Ledge. Removed from Dredged Areas and Disposed will be determined by preliminary and final cross sections taken by the Engineer in the dredging area. The overlying material shall be removed prior to the Engineer taking preliminary cross sections. If this method of measurement is impracticable, the Engineer will determine the method of measurement.

Mobilization and Demobilization will be paid for at the contract lump sum price. The Contractor will be paid sixty percent of the lump sum price upon completion of his mobilization at the work site. The remaining forty percent will be included in the final payment for work under the Contract.

148.81 Basis of Payment.

All classes of dredged material will be paid for at the contract unit price per cubic yard for the particular type of material removed and disposed as defined hereinbefore.

148.82 Payment Items.

148.	Dredging and Disposing of Material	Cubic Yard
148.1	Dredging and Disposing of Material (Hydraulic Method)	Cubic Yard
148.2	Removal and Disposal of Rock from Dredged Areas	Cubic Yard
148.3	Removal and Disposal of Ledge from Dredged Areas	Cubic Yard
148.4	Dredging, Mobilization and Demobilization	Lump Sum

SECTION 150
EMBANKMENT

DESCRIPTION

150.20 General.

Construction of all embankment fill shall be done in accordance with the relevant provisions of Sections 120, 150 and 170 and in accordance with the procedures described herein.

This work comprises the formation of embankments with suitable material obtained from excavation and borrow, thoroughly compacted to produce a stabilized embankment. The work shall be performed in accordance with the lines and grades shown on the plans as directed.

Material available from widened cuts outside the slopes as indicated on the plans or as ordered by the Engineer may be used in embankments or elsewhere upon written request by the Contractor and subsequent written approval by the Engineer. The Engineer shall determine the suitability of any excavation material for incorporation in the embankment.

If the Contractor desires to waste excavated material and provide borrow to replace it for his own convenience, he may do so only after obtaining the written approval of the Engineer and after satisfactory arrangements have been made for the measurements and disposal of the material.

When it is determined by the Engineer that there is not sufficient material available either from excavation within the Right-of-Way or the slope lines of the section under Contract for the formation of embankments, roadbeds in cut sections, foundations, shoulders, or backfill the Contractor shall obtain such additional material as may be necessary from outside the location, and this material will be borrow material.

150.21 Borrow Pit Restrictions.

With the exception of commercial borrow pits, the location, material removal operation and final shaping and finishing of borrow pits, regardless of location, must conform with all local and State regulations, and for the purpose of preventing water pollution shall be subject to approval by the Engineer prior to use, during the material removal operation and upon completion. Borrow pits shall be so graded and finished after material removal is completed that there can be no reasonable possibility of a safety hazard nor ponding of water nor water pollution caused by later erosion of the pit.

Borrow pits located adjacent to the Right-of-Way shall be finished by extending the slope of the cross section to a berm to be constructed or left within the Right-of-Way at the side line. The berm shall be a minimum

of 5 feet high and 2 feet wide across the top with natural slopes in both directions, or as otherwise directed. The floor of the pit shall slope away from the location line at a minimum rate of ½ inch per foot for at least 50 feet.

Portions of borrow pits (within 500 feet of the project or any other highway location line) which may be noticeable from a travelled way, residence or place of business, shall be neatly trimmed and left in a condition satisfactory to the Engineer. Particular attention shall be given to make the slopes harmonize with the general appearance of the adjacent landscape, provided however, that no slope shall be steep enough to constitute a public menace. No unsightly accumulation of material shall be permitted which may in any manner deface the finished landscape.

The cost for the final shaping and finishing of borrow pits shall be included in the contract unit price of the type of borrow furnished with no additional compensation.

MATERIALS

150.40 General.

All embankment materials, whether coming from excavation or borrow shall consist of solid, sound mineral aggregate. It shall be free from deleterious, organic, elastic or foreign matter and shall be adequately graded for satisfactory compaction into a stabilized soil structure.

These materials will be classified into particular groups according to AASHTO Designation M 145, "The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes".

All borrow material to be furnished shall meet the requirements specified in the following Subsections of Division III, Materials:

Ordinary Borrow	M1.01.0
Gravel Borrow	M1.03.0
Sand Borrow	M1.04.0 Type b
Gravel Borrow for Bridge Foundation	M1.03.0 Type a
Special Borrow	M1.02.0
Impervious Soil Borrow	M1.08.0
Crushed Stone for Drainage, Revetment and Water Work Foundations	M2.01.1
Crushed Stone for Bridge Foundation	M2.01.1

CONSTRUCTION METHODS

150.60 General.

Prior to starting work, the Contractor shall obtain approval for the compaction equipment to be used. Unless otherwise required in the Special Provisions, each layer of embankment material shall be thoroughly compacted with power rollers or tamping rollers. Other equipment or equivalent compactive capacity may be used subject to trial on the project and approval by the Engineer. Compacting equipment will not be used for any other purpose during compaction operations.

The use of tractors, trucks, scrapers or other equipment designed primarily for purposes other than compaction and being used for purposes other than solely compaction will not be considered as compaction equipment, but traffic of such vehicles shall be distributed over this fill in such a manner as to take advantage of the additional compaction afforded thereby.

Sufficient levelling and compacting equipment shall be provided to do the work of spreading and compacting the material promptly after it has been deposited. When, in the Engineer's judgment, such equipment is inadequate to spread and compact the material properly, the Contractor shall reduce the rate of excavation and placing of the fill to a rate not to exceed the capacity of the leveling and compacting equipment or employ additional equipment.

The Contractor shall plan his grading operation to use all rock possible from all excavation either as backfill in excavated muck areas or in areas of greatest depth.

Before placing of any fill, the areas under embankments shall be cleared, grubbed, and stripped as specified in Section 101 and 120.

Frozen material shall not be placed on embankments nor shall embankment be placed on material frozen to a depth of over 3 inches. If during the construction of an embankment, the top layer becomes frozen to a depth of over 3 inches, the frozen material shall be removed before a succeeding layer is placed on the embankment. This work shall be performed at no additional expense to the Department.

Frozen excavated material which will be suitable when dry shall be allowed to thaw and dry and then be placed in the embankment. No compensation will be allowed for the storing and rehandling of these materials.

Embankments shall be formed by placing successive layers of material uniformly distributed and compacted over the full width of the cross section unless otherwise directed. Stumps, rubbish, sod, frozen or other unsuitable materials shall not be incorporated in the embankment.

The Contractor shall prosecute his work so that no damage will occur to drainage pipe lines or masonry or brick structures (See Subsection 150.64).

150.61 Preparation of Foundation Areas.

The foundation areas shall be cleared, grubbed and stripped as required, and all soft, spongy or other material unsuitable for embankment foundation shall be removed. When, in the Engineer's judgment, there is reasonable doubt as to the suitability of the existing material for embankment foundation, no further work shall be performed in the area in question until the material is tested and approved for use or remedial methods are ordered by the Engineer.

Embankment areas 3 feet or less in height from the subgrade to the existing ground shall be rough graded and compacted to not less than 95 percent of the maximum dry density of the material as determined by the AASHTO Standard Method of Test T99, Method C at optimum moisture content, as determined by the Engineer, without additional compensation before placing any fill. If the material retained on the #4 sieves is 50% or more of the total sample this test shall not apply and the material shall be compacted to the satisfaction of the Engineer.

For embankments greater in height than 3 feet below the proposed subgrade to existing ground no additional embankment foundation area preparation will be required, provided the material within the area is suitable for the purpose.

Regardless of the height of fill, where embankment is to be placed against existing earth slopes, steeper than 3 to 1, the slope shall be broken up into steps of random width as the fill is placed in order to provide a suitable bond between the existing ground and the new embankment. Both the material cut out and the bottom of the area cut into shall be compacted along with and to the same degree as the material being placed in the embankment without additional compensation for excavation, benching or compacting.

Where foundations for bridges, culverts (span 8 ft or more) and major wall structures are to be founded on the embankment, the embankment to the extent shown on the plans shall be constructed of Gravel Borrow for Bridge Foundations and/or Crushed Stone for Bridge Foundations.

At the sites of footings for abutments, piers or other structures having pile foundations, the material shall be placed in embankment prior to driving piles and shall be of a quality and grading that will not obstruct driving of the piles.

Where foundations for structures are to be supported on newly formed embankments and where flying wingwalls are to be constructed, the embankment shall be placed to an elevation of at least 2 feet above the bottom of the proposed foundation or flying wingwalls and thoroughly and satisfactorily compacted.

After the above work is completed the material within the area of the proposed foundation or flying wingwalls will be excavated to the grade of the bottom of the concrete. Excavation of this compacted fill will be paid for under the item of Bridge Excavation as stipulated in Subsection 140.21.

150.62 Embankment Construction With Materials Other Than Rock.

Embankment construction with materials other than rock shall not be placed from December 1 to April 1, except with written permission of and under such special conditions and restrictions as may be imposed by the Engineer.

Embankment 10 feet or more in height from the elevation of the subgrade to the original ground elevation shall be constructed to the elevation of the proposed subgrade and then allowed to settle for 60 days (or such other period as the Engineer shall direct in writing) before the pavement structure is constructed thereon. If the condition of the subgrade is suitable, not frozen or muddy and is shaped, compacted and fine graded within the tolerance provided in the Specification, the Contractor may apply and the Engineer may approve the placing but not the fine grading of the subbase prior to the termination of the 60 day waiting period.

Earth embankment shall be placed and compacted in uniform layers not exceeding 12 inches in depth, loose measurement; each layer of material shall be spread on the entire width of the embankment and levelled off by approved equipment.

The embankment materials shall be compacted to not less than 95 percent of the maximum dry density of the embankment material as determined by AASHTO Standard Method of Test T99, Method C at

optimum moisture content. If the materials retained on the #4 sieves is 50 percent more of the total sample, this test shall not apply and the material shall be compacted to the satisfaction of the Engineer. The Contractor shall, without additional compensation, employ whatever measures that may be necessary to adjust the natural water content of the suitable embankment material to permit the placement and compaction as hereinbefore specified. The Engineer, during the progress of the work, may make tests as required, determining the in-place density of the soil by one of the following Standard Methods of Test: Density of Soil and Soil Aggregate in place by Nuclear Methods (Shallow Depth), AASHTO T238; Density of Soil In-Place by the Sand-Cone Method, AASHTO T191; or Density of Soil In-Place by the Rubber-Balloon Method, T205.

Each lift of compacted materials shall be visibly crowned to allow drainage of surface and rain waters off the surface of the embankment. No stones larger than 3 inches shall be used to fill where piles are to be driven. Embankment constructed in basement areas of demolished buildings and other areas restricting the use of power rollers, etc., shall be compacted by mechanical tamping with approved power tools.

If the natural-in-place moisture of the excavated material makes it impractical to compact the soil, the Contractor shall dry the soil by disking, harrowing, blading, rotary mixing or by other approved means, or compaction of the layer of wet material may be deferred until the layer has dried so that it can be properly compacted. If these above methods do not produce the desired results, or when in the judgment of the Engineer, excess moisture resulting from climatic conditions beyond the control of the Contractor is considered to have affected adversely the stability of the previously placed and satisfactorily compacted embankment materials, the Engineer may direct the placement of single layers of "Special Borrow" to act as stabilizing drainage layers. When so ordered by the Engineer, the Contractor shall place a layer of "Special Borrow" having a depth of not more than 12 inches in thickness, loose measure. Such materials shall be placed completely over the entire width between the limits designated by the Engineer, and shall be compacted as hereinafter specified before the succeeding layer of suitable embankment materials from the roadway excavation is placed.

The work may be ordered suspended if the weather and climactic conditions are such that the embankment and excavation cannot be performed in accordance with the specifications. No additional compensation will be allowed to the Contractor for such suspension of work. If the work is ordered suspended due to weather or other climatic conditions not under the control of the Contractor, an extension of time may be granted to the Contractor by the Engineer.

150.63 Rock in Embankment.

Where rock is used in embankments the materials shall be carefully spread so that all large stones shall be well distributed and the interstices of each layer shall be practically filled with smaller stones and suitable material from excavation or borrow to form a solid and dense layer of embankment. No rock in excess of 6 inches in its largest dimension shall be incorporated in the top 2 foot layer of embankment immediately below the subgrade. The maximum size of boulders or ledge fragments used in embankments shall be such that they can be incorporated into layers not exceeding 3 feet in depth. Any stones or fragmented material too large to be placed in 3 foot layers shall be broken down by blasting or other means to appropriate size.

Rock in fills shall not be placed adjacent to masonry or brick structures or to any pipe lines. At bridge abutments rock fill shall not be placed within 20 feet of the parapet.

150.64 Backfilling for Structures and Pipes.

A. General.

All backfilling shall consist of suitable materials uniformly distributed and thoroughly compacted. When suitable backfilling materials cannot be obtained from excavation, the material shall consist of satisfactory borrow.

When directed, mechanical tampers shall be used in compacting backfill for trenches, and in hard to reach areas around masonry.

No backfill whatever shall be placed on or against structures, pipes, or other masonry, until permitted by the Engineer. It shall be formed of successive layers not more than 6 inches in depth, uniformly distributed and each layer thoroughly compacted.

B. Structures.

The backfill in back of abutments and wingwalls of bridges shall consist of gravel. The gravel shall meet the specifications of Subsection M1.03.0, Type b. Measurement of "Gravel Borrow" under this work will not include any filling made beyond a vertical plane 1 foot outside the footings except as directed.

Whenever backfill is placed in back of or over arches, culverts or rigid frames, the fill shall be first placed midway between the ends of the structure. The remainder of the fill shall then be placed to equal depths on both sides of the structure, working equally both ways from the center of the structure toward the ends. This procedure shall continue up to the bottom of the subbase of the roadway.

C. Pipes.

No load greater than 8 tons shall be moved over any pipe until a fully compacted backfill of at least 2 feet has been placed over the top of the pipe. This minimum will be increased to 3½ feet for a 40,000 pound single wheel load and to 4 feet for a 60,000 pound single wheel load. The required fully compacted backfill cover shall be placed a minimum of 50 feet on both sides of the pipe crossing. However, compliance with this requirement is not be construed as relieving the Contractor of any responsibility concerning damage to the pipe.

Material used for backfilling to a point 2 feet over the pipe shall contain no stones larger than 3 inches in greatest dimension.

Backfill below the haunches shall be placed in 6 inch layers and compacted simultaneously on both sides of the pipe with railroad tampers or approved mechanical rammers which shall not come in contact with the pipe. Backfill above the haunches shall be placed in 6 inch layers and compacted as directed. Backfill material shall be moist prior to and during compaction.

If directed, backfill material shall consist of gravel borrow, type c.

Backfilling for structural plate pipe, pipe-arches and arches shall be placed evenly on both sides of the structure in layers not exceeding 6 inches in depth. Backfilling shall be placed uniformly on both sides of pipe. The fill material shall be thoroughly tamped around the pipe or pipe-arch, between the pipe or pipe-arch and the sides of the trench, or for a minimum distance each side of the pipe or pipe-arch equal to the diameter or span of the structure.

In all cases the filling material shall be thoroughly tamped. Puddling or jetting the backfill will not be permitted, except with written approval of the Engineer.

150.65 Backfilling Muck Excavation Areas.

Backfilling after muck is removed shall consist of rock fragments, boulders up to 2 cubic yards in size, if available, or selected clean granular material not more than 15% of which will pass through a #200 sieve as determined by AASHTO Test T-11. The backfill shall be obtained from suitable excavation on the project, or from Special Borrow under Item 150.1. When rock is used as backfill, granular material meeting the specifications described above shall also be provided and used with the rock backfill. The volume of the granular material shall be sufficient to fill all voids and interstices of the rock backfill.

Where directed, backfilling shall be placed immediately after the muck has been excavated in order that any remaining soft material may be pushed ahead of the backfill and readily removed.

The backfill shall be placed at least 2 feet above the top of the swamp area or at least 2 feet above the level of any water that is present whichever will give the highest elevation of backfill.

The surface of the embankment shall be kept free of unsuitable material. No muck or unsuitable material shall be entrapped by any successive deposits of fill.

150.66 Gravel Borrow for Bridge Foundations.

The gravel shall be placed on firm material free from standing water and thoroughly compacted in layers not exceeding 12 inches in depth, loose measurement, in accordance with the provisions of Subsection 150.62 to a minimum total depth of 2 feet, except the requirements of AASHTO T-180 shall apply.

In areas where it is not practicable to compact the gravel for bridge foundations by rollers or other rolling moving equipment the compaction shall be accomplished by means of mechanical or pneumatic tampers and the density of the compacted gravel as tested in the field shall not be less than 95% of the laboratory maximum density as determined by AASHTO Test T-180 Method D. If the material retained on the #4 sieves is 40% or more of the total sample this test shall not apply and the material shall be compacted to the satisfaction of the Engineer.

Compaction of the gravel and any adjoining embankment material shall be done simultaneously so that the respective materials will be confined substantially to the indicated lines.

150.67 Crushed Stone for Bridge Foundation.

Crushed stone shall be furnished and placed where shown on the plans and where directed by the Engineer.

In no case shall crushed stone be placed on other than firm material.

The crushed stone shall be placed to an elevation one foot above ground water level or lowered water level.

The entire mass of crushed stone shall be compacted into place by overlapping coverage by pneumatic tired earth rollers having 4 wheels abreast and loaded, vibratory plate type compactors, vibratory rollers or by other means that shall achieve equivalent compaction and are approved by the Engineer.

The compaction operation shall be continued until there is no moving stone directly ahead of the wheels of the moving machine.

150.68 Crushed Stone for Drainage, Revetment, and/or Water Works Foundations.

When directed in writing by the Engineer to place crushed stone in the bottom of the excavation of revetment, drainage and water system installation to stabilize the foundation, the work will be performed under this item.

The minimum total depth of crushed stone to be placed under this item of work shall be 6 inches. No compaction will be required for depth up to 12 inches. For any depth over 12 inches, the crushed stone shall be placed and compacted in layers not to exceed 6 inches. Compaction will be accomplished by means of mechanical or pneumatic tampers. Compaction effects shall continue until the stones are firmly interlocked and the surface is unyielding.

COMPENSATION

150.80 Method of Measurement.

All borrow with the exception of sand borrow and crushed stone will be measured in place. When this method of measurement is impracticable and the Engineer, prior to the start of construction, so directs and the Contractor agrees in writing, borrow, with the exception of sand borrow and crushed stone, will be measured in its original position in the pit after stripping by the cross-section method.

When ordinary borrow is paid for as measured in place, it shall be measured from existing or compacted old ground surface to the lines and grades applicable to embankment as shown on the plans or as directed.

The volume of ordinary and special borrow when in place measure is necessary, shall be determined as follows:

1. Measure the total volume of embankment in place;
2. Add 12.5 percent of this quantity (for compaction);
3. Deduct the total volume of all suitable materials available for embankments, including rock excavation; except that excavated under Section 140.60;
4. Deduct an additional 25 percent of the volume of rock excavation.

When not measured in its original position in the pit by the cross section method, gravel borrow used in subbase, gravel for base course, gravel for surfacing, gravel for bridge foundations and gravel for backfilling around structures and pipes, will be paid for as measured in place plus 15%.

When not measured in its original position in the pit by cross section method gravel borrow used in slope stabilization and other miscellaneous uses will be paid as measured in place plus 12.5%.

If material that is measured in place is taken from a cross sectioned pit, the amount of material to be deducted from the cross-section pit quantity shall be equal to the material measured in place plus any allowable percent added to the in place measurement.

Sand borrow will be measured by the cubic yard by load measurement. The quantity shall be the volume of the load, as measured, divided by 1.15.

If stone screenings are used the volume shall be obtained from its weight using 2700 pounds as the weight of a cubic yard of stone screenings.

Crushed stone complete in place will be measured by the ton.

The weight slips shall be countersigned on delivery by the Engineer, and no weight slip not so countersigned shall be included for any payment under the Contract.

No overhaul allowance will be made for any kind of borrow.

150.81 Basis of Payment.

Payment for the formation of embankments as specified will be included in the items of excavation or borrow. Excavated material used with the permission of the Engineer for other than the formation of embankments will be paid for as specified in Subsection 120.81 and such payment shall include full compensation for the formation of the required embankments. The contract unit prices for the aforesaid items shall constitute full compensation for the satisfactory performance and completion of the entire work.

Borrow will be paid for at the contract unit price per cubic yard, complete in place, which shall include such test pits and borings necessary to procure samples to establish the suitability of the materials and all required stripping operations.

Crushed stone will be paid for at the contract unit price per ton, complete in place.

150.82 Payment Items.

150.	Ordinary Borrow	Cubic Yard

150.1	Special Borrow	Cubic Yard
151.	Gravel Borrow	Cubic Yard
151.1	Gravel Borrow for Bridge Foundation	Cubic Yard
151.2	Gravel Borrow for Backfilling Structures and Pipes	Cubic Yard
154.	Sand Borrow	Cubic Yard
156.	Crushed Stone for Drainage, Revetment, and/or Water Works Foundations	Ton
156.1	Crushed Stone for Bridge Foundations	Ton

SECTION 170
GRADING

DESCRIPTION

170.20 General.

The shaping, trimming, compacting and finishing of the surface of the subgrade, the grading and finishing of all unpaved shoulders and slopes, and the preparation of all areas for topsoil, loam, riprap or slope paving as shown on the plans or as directed, shall be constructed in accordance with these specifications and in close conforming with the lines, grades and typical cross sections shown on the plans or established by the Engineer.

CONSTRUCTION METHODS

170.60 General.

All soft or spongy material below the subgrade shall be removed to a depth to be determined by the Engineer and backfilled with satisfactory material.

All material within a depth of 2 feet below the subgrade in embankment areas shall conform to the requirements of Subsection M1.02.0 for Special Borrow Material except that it shall contain no stone larger than 6 inches in its greatest dimension and shall be placed and compacted in layers not exceeding 8 inches in depth, compacted measurement.

In cut sections (excluding rock excavation) where existing soil within a depth of 2 feet below the subgrade, after testing, is found to comply with the requirements of Subsection M1.02.0 for Special Borrow Material, it shall not be excavated.

In cut sections (excluding rock excavation) where the existing soil within a depth of 2 feet below the subgrade, after testing for gradation requirements, is found to have greater than 14% material passing the #200 mesh, the material shall be excavated.

The replacing material shall conform to the requirements of Subsection M1.02.0 for Special Borrow Material, except that it shall contain no stone larger than 6 inches in its greatest dimension and shall be placed in layers not exceeding 8 inches in depth, compacted measurement.

In the areas described above where Special Borrow is to be used, the plane of the base upon which the material is to be placed shall be compacted and graded until the surface is smooth, without additional compensation. A tolerance of 1 inch above or below the proposed grade will be allowed, provided that this 1 inch above or below grade is not maintained for a distance longer than 50 feet and that the required crown is maintained.

170.61 Fine Grading and Compacting.

Before surfacing or sub-base is spread, the subgrade shall be shaped to a true surface conforming to the proposed cross section of the highway and compacted in accordance with the provisions of Subsections 150.60 and 150.62. All depressions and high spots shall be filled with suitable material or removed and such areas again compacted until the surface is smooth and satisfactorily compacted. A tolerance of ½ inch above or below the finished subgrade will be allowed provided that this ½ inch above or below grade is not maintained for

a distance longer than 50 feet and that the required crown is maintained in the subgrade. Any portion of the subgrade which is not accessible to a roller shall be thoroughly compacted with the mechanical tampers or by other adequate methods approved as satisfactory by the Engineer.

COMPENSATION

170.80 Method of Measurement.

The grading and compaction of the subgrade will be measured by the horizontal square yard at the plane at the bottom of subgrade in all areas where a subgrade was placed.

Grading and finishing for the entire project will include all grading work not included under the item of Fine Grading and Compacting (in subgrade area).

170.81 Basis of Payment.

Payment for the shaping and compacting of the subgrade as specified herein shall be included in the item for Fine Grading and Compacting (in subgrade area). The removal and disposal of material below subgrade will be paid for at the contract unit price per cubic yard for the appropriate Excavation Items in Section 120.

Grading and finishing other than subgrade areas will be included in the price of the other respective items of work involved.

In areas where Special Borrow material is required as stipulated in Subsection 170.60, the material shall be paid for as Special Borrow. The provisions of Subsection 120.81 shall apply when the Special Borrow is obtained from excavated materials.

170.82 Payment Items.

170.	Fine Grading and Compacting—Subgrade areas	Square Yard
150.1	Special Borrow	Cubic Yard

SECTION 190
BORINGS

DESCRIPTION

190.20 General.

This work shall consist of making soil-test borings, obtaining and preserving acceptable samples, preparing a report of the results obtained and delivery of the report and samples.

The Engineer will establish the location and provide the ground surface elevation for each boring. No change in boring locations shall be made unless prior consent of the Engineer is obtained. The Contractor shall complete the borings to the specified highest bottom elevations or as directed. The actual location at which each boring is made shall be shown on the plans and the actual starting grade shown on the boring log.

The Contractor shall confine his operation as closely as possible to each location where work is to be performed. He shall take precautions necessary to prevent damage to existing structures and conduits both above and below ground, and to lawns, walks and pavements.

When the work at each borehole is completed, the hole shall be adequately blocked and solidly filled tc a depth of at least 5 feet in a manner to preclude any possibility of injury to man or animal, or damage

to property. Special Provisions for backfilling boreholes on railroad property may also be employed in accordance with railroad requirements.

Boreholes within the limits of travel ways, shoulders, sidewalks and paved areas shall be backfilled and compacted with granular materials and brought to the grade of the adjacent surface with a minimum of 6" of bituminous concrete or cement concrete, whichever is applicable.

The Department reserves the right, at any time during the life of the Contract, to determine the order in which remaining borings are to be taken and reserves the right to eliminate borings from, or to add borings to those shown on the plans and the right to increase or decrease the depth of any and/or all borings.

The Contractor shall be responsible for any claims resulting from damage to underground pipes, conduits, and structures. It is suggested that possible damage to such utilities can be minimized or eliminated by hand augering the first several feet of each borehole. The Contractor's attention is called to Subsection 7.13 of the Standard Specifications regarding Protection and Restoration of Property.

190.21 Boring Samples and Reports.

All Borings including Trial Borings, Auger Borings, Wellpoints and Test Pits shall require boring logs and/or records. Four copies of the typewritten boring report shall be submitted to the Research and Materials Engineer within ten (10) calendar days after completion of the work at each site. One (1) copy shall be on transparent paper (onion skin, vellum, etc.) from which satisfactory prints can be made. Abbreviations shall not be used on the final typewritten log.

Boring samples, packaged, packed and labeled as required and described hereinafter under each type of boring and sample, shall be delivered at the time the boring report is submitted, transportation prepaid, to the Research and Materials Engineer, 99 Worcester Street, Wellesley Hills, Massachusetts 02181.

In advance of shipment of boring samples, a letter of transmittal shall be sent to the Research and Materials Engineer, with a copy of the boring report and one copy of the Boring Record Cards as required in Subsection 190.61. A supply of Boring Record Cards for Department projects may be obtained upon request from the Research and Materials Engineer.

Where Control Borings are specified on the plans or in the Special Provisions, a legible copy of the driller's field log shall be forwarded to the Research and Materials Engineer or as directed in the Special Provisions the day after the Control Boring work at each site is completed.

The original drillers field log (copy) will be submitted to the Research and Materials Engineer with the drillers field description unaltered. Should the contractor's office engineer or geologist after review, find it necessary to change a description he shall do so on a separate copy of the field log, date, sign, and clip the copy to the original driller's log. Copies of these logs shall be sent to the Research and Materials Engineer, District Highway Engineer and all others concerned. The field logs shall be sent to all concerned no later than one (1) day after the completion of each borehole.

190.22 Supervision.

The work shall be performed under the supervision of the authorized representative of the Engineer. No subsurface exploratory work shall be done in the absence of the Inspector

The Contractor shall furnish the means and the men required to transport safely the Inspector to and from high ground and the position of borings located on water, in a swamp, or other surface conditions over which it is impossible or difficult to travel on foot.

The Contractor shall notify the Research and Materials Engineer and the District Highway Engineer, who is supplying the inspector, not less than forty eight (48) hours in advance of when he intends to commence work at a particular job site or when he intends to increase or decrease the number of rigs on a project in order that the Engineer may have time to provide a proper number of inspectors for the project.

190.23 Driller Qualification.

The driller of each boring crew shall be responsible for determining changes in the soil. He shall be experienced in detecting variations in the soil by changes in the feel and sound of the hollow rod to which the bit is attached. He shall also be competent to classify the recovered soil samples in accordance with the Department's Visual Identification of Soils Table (copies may be obtained from the Research and Materials Engineer).

Before beginning on the Department's work, the Contractor shall certify in writing to the Engineer, the name of each driller he proposes to use. The driller shall be qualified as acceptable to the Engineer by exhibiting satisfactory abilities using the methods defined herein.

Once qualified a driller need not be requalified for subsequent projects, although approval must be obtained

for his employment on each Contract. The Engineer reserves the right to determine the acceptability of the driller at any time during the prosecution of the work. The Contractor shall designate a field supervisor on each Project.

DRILLING METHODS

190.60 General.

A. Starting Boring

Every boring shall start as a Drive Sample Boring, except Auger, Undisturbed Sample Preparatory, and Vane Shear Test Preparatory Borings.

Where the resistance to penetration with earth boring tools, as defined herein by "Practical Refusal" (Section F.), is encountered above the specified highest bottom elevation, the borehole nevertheless shall be made to said elevation. Should bedrock be encountered above the specified highest bottom elevation, the borehole shall be continued as a rock core boring for 10 ft. unless otherwise directed.

B. Casing

Casing shall be of a size that will permit the specified sample to be obtained or groundwater observation well to be installed or to allow for telescoping and spinning of casing. All pieces of casing and wash-pipe shall be equal in length. Casing may be driven into the ground only so far as is necessary to keep the wall of the borehole in place and then open hole techniques may be employed. However if the Contractor so elects, casing may be used throughout the borehole as required. Casing for rock core borings shall be sealed on bedrock to prevent loose material from entering the hole and to prevent the loss of drilling fluid return, regardless of the type or types of material encountered. Except for the first piece, when starting each borehole, the bottom of the casing should not be advanced below the bottom of the borehole that has been made with a chopping or drilling bit without the approval of the Engineer.

C. Making the Borehole

Independent of whether casing or open hole techniques are employed, the borehole shall be started and made by loosening the soil with a bit attached to the lower end of a hollow rod and given a chopping motion with a clockwise twist at the bottom of each stroke. An auger, either hand or power driven, a well-drill or a rotary drill shall not be used for advancing the borehole in less than "Dense" or "Very Dense" or "Practical Refusal" soil. However when casing is used a rotary bit may be used to clean the casing. A sampler shall not be used instead of a chopping or drilling bit for making a borehole. To make a borehole through "Dense", "Very Dense" or "Practical Refusal" soil, boulders, rockfill or other similar material the Contractor may employ whatever method he chooses, including roller bits, telescoping and spinning of a casing without endangering life and property or affecting the purpose for which the boring is being made. The Contractor shall not use a backhoe or other earth moving equipment without the express approval of the Engineer to start a boring. The soil thus loosened shall be borne to the surface in a liquid which is forced down through the hollow rod, out through the discharge ports in the bit, and up the annular space between the hollow rod and the wall of the borehole and/or casing. Except when preparing the borehole for special sampling, the discharge ports shall direct the flow downward. The returning liquid shall be discharged into a settling basin and shall be reused (recirculated) to form a native mud. Water alone, for transporting the loosened soil, shall not be used except at the very beginning of each borehole. If a contractor elects to use open hole techniques, an effective mud for the purpose of transporting out the loosened soil and for stabilizing the wall and bottom of the borehole may be manufactured by adding a fat clay or bentonite, or one of its derivatives, in sufficient amount, to the native mud. When making boreholes in very porous material, the Contractor may, with the prior consent of the Engineer, drive casing to seal the wall of the borehole. The volume of mud to be calculated at any time shall be no more than is necessary to transport the loosened soil, but in no event more than 10 gallons per minute when making the borehole in 2½" casing. No rig shall be removed from its position above the borehole nor shall the casing be pulled from the hole until the inspector has been shown a copy of the field log for that hole and has approved the removal of the rig and/or of the casing.

D. Changes in Soil

At each change in soil, as detected by the driller with intervals not to exceed those as stated under Item 190.61, the drilling operation shall cease and the borehole conditioned for sampling by slowing the pump, raising the bit off the bottom and circulating the liquid to remove from suspension large particles which might become settled solids and thus a part of the sample. The bit on the bottom end of the hollow rod shall then be replaced with a 1-3/8" inside diameter split-tube sampler which shall be entered into the undisturbed soil at the bottom of the borehole for the sample.

E. Obstructions

Should an obstruction be encountered in a drive sample boring, the Engineer may require the Contractor to make additional borings at locations to be determined by the Engineer to attempt to pass the obstruction and complete the boring. "Practical Refusal", boulders, hard material or rock fill will not be considered an obstruction. Final determination when and if an obstruction is encountered shall be made by the Engineer. Borings terminating on obstructions shall be considered trial borings and paid as a drive sample boring.

F. "Practical Refusal"

The term "Practical Refusal" shall mean failure of the sampler to penetrate at least 12 inches, when driven 120 blows using a 140 pound weight free-falling 30". In each case the Engineer by observation shall determine that a Practical Refusal actually has been encountered. A Practical Refusal will not be accepted as the termination of a borehole above the highest bottom elevation as specified on the plans stated elsewhere.

190.61 Drive Sample Borings.

Control Borings and Complementary Borings, when required for design and/or construction purposes, shall be started as drive sample borings and compensated for as hereinafter provided. Control Borings should be completed and boring reports on same submitted as specified under Subsection 190.21 before any Complementary Borings are started. All, some, or none of the Complementary Borings may be required, depending on analysis of the Control Boring Data.

A sample shall be obtained at the beginning of each borehole and at each change in:

a. soil
b. consistency of a plastic stratum
c. density of a granular stratum

In addition to the above, samples shall be taken so that no sampling interval exceeds five (5) feet in a continuous stratum. However the sampling procedure of obtaining a sample at each change as specified will take precedent.

In addition to taking the samples as mentioned, a sample shall also be obtained at specific elevations for certain borings when shown on the boring plans. These samples from certain elevations shall be placed in as many 4 oz. jars as necessary to accommodate the contents of the entire sample recovered from the split spoon sampler and all jars shall be properly labeled and preserved as specified in the Standard Specifications. If a sample is lost during the recovery then the borehole shall be sampled again to recover a suitable sample at the specific elevation (or as close to it as possible) as given on the plans for certain borings. An acceptable minimum size sample shall be at least six inches in length. This requirement shall not apply if bedrock is encountered above the specified elevation.

A sampler of the size and type specified in Subsection 190.60D shall be driven to obtain the sample. Between each blow of the drive-weight, the sampler shall be turned clockwise at least one-quarter of a revolution to keep it free.

In no event will washed, bucketed, or bobbed samples be accepted. During the sampling operation, the driller of the boring crew shall count and record the number of blows required to drive the sampler one foot, after it has been fully seated, using a 140-lb. weight free falling 30". When specified in the Special Provisions or directed by the Engineer and/or if the blow counts are recorded in 6" increments on the field logs the following shall apply:

The number of blows required to effect each 6" of penetration or fraction thereof for a distance of 18" shall be recorded on the field log only. The first six inches shall be considered to be the seating drive. The summation of blows for the second and third six inch increment of penetration shall be the penetration resistance and shown on the final log in blows per foot or the designated fraction or multiple thereof, if the sampler fails to penetrate the full 12".

The borehole shall be kept completely full of drilling liquid during the sampling and recovery operation.

Each sample, immediately upon its recovery, shall be placed, (not jammed) in a 4 oz. glass jar. Sample jars shall be of the same diameter for their full length and shall have screw tops fitted with gaskets. Samples of cohesive soils shall be struck even with the top of the jar. Jars containing samples shall be stored in a cool, damp place, free from exposure to frost or excessive heat. Each jar shall be properly labeled and its lid marked to identify its contained sample. The labeling shall be typewritten and the label glued to the side of the jar.

These labels shall show the following information in a neat, legible manner:

Name and address of boring contractor.

Date the boring was made.

Location and name of project.

Number of each boring as shown on the boring plans and log.

Number of the sample as shown on the boring log.

Depth at which the sample was obtained.

Number of blows required to drive the sampler one foot, using a 140 pound weight free-falling 30″.

Brief description of the classification of the material composing the sample.

All jars shall be packed one tier in clean, unused, substantial, partitioned paperboard cartons. Each carton shall contain exactly 24 jars. If the number of jars containing soil samples is less than 24, the remaining spaces in the carton shall be filled with empty jars.

In each carton the jars shall be arranged in successive order as the samples were obtained from each borehole, starting in the upper left hand corner, which shall be clearly identified with a felt tip marker on the outside, then moving from the top to the bottom of each succeeding row until all compartments have been filled. Jars left over to complete a borehole shall be similarly arranged, starting in the next numbered carton. Cartons shall be numbered successively on both ends with a felt tip marker. On both ends of each carton shall be glued a typewritten paper label, containing in the same format the information required on the boring Record Cards, which fully describes its contents.

Each driller shall sign only the notes for the borings he himself has made. These notes shall be preserved by the Contractor for future reference. The Inspector shall sign the field copy of the notes also.

At the completion of the boring work, the Contractor shall prepare a boring report containing a graphic representation (or log) of the results obtained. The log for each boring shall be a continuous vertical column, without discontinuity or offset and plotted to not less than 1/8″ per foot. The logs for all borings for each structure or construction unit shall be plotted to the same sale, on a type of transparent paper such as onion skin 8½″ wide and not less than 11″ long; and contain one log per sheet.

The boring report shall contain the following minimum information and be typewritten:

(1) Date, location and name of project.

(2) Boring number or other designation.

(3) Survey station and offset.

(4) Starting grade of each boring (to be supplied by the Engineer).

(5) Depth and a brief, proper classification by visual and manual inspection of each type of material including rock successively encountered in each borehole. Granular soils shall be classified by apparent grain size and state of denseness; clay soils by color and state of consistency, either as hard, medium or soft, and silts as organic or inorganic all in accordance with the Department's Visual Identification of Soils Table. Abbreviations shall not be used on the final typewritten log.

(6) The resistance offered to penetration of the sampler, when sampling each stratum of soil, as represented by the number of blows required to drive the specified sampler one foot, or the designated fraction or multiple thereof, with a 140 pound weight free falling 30″.

(7) Special Note "CHANGED LOCATION" shall be made on each boring log to indicate any field change from survey layout, and an explanation of the reason for the change.

(8) Distance below starting grade to the surface of water in the borehole at its completion and at other times (if any) as required in the Special Provisions, and any unusual behavior of ground-water observed during the boring operation.

(9) Every unusual condition noted during the entire operation. When boulders or cobbles are encountered the driller shall note this on the log and how the boring was made through the boulders or cobbles.

(10) Below each boring log shall be noted the hour and date of start and completion, the actual hours worked to complete the borehole and the name of the driller and inspector.

190.62 Hollow Stem Auger Borings.

This type of Boring, when specified by the Engineer will be made in accordance with the specification and the special provisions of the Contract. When Hollow Stem Augers are used the type samplers specified under Section 190.60D shall be used. A center rod, plug, and pilot bit will be in place unless otherwise directed while advancing the hole by rotation but to a depth no greater than the sampling interval. The center rod, plug, and pilot bit shall be removed and the sample obtained by driving the sampler 18 inches into the undisturbed material below the bottom of the auger. When sampling below the water table, the Hollow Stem Auger shall be kept full of water or drilling fluid unless otherwise directed. The auger flights shall be 5 feet in length and the maximum sampling interval shall not be greater than five feet.

However, the sampling procedure of obtaining a sample at each change shall take precedent as specified

in section 190.61. If the hollow stem auger encounters cobbles, boulders or similar material and fails to penetrate the material after an attempt has been made, then the Engineer may direct the contractor to make the boring by other methods such as a drive sample boring. However, the Engineer will decide when and if this procedure will be employed. Logs, samples and other pertinent information will be as specified in Section 190 contained herein.

190.63 Core Borings.

This type of boring is made after the casing has been sealed on bedrock to prevent loose material from entering the hole and to prevent the loss of drilling fluid return, regardless of the type or types of material encountered. Core Borings into bedrock shall be accomplished by the diamond bit, rotary drilling method. The minimum distance of coring into bedrock shall be 10 feet. The minimum diameter of acceptable core shall be 1-3/8". Where rock cores are required, the coring shall be done with a Double Tube Core Barrel in runs of five (5') feet or less.

Every effort and precaution shall be made by the Contractor to insure the best possible recovery and preservation of the rock cores.

Should the recovered length of core be less than 75% of the depth cored, the Contractor shall adopt measures as may be necessary to improve the percentage of recovery.

Measures to improve recovery may include changes in:

(1) Type of diamond bit.
(2) Rate of feed.
(3) Speed of rotation.
(4) Volume of cooling water.
(5) Style of core barrel
(6) Depth of coring for each removal of core.
(7) Machine operator.
(8) Type of machine.

All recovered cores, including fragments, shall be carefully handled to avoid breakage. They shall be placed in wooden boxes furnished by the Contractor. Boxes shall be in accordance with details furnished by the Department.

Cores shall be placed in the box in consecutive order as they are removed from the core barrel. The trough containing each core shall be fully identified and marked to show the top and bottom of the core.

Upon completion of each core boring all information obtained, including a brief description of the rock type, length or run, length recovered, percentage recovered, coring time, type of barrel used, etc., shall be added to the log of the corresponding boring. The boxed cores and completed logs shall be delivered to the Research & Materials Engineer, as required under Subsection 190.21. All lengths and percentages recovered shall be verified by the Inspector.

190.64 Thin-Wall Steel Tube Drive Samples.

Where organic and inorganic clay or other soils are encountered while making a borehole, the Engineer may require the Contractor to obtain thin-wall steel tube drive samples. The tube shall not be less than 2 inches in diameter nor less than 18 inches long and need not be sharpened. The diameter of the thin-wall tube shall be specified in the special provisions. Making the borehole shall follow the procedure outlined under Subsection 190.60C. The steel tube shall be driven its full length into the material to be sampled. The loaded steel tube shall be sealed, marked for identification and handled in the manner described under Subsection 190.66.

190.65 Undisturbed Sample Preparatory Borings.

The results of Drive Sample borings will determine whether Undisturbed Samples are required and the elevations at which they can be obtained.

The applicable parts of Subsection 190.60C shall be followed in making this type of boring. The volume of mud circulated shall be increased just enough to transport the loosened soil from the borehole. The last two (2) feet of borehole above the elevation at which an undisturbed sample is to be obtained shall be made with a bit built to deflect the flow of mud from a downward direction. Final preparation of the borehole to the top of each undisturbed sample shall be accomplished with a properly constructed and operated clean-out auger. The borehole shall be free of soil particles, soil shavings and settled solids to the surface of undisturbed soil and shall be full of mud to the overflow nipple at the top of the casing.

(1) Drilling Procedure.

"Open hole" techniques may be allowed for advancement of the borehole. When casing is used the diameter shall be at least 1 " larger than the diameter of the undisturbed sample called for.

Independent of the hole advancement technique (casing or open hole) selected, heavyweight drilling fluid with a unit weight between 75 and 95 pcf will be required. The unit weight employed will be selected by the Engineer or his representative in the field, based on hole depth and soil characteristics. The purpose of the drilling fluid is to maintain hole stability and minimize sample disturbance.

(2) Drilling Fluid.

Drilling Fluid shall be produced using clean water and bentonite or one of its derivatives. The drilling fluid shall be mixed to a uniform consistency acceptable to the Engineer. A drilling fluid net weight of 75 to 95 pounds per cubic foot (as determined by the Engineer) shall be obtained and thereafter maintained during execution of the borings, from which undisturbed samples are obtained. The borehole shall be filled with drilling fluid; the fluid level shall be maintained above the ground or water surface at all times until the last sample is taken from the drill hole.

(3) Drill Rods

Drill rods provided for drilling, washing, and sampling within the borehole shall be of such a size that sufficient fluid flow (as determined by the Engineer) can be delivered to the bottom of the hole to permit complete flushing of soil when drilling at maximum depth. Drill rod fittings shall be provided to permit attachment of the drill rods to the thin wall tube sampler.

(4) Pump

The Contractor shall furnish a suitable pump capable of pumping and recirculating the weighted drilling fluid used for the depth and diameter of boring required.

The use of casing for Undisturbed Sample Preparatory Boring shall follow the procedure outlined under Subsection 190.60B. The casing shall have a nominal diameter at least 1 " larger than that of the undisturbed sample called for in the Special Provisions. Drive Samples shall be obtained as directed by the Engineer.

Immediately after recovery of an undisturbed sample, as described in Subsection 190.66 the Inspector will examine the ends of the tube for adequacy and condition of the sample. If unacceptable, the borehole shall be re-prepared and additional samples taken until a satisfactory recovery is made.

190.66 Undisturbed Samples.

Undisturbed samples shall be obtained with a stationary piston, thin-wall, steel tube sampler operated by a separate piston rod (actuating rod) and a sampler head with an appropriate spring and piston rod cone check. The diameter of the undisturbed samples shall be as specified in the Special Provisions. The sampler must be kept in perfect mechanical condition and operated at all times in a manner that will produce acceptable undisturbed samples.

The Osterberg method for obtaining an undisturbed sample may be substituted for the stationary piston method, if approved by the Engineer.

The seamless steel tube shall have a wall thickness not greater than #16 gauge. It shall be of a proper length to produce a net sample 24 " long. Its bottom edge shall be drawn and reamed knife-sharp to an internal diameter approximately 1.75% less than the inside diameter of the tube. The tube shall be free of all scale or other deleterious material and may have a coat of thin enamel paint, lacquer, teflon, or other similar material. Just before being lowered to sample, the inside of the tube shall be wiped dry. Tubes with rusted surfaces shall not be used.

After being fully assembled and lowered to sampling position, the sampler shall be entered into the undisturbed soil by a rapid, continuous movement, without rotation.

A rest period of not less than 15 minutes shall be allowed for the sample to develop friction on the inside of the tube. The loaded tube shall then be rotated by turning the top of the drill-rod. A direct, slow and steady pull, accompanied by rotation, shall remove the loaded tube from the soil. Raising the tube to the surface shall be done without quick starts, sudden stops or vibrations. The borehole is to be kept full of mud during the entire recovery operation.

To free the loaded tube from the sampler-head, without damaging the sample, the vacuum breaker shall be opened. Immediately after the tube is freed, its end shall be inspected and if found satisfactory shall be sealed against loss of moisture.

The top and bottom of the tube shall be sealed with molten beeswax or a microcrystalline petroleum wax heated to a temperature not higher than its melting point. The total thickness of seal shall be approximately ¾ ". Any space remaining at either end shall be filled to within ¾ " of the end of the tube with firmly pressed damp sand. Sealing wax shall then be poured flush with the end of the tube, which shall be covered with several layers of electrician's tape.

A paper label, on which is recorded in ink all pertinent information as required in Subsection 190.61 relating

to the contained sample, shall be glued to the tube. The same data shall be printed directly on the tube with a felt-tip marker of a contrasting color.

The loaded tubes shall be packed in well built wooden boxes at the sampling site. Each box shall contain not more than one 5" nor more than two 3" or four 2" tubes. Each tube shall be surrounded by at least 2" of resilient packing. A record of its contents shall be marked on the lid of each box with a felt-tip marker. The boxes shall be delivered at the completion of each borehole as directed in writing by the Engineer.

An acceptable undisturbed sample for laboratory tests shall, when split in two longitudinally and partially dried, disclose no observable distortions in its stratifications and/or shear planes that can be reasonably attributed to the sampling and handling operations. The Engineer may direct the Contractor to alter the cutting edge clearance of the sampling tube.

Where undisturbed samples are to be taken over water (tidal or otherwise), the Contractor shall have the necessary equipment to properly obtain an undisturbed sample on water and have the necessary devices to stabilize the barge or raft while making an undisturbed sample.

190.67 Vane Shear Test Preparatory Borings.

The borehole shall be made under applicable parts of Subsection 190.60C and 190.65 to a point four feet above the elevation at which a vane shear test is to be made. The next two feet of borehole shall be made with a bit built to deflect the flow of mud from a downward direction. By means of a clean-out auger built for the purpose, all soil and shavings shall be removed to an elevation one foot above the position of the top of the vane tool during the test. Drive samples shall be obtained as directed by the Engineer.

190.68 Vane Shear Test.

The in-place shear strengths of cohesive soils shall be measured by means of field vane shear tests. The Contractor shall have the required vanes as specified in the contract.

The penetrating edge of the vane blade shall be sharpened having an included angle of 90 degrees. A ball bearing casing guide shall be attached to the drill rods 2 feet above the vane and additional ball bearing casing guides shall be provided for each 20 ft. of drill rods required thereafter. All drill rods shall be made up tightly. The vane shall be pushed into the soil below the bottom of the hole in a manner that will prevent rotation during insertion. The bottom of the vane shall be inserted 18 inches into the undisturbed soil at the bottom of the hole.

After insertion, the drill rods shall be clamped securely to a thrust type ball bearing reacting against the casing, this bearing should support the entire weight of the vane and rods during test. A rotation of the vane shall be accomplished by means of a mechanical gear driven mechanism which shall produce a uniform rate of rotation of about 1 degree every 10 seconds (6 degrees per minute). Accurately calibrated torque mechanism or proving rings with maximum readings of 50 ft.-lbs. shall be provided to measure the applied torque. Acceptable equipment is the Acker Precision Drive, Barros, Geonor, Sprague & Henwood, or approved equal in good working condition. Torque wrenches will not be allowed. Calibration of Vane Shear Equipment by an acceptable organization capable and specializing in this work will be required. If said equipment has been calibrated and checked within the last six months by a recognized laboratory no additional calibration will be necessary. Certificate of Proof will be required.

A friction check will be run prior to each test when directed by the Engineer.

One man shall rotate the vane while the Engineer observes the torque gauge. Special attention shall be given to determine the maximum torque registered.

Following the determination of the maximum torque the remolded shear strength shall be determined in the same manner after rapidly rotating the drill rods about 12 revolutions. The determination of the remolded strength should be started immediately after completion of the rapid rotation and in all cases within one minute after the remolded process.

During the tests, readings of time, applied torque and angular rotation should be recorded at 15 sec. intervals unless otherwise directed until the maximum torque is achieved. The maximum torque in foot pounds, the time and angle of rotation measured from the start of the test to the development of maximum torque shall also be recorded. A complete description of the apparatus and detailed dimensions of the vane shear tool shall be submitted with the test report.

Completion of the procedure described above including determination of the remolded shear strength shall constitute one (1) field vane shear test for payment purposes.

If the Contractor is unable to push or drive the vane into the soil below the bottom of the hole after lowering the drill rods and vane to the required depth or if he is unable to rotate the vane to determine the maximum torque due to the stiffness of the soils or due to an obstruction, compensation will be considered included in the

Unit Bid Price per linear foot for Vane Shear Test Preparatory Boring and no further compensation will be made.

190.69 Auger Borings.

Auger borings shall be made where directed to obtain large volume soil samples for laboratory testing. The borings shall be made to depths required by the Engineer, with an earth auger not less than 4 ″ in diameter, either manually or power operated. The auger section shall not exceed five feet in length and shall be removed from the auger hole each time its hollows have become filled with soil.

190.70 Auger Boring Samples.

Large volume soil samples for laboratory testing shall be obtained from auger borings. Each sample shall weigh at least 50 pounds and shall be preserved in an approved container. The number of samples required at each borehole shall be determined by the Engineer.

The container for each sample shall have positive identification of the contents, either by typewritten glued-on label, by wired-on tag or by felt-tip marker. The following information shall be shown:

1. Name and address of boring contractor.
2. Date sample was taken.
3. Location and name of project.
4. Location of auger borehole by station and offset or identifying number of auger borehole, if so identified on plan.
5. Depth below ground surface at which sample was obtained.

190.71 Ground Water Observation Wellpoints.

Type I — A 2½ ″ minimum diameter hole shall be advanced by the Contractor by whatever method he chooses to the elevation specified regardless of type of material encountered such as boulders, "Practical Refusal" material, rock fill, etc., with the exception of bedrock. When the bottom of the hole has reached the elevation specified for the tip of the wellpoint, it shall be purged to its full depth with clean water.

The wellpoint shall have ample clearance so that it may be lowered freely in the borehole. The screen shall be 60 mesh unless otherwise stated. The minimum dimension of the wellpoint shall be 1¼ ″ × 24 ″. The riser, rigidly fastened to the wellpoint, shall be 1¼ ″ galvanized pipe. A galvanized pipe plug or a cap with a vent hole shall be furnished to close the top of the riser. After the wellpoint has been lowered to the specified elevation, the annular space between the wellpoint and riser pipe and the 2½ ″ casing shall be filled with clean, dry sand, unless otherwise directed. This sand shall be retained on a 50 mesh and shall pass a 30 mesh sieve. It shall be poured in slowly to fill the annular space as the casing is pulled.

During the pulling of the casing the wellpoint shall not be raised from its original position.

At completion, the top of the riser pipe shall be closed wrenchtight with a vented pipe plug or cap.

Type II — Ground Water Observation Wellpoints Type II may be installed in a completed borehole after all samples and information have been obtained from these holes. Prior to placing the wellpoint, these holes shall be purged to their full depth with clean water. Where the bottom of the borehole is lower than the highest bottom elevation of the wellpoint, that portion of the borehole below the bottom of the wellpoint, shall be backfilled with a clean dry sand to the elevation of the bottom of the wellpoint unless otherwise directed. If the bottom of the casing is below the highest bottom elevation of the wellpoint when the sand has reached the elevation of the bottom of the casing, the backfilling and pulling of casing shall be carried out simultaneously to the highest bottom elevation of wellpoint and continued as directed for Type I Groundwater Observation Wellpoints unless otherwise directed.

Backfilling of boreholes below bottom of wellpoint, where required shall be included in the cost of Ground Water Observation Wellpoints Type II. Where bedrock is encountered the diameter of the borehole and rock core shall be large enough to accommodate a wellpont and riser pipe.

Type III — Ground Water Observation Wellpoints Type III wellpipe and screen shall be installed as described in these specifications for Type I Ground Water Observation Wellpoints, except that the wellpipe and screen used shall be 2 ″ P.V.C. schedule 40 threaded flush joint wellpipe and wellscreen. Wellscreen slot width shall be .010 ″. A suitable threaded plug shall be installed at the bottom of the wellscreen. A suitable vented thread cap shall also be installed at the top of the well pipe when requested by the engineer. No cementing will be allowed. The length of the wellscreen for each Type III Ground water Observation Wellpoint will be designated on the plan by the Engineer. Separate payment will be made for the wellpipe used and the wellscreen used.

The hole made shall be of sufficient diameter to accommodate the wellpipe and screen.

Type IV — Ground Water Observation Wellpoint Type IV wellpipe and wellscreen may be installed in a completed borehole after all samples and information have been obtained from these holes. The method of installation shall be the same as described in these specifications for Type II Ground Water Observation

Wellpoints except that the wellpipe and screen used shall be 2" P.V.C. schedule 40 threaded flush joint wellpipe and wellscreen. Wellscreen slot width shall be .010". A suitable threaded plug shall be installed at the bottom of the wellscreen. A suitable vented threaded cap shall be installed at the top of the well when requested by the Engineer. No cementing will be allowed. The length of the wellscreen for each Type IV well will be designated on the plan by the Engineer.

The borehole shall be of sufficient diameter to accommodate the wellpipe and screen. If bedrock is encountered the corehole shall be large enough to accommodate the wellpipe and screen.

When directed by the Engineer, sand may be omitted on all types of well installation.

190.72 Mobilization and Dismantling of Boring Equipment.

This work shall include the furnishing at the site of all men and equipment necessary to properly complete the work detailed in the Proposal, including the moving of men and equipment from one project site to another and the restoration of each site after the boring equipment has been removed. It shall also include all special tools and equipment necessary to perform the work in or on water and in other places not readily accessible.

190.73 Test Pits.

Dimensions of Test Pits will be such that a 50 lb. sample can be obtained at depths specified. The pit can be dug by hand or machine at locations as directed by the Engineer. In no case will the depth of pit be more than 12 feet. Test Pits shall be properly sheeted to protect the workers as required in Subsection 140.60, Paragraph F, and shall be large enough to allow the inspection of soil conditions and/or the procurement of 50 lb. bag samples. (Maximum number not to exceed three (3).)

Each sample shall weigh at least 50 lbs. and shall be preserved in a suitable and approved container.

The container for each sample shall have positive identification of contents either by typewritten glued-on label, by wired-on tag or by felt-tip marker. The label shall be covered completely with a transparent material such as tape, plastic, etc.

The following information shall be shown:

1. Name and Address of Boring Contractor.
2. Date Sample was taken.
3. Location and name of Project.
4. Location of Test Pit by Station and Offset or Identifying No. if so identified on plan.
5. Depth below ground surface at which the sample was obtained.

When the test pit is completed and required samples taken and approved by the Engineer, it shall be backfilled and compacted in an approved manner so as not to cause a hazardous condition.

Test Pits Through Pavements

When test pits are required where the Contractor must break through pavements, he shall make as small a test pit as possible. After he obtains the proper number of samples required he shall backfill the test pit with suitable material, compact it in accordance with the Standard Specification. The test pit then shall be brought to the proper grade with the last six inches (6") being bituminous concrete or cement concrete whichever is applicable. The cost of patching where required shall be included in the cost of the test pit.

Test pits made through pavements shall be cut on a neat line by a jack hammer, saw or other mechanical means. The cost of cutting the pavement on a neat line by jack hammer, saw or other mechanical means and patching the pavements as required shall be included in the unit bid price for test pits made through pavements.

COMPENSATION

190.80 Method of Measurement.

Drive Sample Borings and Hollow Stem Auger Borings when completed as such, will be measured by the linear foot of borehole made in original and trial borings below the ground surface, regardless of the type of materials encountered, such as boulders, "Practical Refusal" material, rockfill, etc. with the exception of bedrock.

Core Borings will be measured by the linear foot cored into bedrock.

Undisturbed Sample Preparatory Borings and Vane Shear Test Preparatory Borings will be measured by the linear foot of borehole made below the ground surface to the lowest undisturbed sample made or Vane Shear Test performed.

Thin-wall Steel Tube Drive Samples, Undisturbed Samples, Auger Boring Samples and Vane Shear Tests will be measured for each acceptable sample recovered or test made.

Auger Borings will be measured by the linear foot of borehole made below the ground surface.

Ground Water Observation Wellpoints Type I and Type II will be measured by the linear foot from the tip of the wellpoint to the top of the riser pipe, but not more than two (2) feet above the ground surface regardless of the type of materials encountered such as boulders, "Practical Refusal" material, rockfill, etc., with the exception of bedrock.

Ground Water Observation Wellpoints Type III and IV wellpoint will be measured by linear foot from the top of the wellscreen to the top of the riser pipe but no more than two (2) feet above the ground surface regardless of the type of materials encountered such as "Practical Refusal," Boulders, Rock Fill, etc., with the exception of bedrock. Ground Water Observation Wellpoints Type III and IV wellscreen will be measured by the linear foot from the bottom of the wellscreen to the top of the wellscreen or the actual length used regardless of the type of materials encountered such as Boulders, "Practical Refusal," Rock Fill, etc., with the exception of bedrock.

Test Pits will be measured by each Test Pit made.

190.81 Basis of Payment.

Drive Sample Borings, Hollow Stem Auger Borings,Core Borings, Undisturbed Sample Preparatory Borings and Vane Shear Test Preparatory Borings will be paid at the contract unit price per linear foot for the kind of boring completed as required: payment to include installation of casing as required, including telescoping and spinning of casing when necessary, recovered cores and drive samples. Payment for Undisturbed Preparatory and/or Vane Shear Test Preparatory will only be made to the lowest undisturbed sample made or to the last Vane Shear Test performed. If the boring is continued beyond this point it shall be paid as a Drive Sample boring or other type for the remainder of the borehole or as specified in the Special Provisions.

When borings are located on the water, payment shall be made at the contract unit price per foot for the type of boring made only for the depth of hole below the river, lake, stream, etc., bottom.

Auger Borings will be paid at the contract unit price per linear foot completed as required.

The cost of any materials required to restore the site to its original condition will be included in the unit price of the item.

Ground Water Observation Wellpoints Type I and Type II will be paid at the contract unit price per linear foot which shall include full compensation for a log and all materials left in place.

Ground Water Observation Wellpoints Type III and IV wellpipe and wellscreen will be paid at the contract unit bid price per linear foot which shall include full compensation for a log and all materials left in place.

Thin-Wall Steel Tube Drive Samples, Undisturbed Samples, Auger Boring Samples and Vane Shear Tests will be paid for at the contract unit price for each acceptable sample or test completed as required.

Mobilization and Dismantling of boring equipment will be paid for at the contract lump sum price for Item 193.

Test Pits will be paid at the contract unit price for each test pit actually dug. The contract unit price shall include all labor, equipment, supplies, tools and incidentals required to dig the test pits. The cost for any material to restore the site to its original condition and cutting through pavements will be included in the Item. The Unit Bid Price shall also include the cost of obtaining 50 lb. bag samples (maximum number of 3) as directed and all other incidental work thereto, including a log.

190.82 Payment Items.

191.	Drive Sample Boring	Linear Foot
191.10	Hollow Stem Auger Borings	Linear Foot
191.11	Core Boring	Linear Foot
191.2	Undisturbed Sample Prep. Boring	Linear Foot
191.21	Undisturbed Sample	Each
191.3	Vane Shear Test Prep. Boring	Linear Foot
191.31	Vane Shear Test	Each
191.4	Auger Boring	Linear Foot
191.41	Auger Boring Sample	Each
191.5	Thin Wall Steel Tube Drive Sample	Each
191.6	Test Pit	Each
191.61	Test Pits through Pavements	Each
192.	Ground Water Observation Wellpoint Type I	Linear Foot

192.1	Ground Water Observation Wellpoint Type II	Linear Foot
192.2	Ground Water Observation Wellpoint Type III — Solid Pipe	Linear Foot
192.21	Ground Water Observation Wellpoint Type III — Wellscreen	Linear Foot
192.3	Ground Water Observation Wellpoint Type IV — Solid Pipe	Linear Foot
192.31	Ground Water Observation Wellpoint Type IV — Wellscreen	Linear Foot
193.	Mobilization and Dismantling of of Boring Equipment	Lump Sum

SECTION 200
DRAINAGE

SECTION 201
BASINS, MANHOLES AND INLETS

DESCRIPTION

201.20 General.

This work shall consist of the construction of manholes, inlets and basins in accordance with the specifications, and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

201.40 General.

Concrete for these structures shall meet the requirements of Section 901 Cement Concrete Masonry. Other materials shall meet the requirements specified in the following Subsections of Division III, Materials.

Clay Brick	M4.05.2
Cement Concrete Blocks	M4.05.1
Precast Units	M4.02.14
Cement Mortar	M4.02.15
Reinforcing Bars	M8.01.1
Iron Castings	M8.03.0
Steel Castings	M8.03.2
Dry Stone Masonry	M9.04.9

CONSTRUCTION METHODS

201.60 General.

Basins, manholes and inlets shall be built to the lines, grades, dimensions and design shown on the plans and as directed with the necessary frames, gratings, covers, hoods, etc., and in accordance with these specifications. Basin and inlet grates other than Cascade type may be Type A-1 or A-3, but only one type may be used throughout the project.

Sanitary Sewer Manholes shall be constructed according to the specifications of the Municipality as designated in the Contract. Castings shall be obtained as directed without cost to the Contractor at the site of the improvements from existing structures; from the Party of the First Part at the Town or City Yard; from the Massachusetts Correctional Institute of Walpole; furnished under Section 220, or furnished as a contract item. It will be the Contractor's responsibility to determine, prior to submitting his bid, from which of the above mentioned sources he will obtain the castings. Transportation, delivery, and installation of all castings will be included in the contract unit bid price for the kind of structure involved.

201.61 Excavation (See Subsection 140.60).

201.62 Laying Brick and Blocks.

Brick and concrete blocks shall be soaked in water before laying. All joints in brick structures shall be thoroughly flushed full of mortar and no joint on the inside face shall be greater than 1/8 inch. After the bricks are laid, the joints shall be pointed on the outside. As brick walls are laid up, the outside of the structure shall be plastered with 1/2 inch thick mortar coat. As circular concrete block walls are laid-up the horizontal joints and keyways shall be flushed full with mortar. As rectangular blocks are laid up all horizontal and vertical

joints shall be flushed full with mortar. Plastering of the outside of block structures will not be required. The joints in precast units shall be wetted and completely mortared immediately prior to setting a section. No structure shall be backfilled until all mortar has completely set. When the floors of structures are made of concrete sectional plates the opening in the floor shall be filled with brick chips and mortar, cement concrete, or left open, as directed.

201.63 Placing Castings.

Frame castings for basins, manholes and inlets shall be set in full mortar beds true to the lines and grades as directed.

Where directed the castings shall be temporarily set at such grades as to provide drainage during the construction.

The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid.

The final setting of all other castings shall be performed at the proper stage of construction as directed.

Cement concrete collars shall be placed around the castings after the final setting as shown on the plans and as directed.

Hoods shall be installed in catch basins only when required by the Special Provisions.

201.64 Weep Holes.

Unless otherwise directed or specified in the Special Provisions, 2 weep holes shall be built into the walls of all new basins, precast units and in Types C, CF, D and DF drop inlets as shown on the plans. Each weep hole shall consist of a section of 4 inch pipe or equivalent opening to carry water through the wall of the structure.

The ends of the pipe, if used, shall be saw cut and left flush with the walls of the structure.

The outside end of the pipe or opening shall be covered with a 1/4 inch mesh galvanized wire screen 23 gauge satisfactorily fastened against the wall. The drain to the weep hole shall be excavated and backfilled with 2 cubic feet of crushed stone conforming to Material Section M2. The stone shall be placed against and over the end of the pipe or opening to prevent the entrance of the finer filling material. Only one type of weep hole shall be used throughout the project.

201.65 Backfilling.

Backfilling requirements shall conform to the Provisions of Subsections 120.60B, 150.60 and 150.64.

COMPENSATION

201.80 Method of Measurement.

Measurement for catch basins, leaching basins, manholes and drop inlets (Types C and D), will be based on a standard unit having a depth of 6½ feet; for drop inlets (Types A and B) having a depth of 4 feet 10 inches, as measured vertically at the center of the structure from the top of the grating or cover to the top of the floor in the case of basins and inlets and the invert in the case of manholes. When the measured depth exceeds the standard unit, the number of units paid for will be in the proportion of the measured depth to the standard depth down to 9 feet. Basins, manholes, or drop inlets having a depth less than this standard unit will be counted as one unit. Each gutter inlet shall be counted as one unit. Measurement for manholes more than 9 feet down to a depth of 14 feet will be based on a standard unit depth of 9 feet as measured vertically at the center of the structure from the top of the cover to the invert. Measurement for manholes more than 14 feet down to a depth of 18 feet will be based on a standard unit depth of 14 feet as measured vertically at the center of the structure from the top of the cover to the invert.

When items for Manholes (9′ to 14′ Depth) or Manholes (14′ to 18′ Depth) do not appear in the Proposal the standard unit of depth for all structures shall be 6½ feet.

Special manholes will be measured as complete units regardless of depth.

Transportation, delivery and installation of all castings will be included in the contract unit bid price for the kind of structure involved.

201.81 Basis of Payment.

The accepted quantities of manholes, inlets and basins will be paid for at the contract unit price each, complete in place, which shall not include the cost of castings.

Payment for the concrete collars shall be included in the contract unit price of the structure involved.

Extra depth excavation below the proposed bottom of structure to obtain a stable foundation will be paid for as Class B Trench Excavation.

When directed, the castings of drainage structures on roadways opened to traffic will be set to a temporary grade, and the unit will be considered complete in place and paid for at the contract unit price for the type of structure involved. At such time as the casting or structure and casting is adjusted to final grade the work shall be done and payment made under the provisions of Section 220. Crushed stone for weep holes will be included in the price of the structure.

If the material for backfill is obtained from borrow it will be paid for at the contract unit price per cubic yard or ton for the kind of borrow required.

Furnishing new castings will be paid for at the contract unit price each under the items for Frame and Grate or Frame and Cover or — inch Hood.

201.82 Payment of Items.

201.	Catch Basin	Each
202.	Manhole	Each
202.2	Manhole (9′ to 14′ Depth)	Each
202.3	Manhole (14′ to 18′ Depth)	Each
203.	Special Manhole	Each
204.	Gutter Inlet	Each
205.	Leaching Basin	Each
206.	Drop Inlet, Type A	Each
206.1	Drop Inlet, Type AF	Each
207.	Drop Inlet, Type B	Each
207.1	Drop Inlet, Type BF	Each
208.	Drop Inlet, Type C	Each
208.1	Drop Inlet, Type CF	Each
209.	Drop Inlet, Type D	Each
209.1	Drop Inlet, Type DF	Each
220.	Drainage Structure Adjusted	Each
221.	Frame and Cover	Each
222.	Frame and Grate	Each
222.1	Frame and Grate, MDPW Cascade Type	Each
*224.	—inch Hood	Each
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
156.	Crushed Stone for Drainage. Revetment and Water Work Foundation	Ton

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 220

ADJUSTMENT, REBUILDING AND REMODELING OF DRAINAGE STRUCTURES

220.20 General.

The work shall consist of rebuilding, removing, replacing and adjusting the masonry and castings of present structures, as required, to conform to newly proposed line and grade changes; to change in type of structure, or changes in type of castings; all in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

220.40 Materials.

Such materials as will be required shall conform to Subsection 201.40.

CONSTRUCTION METHODS

220.60 General.

When the line or grade or both the line and grade of the structure changes by 6 inches or less, the structure shall be adjusted to line and grade. The masonry shall be removed to such depth as directed by the Engineer and new masonry shall be constructed to conform to the proposed design and in conformity with the requirements of the applicable parts of Section 201.

When the line or grade or both the line and grade of the structure changes more than 6 inches the structure shall be remodeled. The sloped masonry and the vertical masonry shall be removed to such depths as directed by the Engineer and new masonry shall be constructed to conform to the proposed design and in conformity with the requirements of the applicable parts of Section 201.

When a change in type of structure is required, as converting a basin to a manhole, the masonry shall be removed to such a depth as directed by the Engineer and new masonry, including a brick invert, shall be constructed to conform to the proposed design.

When in the judgement of the Engineer the masonry shows deterioration, the structure shall be rebuilt. The casting and deteriorated masonry shall be removed in a neat manner until a clean sound base is obtained upon which concrete blocks and clay bricks may be set to rebuild the structure. Gravel borrow shall be furnished for backfill where required when excavated material is unsuitable. The casting shall be set to line and grade with a concrete collar and surfaced with a minimum of one and one half inches of Class I Bituminous Concrete Top Course as directed.

The new masonry construction, replacing of castings, highly early strength concrete collars, backfilling around structures and other incidental work shall be as specified in Section 201.

220.61 Protection of Work.

The Contractor will be held responsible for the protection of the castings. Any frames, grates, or covers damaged in any manner during the progress of the construction shall be replaced with new castings by the Contractor, at his expense.

Prior to the actual removal of the present castings a count will be made and recorded of all castings which are in satisfactory condition for reuse. The Contractor shall supply the number of castings recorded in the initial count, when they are required for reuse or when they are to be removed from the project by the Owner.

COMPENSATION

220.80 Method of Measurement.

Adjustment of structures to line or grade or both line and grade when the change is 6 inches or less, will be measured in place by the unit each, complete and approved.

When the adjustment of structures to line or grade or both line and grade is greater than 6 inches, the structure will be included in the item for structures remodeled.

Structures changed in type will be measured in place by the unit each, complete and approved.

Structures remodeled will be measured in place by the unit each, complete and approved.

Structures rebuilt shall be measured by the average height in vertical feet and tenths of feet from the bottom row of rebuilt masonry to the bottom of the casting. The removal and resetting of the casting will be measured by the unit each, complete and approved for all work described above.

Transportation, delivery and installation of all new castings will be included in the contract unit bid price for the kind of structure involved.

220.81 Basis of Payment.

Adjustment of structures to line and/or grade or both line and grade when the change is 6 inches or less will be paid for at the contract unit price each under the item for Drainage Structure Adjusted.

Structures, changed in type will be paid for at the contract unit price each under the item for Drainage Structure, Change in Type.

Structures remodeled will be paid for at the contract unit price under the item Drainage Structure Remodeled.

Structures rebuilt will be paid for at the contract unit price per vertical foot.

Castings removed and reset for Drainage Structures Rebuilt will be paid for at the contract unit price each under the item Frame and Grate (or Cover) Removed and Reset.

Furnishing new castings will be paid for at the contract unit price each under the items for Frame and Grate or Cover, — inch Hood.

220.82 Payment Items.

220.		Each
220.2	Drainage Structure Rebuilt	Vertical Foot
220.3	Drainage Structure Change in Type	Each
220.5	Drainage Structure Remodeled	Each
220.7	Sanitary Structures Adjusted	Each
221.	Frame and Cover	Each
222.	Frame and Grate	Each
222.1	Frame and Grate MDPW Cascade Type	Each
223.	Frame and Grate (or Cover) Removed and Reset	Each
224.*	— inch Hood	Each

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 230

CULVERTS, STORM DRAINS AND SEWER PIPES

DESCRIPTION

230.20 General.

This work shall consist of the construction of culvert storm drains, sewer pipes, hereinafter referred to as "Pipe", and flared end sections for Reinforced Concrete or Metal Pipe, in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

230.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Asphalt Coated Corrugated Metal Pipe	M5.03.0
Asphalt Coated Corrugated Metal Pipe Arch	M5.04.0
Asphalt Coated Corrugated Metal Pipe (Aluminum)	M5.03.3
Asphalt Coated Smooth Steel Liner Helically Corrugated Shell Metal Pipe	M5.04.3
Cement Concrete Pipe	M5.02.0
Clay Pipe	M5.01.0
Reinforced Concrete Pipe	M5.02.1
Ductile Iron Pipe	M5.05.3
Structural Plate for Pipe and Pipe-Arch	M5.04.2
Jointing Materials For Pipe	M9.10.0
Mortar for Pipe Joints	M4.02.15
Reinforced Concrete Pipe. Flared Ends	M5.02.2
Metal End Sections	M5.03.6
Polymeric Precoated Corrugated Metal Pipe	M5.03.8

CONSTRUCTION METHODS

230.60 General.

Excavation (See Subsection 140.60).

230.61 Bedding Pipes.

The bedding for the pipe shall be shaped to conform reasonably close to the lower 10% of the pipe and recesses excavated for bells of bell and spigot pipes.

All pipe shall be laid to the specified line and grade, with a firm bearing throughout each length and with bell ends uphill.

230.62 Pipe Joints.

The joints of clay, cement concrete and reinforced concrete pipe, shall be formed by caulking into the ball a gasket of jute or oakum and then filling the remainder of the joint with cement mortar. The invert shall be kept smooth and free of any obstructions. In the case of concrete pipe the surfaces to be joined shall be thoroughly cleaned and wetted with water before the joint is made. Asphalt coated corrugated metal pipe shall be firmly joined with an approved coupling.

When rubber type ring gaskets are used the pipe ends shall be designed so that the gasket will be confined on all sides and will not support the weight of the pipe. Regardless of the type of joint used the interior surfaces of abutting pipes shall form a smooth grade when pipe laying is completed.

Where water tight joints are required respective pipes shall be joined as follows:

Clay pipe shall employ a compression joint consisting of a plastic material applied to the bell and spigot ends of the pipe and a compression ring of elastomeric material conforming to ASTM-C425, Type III.

Cement concrete or reinforced cement concrete pipe shall be joined using flexible water tight rubber gaskets conforming to ASTM-C443.

In designated areas, as directed, certain joints may be left open to allow for entrance of underground water into the pipe line.

230.63 Structural Plate Pipe and Pipe-Arch.

A. Excavation. (See Subsection 140.60)

B. Bedding.

The pipe or pipe-arch structure shall be placed on a prepared foundation carefully shaped to fit the lower plate or plates of the structure so that the flow line will conform to the required grade.

The arch structure shall be placed on a foundation as shown on the plans. Each side of the arch shall rest on a galvanized channel, as detailed on the plans, securely embedded in the substructure.

C. Erections.

The plates for the structure shall be assembled according to the manufacturer's assembly instructions. Pipe or pipe-arch structures may be assembled in their final location or adjacent to it, and then placed on the prepared foundation as a complete unit. Arches shall be erected in place upon the prepared substructure. When completed, all bolts shall be effectively tightened.

D. Elongation of Pipe.

All pipe shall be fabricated elliptically so as to increase the vertical diameter 5 percent and decrease the horizontal diameter 5 percent. These dimensions shall be subject to manufacturing tolerances.

E. Coating.

The entire outside surface and the inside bottom half of the pipes and the entire outside and inside of the bottom and corner plates of pipe arches shall be covered with a coat of bituminous material conforming to Subsection M7.04.01 of Division III, Materials.

When the structure is erected in the final location, the bottom of all plates that are to be in contact with the ground shall be coated and allowed to dry before they are placed in the structure.

For arches, the entire outside surface shall be covered with one coat of bituminous material as specified above. The metal bearing channel shall be filled with an approved asphalt filler to the level of the concrete after erection of the arch and before backfilling is started.

F. Backfilling.

Backfilling requirements shall conform to the provisions of Subsections 120.60B, 150.60 and 150.64.

G. Flared End Sections.

The unit shall be accurately aligned on a prepared bed on the existing ground, or if so directed by the Engineer, on compacted gravel fill.

COMPENSATION

230.80 Method of Measurement.

A. Pipes shall be measured in place and the quantity to be paid for shall be the length actually constructed as directed within the limits specified below.

For measurement purposes the end of pipe in closed structures shall be considered at the inside face of the wall and at masonry headwalls it shall be considered to be at the face of the headwall.

Pipe bends for ACCM pipe shall be in accordance with current Standard Construction Drawings and the length of pipe sections containing bends shall be measured along the centerline and paid for as straight sections of pipe.

Reinforced Concrete Pipe Flared Ends and Metal End Sections will be measured in place by the unit each, complete and approved.

Trench excavation in excess of 5 feet and rock excavation shall be measured as specified in Subsection 140.80 for Class B Trench Excavation and Class B Rock Excavation respectively.

B. Structural plate pipe or pipe arches shall be measured in place and the quantity to be paid for shall be the length actually constructed as directed and to the following limits:

For structural plate pipe the length shall be the average of the top and bottom center line length; for pipe arches, the bottom center line length; and for arches, the average of the springing line lengths.

Trench Excavation in excess of 5 feet and Rock Excavation for structural plate pipe, arches and pipe arches shall be measured in accordance with the relevant provisions of Subsection 140.80 for Class B Trench Excavation and Class B Rock Excavation.

230.81 Basis of Payments.

Pipe culverts, pipe drains and pipe sewers will be paid for at the contract unit price per lineal foot of the kind of pipe required, installed and complete in place.

Reinforced Concrete Pipe Flared Ends and Metal End Sections will be paid for at the contract unit price each for the size and kind of pipe end specified.

Trench excavation for pipe culverts, pipe drains, pipe sewers, structural plate pipe arches and pipe arches greater than a depth of 5 feet and rock excavation will be paid for as specified in Subsection 140.81 for Class B Trench Excavation and Class B Rock Excavation. No payment for trench excavation for pipes will be made within the limits of one foot outside the base section of catch basins, manholes or leaching basins.

Backfill for trenches 5 feet or less in depth for pipe culverts, pipe drains, structural plate pipe arches and pipe arches and pipe sewers shall be included in the various items of pipe. Backfill for that part of a trench which is more than 5 feet in depth shall be included in the item for Class B Trench Excavation. If the material for backfill is obtained from borrow it will be paid for at the contract unit price per cubic yard or ton of the kind of borrow required.

Masonry ends and foundations will be paid for at the contract unit price per cubic yard of the kind of masonry required.

Gravel Borrow will be paid in accordance with Subsection 150.80.

230.82 Payment Items.

*230.	Asphalt Coated Corrugated Metal Pipe...Gage	Linear Foot
*230.7—	—Inch Asphalt Coated Corrugated Metal Pipe Ends Sections...Gage	Each
*231.	Asphalt Coated Corrugated Metal Pipe (Aluminum)...Gage	Linear Foot
*231.6—	—Inch Asphalt Smooth Steel Linear Helically Corrugated Shell Metal Pipe ...Gage (of outer shell)	Linear Foot
*231.7—	—Inch Asphalt Coated Corrugated Metal Pipe (Aluminum) End Sections...Gage	Each
*232.	Asphalt Coated Corrugated Metal Pipe-Arch...Gage	Linear Foot
*233.	Cement Concrete Pipe	Linear Foot
*234.	Pipe-Option	Linear Foot
*235.	Clay Pipe	Linear Foot

*238.	Ductile Iron Pipe	Linear Foot
*239.	Structural Plate Pipe	Linear Foot
*240.	Structural Plate Pipe-Arch...Gage	Linear Foot
*241.— to *245.—	—Inch Reinforced Concrete Pipe	Linear Foot
*241.—1 to *245.—1	—Inch Reinforced Concrete Pipe. Flared End	Each
*255.—	Polymeric Precoated Corrugated Metal Pipe	Linear Foot
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
156.	Crushed Stone for Drainage Foundation	Ton
903.	3000 psi, 1½", 470-Cement Concrete Masonry	Cubic Yard
685.	Field Stone Masonry in Cement Mortar	Cubic Yard

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 258

STONE FOR PIPE ENDS

DESCRIPTION

258.20 General.

Stone for pipe ends shall consist of a protective covering of angular shaped stones laid on slopes in front of and around drainage ends to insure protection of the pipe ends and the embankment and shall conform to the Department Standard "Stone for Pipe Ends".

MATERIAL

258.40 General.

Stone for pipe ends shall comply with the provisions of Subsection M2.02.3.

CONSTRUCTION METHODS

258.60 General.

The stone shall be placed to line and grade as shown on the plans or as directed on a prepared bed of embankment material or existing materials. Each stone shall be carefully placed by hand, normal to the slope and firmly bedded thereon. The larger stones shall be placed directly at the drainage end to prevent erosion and displacement. Each stone shall weigh not less than 50 pounds nor more than 125 pounds and at least 75% of the volume shall consist of stones weighing not less than 75 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones, the entire mass will be compact with a minimum percentage of voids and minimum thickness of 6 inches.

COMPENSATION

258.80 Method of Measurement.

Stone for pipe ends will be measured in place by the square yard. No allowance will be made beyond the dimensions indicated or as directed.

258.81 Basis of Payment.

Payment for the above work will be at the contract unit price per square yard complete in place including all excavation, material and labor.

258.82 Payment Item.

258.	Stone for Pipe Ends	Square Yard

SECTION 259
CRUSHED STONE FOR BLEEDERS

DESCRIPTION

259.20 General.

The work under this item consists of constructing foundation drains, using crushed stone filter material, in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

259.40 General.

Crushed Stone shall comply with the provisions of Subsections M2.01.0 and M2.02.4.

CONSTRUCTION METHODS

259.60 General.

The trench for crushed stone bleeder shall be excavated to the specified line and grade. The width and the depth shall be as shown on the plans. The sides of the trench shall be vertical.

Crushed stone shall be placed and rough graded after the Special Borrow has been placed but before the subbase or surface course, except as otherwise directed.

COMPENSATION

259.80 Method of Measurement.

Measurement of the above work shall be the quantity of Crushed Stone actually used. The weight slips shall be countersigned on delivery by the Engineer, and no weight slip not so countersigned shall be included for payment.

259.81 Basis of Payment.

Payment for the above work shall be made at the contract unit price per ton for the quantity of crushed stone actually used, which shall include full compensation for the excavation and all other materials necessary to satisfactorily complete the work.

259.82 Payment Item.

259. Crushed Stone for Bleeders.	Ton

SECTION 260
SUBDRAINS

DESCRIPTION

260.20 General.

This work shall consist of constructing subdrains, using pipe and crushed stone filter material in accordance with the plans and these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

The kind of pipe to be used shall be as designated on the plans and in the Proposal under the item for the particular kind of subdrains required. If the item calls for a choice of pipe, Bidder shall insert his price for the kind of pipe he will supply in the proper space provided.

MATERIALS

260.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Perforated Asphalt Coated Corrugated Metal Pipe (Subdrain)	M5.03.1
Perforated Corrugated Metal Pipe (Subdrain)	M5.03.2
Perforated Corrugated Aluminum Pipe (Subdrain)	M5.03.5
Perforated Asphalt Coated Corrugated Aluminum Pipe	M5.03.4
Crushed Stone	M2.01.5
Slot-Perforated Corrugated Plastic Pipe	M5.03.9

CONSTRUCTION METHODS

260.60 Excavation. (See Subsection 140.60).

The drain trench shall be excavated to the depth designated on the plans or, if directed, to a stratum of impervious material.

Where no structure is to be placed at the ends of the subdrain pipe, the trench shall be excavated a distance of three feet beyond the end of the pipe.

The excavation shall proceed in advance of the actual drain construction only to the extent the Engineer directs. The width of the trench for pipe of more than 12 inches in diameter shall be 1 foot greater than the nominal diameter of the pipe. The width of the trench for pipe 12 inches or less in diameter shall be 2 feet.

Where rock is encountered in the excavation, no part of any rock remaining in the trench shall come within 6 inches of any portion of the pipe.

260.61 Laying Pipe.

Perforated subdrain pipe of the type specified shall normally be laid with the perforations located as shown on the Construction Standard Drawings; however the Engineer may direct that the perforations be located otherwise, if conditions warrant.

Joints shall be grouted or sealed unless otherwise specified on the plans or in the Special Provisons.

260.62 Filling Drain Trench.

The pipe shall be laid on a 2 inch bed of crushed stone and the space about, above, and in the 3 feet beyond the ends of the pipe shall be filled with 1/2 inch or 3/4 inch crushed stone.

The Contractor shall be responsible for keeping the backfill material clean and free of objectionable material from a line 1 inch below the flow line of the pipe to the top of the trench.

260.63 Protection of Inlets and Open Outlets.

Inlets and open outlets of subdrains shall be covered with a #23 gauge galvanized wire screen of 1/4 inch mesh satisfactorily fastened to the pipe.

COMPENSATION

260.80 Method of Measurement.

Subdrain pipe shall be measured in place and the quantity to be paid for shall be the length of pipe actually constructed, plus an allowance of three (3) feet for open ends.

Trench excavation greater than a depth of 5 feet and rock excavation shall be measured as specified in Subsection 140.80 for Class B Trench Excavation and Class B Rock Excavation respectively.

260.81 Basis of Payment.

The above work will be paid for at the contract unit price per linear foot under the appropriate item for Subdrains with the specified size and kind of pipe, complete in place.

Trench excavation greater than a depth of 5 feet and rock excavation will be paid for as specified in Subsection 140.81 for Class B Trench Excavation and Class B Rock Excavation.

260.82 Payment Items.

*261.	Perforated Corrugated Metal Pipe...Gage (Subdrains)	Linear Foot
*262.	Perforated Corrugated Aluminum Pipe...Gage (Subdrain)	Linear Foot
*263.	Perforated Asphalt Coated Corrugated Metal Pipe...Gage (Subdrain)	Linear Foot
*264.	Perforated Asphalt Coated Corrugated Aluminum Pipe...Gage (Subdrain)	Linear Foot
*265.	Pipe Subdrain—Option	Linear Foot
*269.	Slot-Perforated Corrugated Plastic Pipe (Subdrain)	Linear Foot
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic yard

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 270
PIPES REMOVED AND RELAID OR STACKED

DESCRIPTION

270.20 General.

This work shall consist of removing present pipes and relaying or stacking them in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

270.40 Material for Pipe Joints shall conform to the requirement of Subsection 230.40.

CONSTRUCTION METHODS

270.60 Removal of Pipe.

A trench of sufficient width and depth shall be excavated so that the present pipe can be removed without damage to the pipe. All joints shall then be opened and the pipe removed in its original sectional lengths.

Existing pipe in good condition which is damaged in removing or other handling due to carelessness of the Contractor, shall be replaced with new pipe at the Contractor's expense.

270.61 Relaying.

The construction methods for relaying the pipe in its final location shall conform to the requirements of Subsections 230.60 to 230.63 inclusive. In the case of corrugated metal pipe culverts, the Contractor shall furnish and place new collars and bolts, and repair the coating of the pipe as directed.

270.62 Stacking.

The Contractor shall accept and hold entire responsibility for the removal, handling, stacking at a location convenient for removal by the owner, and protection of all pipe until its final removal by others as designated and in accordance with the following:

Any pipe lost or damaged through lack of protection or carelessness by the Contractor shall be replaced with satisfactory pipe at his expense. The Contractor's responsibility will cease upon final acceptance of the work or 60 days from the time a certified notice, with copy to Engineer, is sent by Contractor to owner of material that all material is available for removal.

270.63 Backfilling Trenches.

The trench left by the removal of the pipes shall be backfilled in conformance with the relevant provisions of Subsection 150.64.

COMPENSATION

270.80 Method of Measurement.

Pipes removed and relaid as directed will be measured in place after being relaid and quantity to be paid for shall be the length actually relaid. Any remaining pipe not required to be stacked shall become the property of the Contractor and shall be removed from the work without additional compensation.

Pipes removed and stacked, as directed, will be measured as the actual length of pipe removed and stacked in good condition.

Trench excavation greater than a depth of 5 feet and rock excavation will be measured as specified in Subsection 140.80 for Class B Trench Excavation and Class B Rock Excavation, respectively.

270.81 Basis of Payment.

Pipes removed and relaid will be paid for at the contract unit price per linear foot of the kind of pipe required to be removed and relaid, installed and complete in place.

Pipes removed and stacked will be paid for at the contract unit price per linear foot of the kind of pipe required to be removed and stacked.

Masonry ends will be paid for at the contract unit price per cubic yard of the class of masonry required.

Trench excavation for both removing and relaying greater than a depth of 5 feet and rock excavation for relaying will be paid for as specified in Subsection 140.81 for Class B Trench Excavation and Class B Rock Excavation.

Backfill for trenches 5 feet or less in depth shall be included in the various items of pipe. Backfill for that part of a trench which is more than 5 feet in depth shall be included in the item for Class B Trench Excavation.

If borrow material is used for backfilling, it will be paid for at the contract price per cubic yard of the kind of borrow required.

270.82 Payment Items.

*270.	Pipe Removed and Relaid	Linear Foot
*271.	Pipe Removed and Stacked	Linear Foot
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard

151.	Gravel Borrow	Cubic Yard
156.	Crushed Stone for Drainage, Revetment and/or Water Works Foundation	Ton
903.	3000 psi, 1½", 470 Cement Concrete Masonry	Cubic Yard
685.	Field Stone Masonry in Cement Mortar	Cubic Yard

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 280
WATERWAYS

DESCRIPTION

280.20 General.

This work shall consist of the construction of waterways in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

280.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials.

Gravel Borrow	M1.03.0 Type b
Bituminous Concrete	M3.11.00
Cement Concrete	M4.02.00
Half Circle ACCM Pipe	M5.04.1
Preformed Expansion Joint Filler	M9.14.0
Welded Steel Wire Fabric	M8.01.2
Load Transfer Assembly	M8.14.0
Lubricant	M8.14.0

CONSTRUCTION METHODS

280.60 General.

A. Excavation (See Subsection 140.60).

B. Foundation. The gravel may be placed in one layer and compacted (See Subsection 401.60).

280.61 Bituminous Concrete Waterways.

Bituminous mixture shall be spread in 2 courses on the prepared gravel base and compacted by tamping or rolling.

280.62 Cement Concrete Paving (Waterways).

The cement concrete shall be mixed, placed, finished, protected and cured in conformity with requirements of Section 901, except that consolidation of the cement concrete in paved waterways may be accomplished by rodding, without vibration.

280.63 Half Circle ACCM Pipe.

Wooden stakes of the required dimensions shall be driven at the indicated locations and the pipe fastened thereto.

Backfill around the pipe shall be placed as required as specified under Subsection 150.64.

COMPENSATION

280.80 Method of Measurement.

The actual area of the exposed surfaces will be measured on paved waterways.

Half Circle ACCM Pipe shall be measured in place and quantity to be paid will be in linear feet from end to end of pipe.

280.81 Basis of Payment.

The paving of waterways, together with the construction of a gravel foundation, fine grading and compacting, will be paid for at the contract unit price per square yard, respectively, under the item for Bituminous Concrete or Cement Concrete Paving, complete in place.

Half Circle ACCM Pipe will paid for at the contract unit price per linear foot of the kind of pipe required, installed and complete in place.

Excavation (except rock) will be paid for at the contract unit price per cubic yard under the item for Class A Trench Excavation as specified in Subsection 140.81.

Rock Excavation will be paid for at the contract unit price per cubic yard under the item for Class B Rock Excavation if not already paid for under previous rock excavation.

280.82 Payment Items.

280.	Bituminous Concrete Waterway	Square Yard
281.	Cement Concrete Paving (Waterway)	Square Yard
*279.	Half-Circle ACCM Pipe (Waterway)	Linear Foot
141.	Class A Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between the sizes.

SECTION 300
WATER SYSTEMS

SECTION 301
WATER SYSTEMS

DESCRIPTION

301.20 General.

Work under this section shall consist of making alterations in existing municipal water main systems or constructing new sections of existing systems affected by highway and bridge construction. The work includes furnishing and installing new water pipe and appurtenances and removing and resetting existing materials in the same or new locations in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

301.21 Workmen.

All personnel employed by the Contractor on this work shall be experienced and skilled in water main installation.

301.22 Protection of Underground Structures.

All conduits, pipes or structures uncovered during excavation, whether or not they are shown on the plans, shall be protected, and if damaged by the Contractor shall be repaired by him or the utility company at the expense of the Contractor.

The Contractor shall not abandon existing conduits, pipes or structures without the prior approval of the Engineer.

301.23 Notices.

Prior written notice of at least 48 hours shall be given by the Contractor to affected Municipal Water and Fire Departments, with a copy of such notice submitted to the Engineer, before any water main is shut off and in no case shall a gate or hydrant be opened or shut without proper authorization.

MATERIALS

301.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Thrust Blocks	
Cement Concrete	M4.02.00
Water Pipe and Fittings	
Cast Iron for Water Systems	M5.05.1
Copper Tubing	M5.06.0
Ductile Iron Pipe and Fittings	M5.05.3
Insulation and Waterproof Jackets	M9.11.0
Cellular Glass	M9.11.1
Fiber Glass	M9.11.2
Expanded Polystyrene	M9.11.3
Urethane	M9.11.4
Jointing Materials for Pipes	M9.10.0
Waterproof Jackets	M9.11.5

Valve boxes, service boxes, corporation cocks, air relief valves, yokes and tie-rods, curb stops, plugs and any other materials which are required shall be the type used by the particular municipality involved or as specified in the Special Provisions. Air relief valves shall be installed at the high points of the main or where and as directed.

CONSTRUCTION METHODS

301.60 General.

The installation or removal and reinstallation of water systems or parts thereof shall conform to the following construction procedures:

A. Pipe Fittings, etc.

All pipe fittings, valves, hydrants and other heavy accessories shall be carefully handled by the use of hoists or skidways to avoid shock or damage. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground. The Contractor shall replace or repair, at his own expense, any materials that have been damaged due to his negligence.

Where pipes are required in less than standard lengths, the cutting shall be done in a neat and workmanlike manner without damage to the pipe.

B. Excavation.

See Subsection 140.60.

C. Bedding Pipe.

See Subsection 230.61.

D. Bridging.

Where required, the Contractor shall provide suitable bridges for traffic to cross open trenches at streets and driveways.

E. Cleaning and Plugging Pipe.

The pipes and fittings shall be thoroughly cleaned before being laid and shall be kept clean until accepted in the finished work. The ends of all uncompleted lines shall be tightly closed with temporary plugs at all times when the pipe laying is not in progress, and no trench water or debris shall be permitted to enter the pipe.

F. Removal of Castings.

In the work of removing hydrants and other castings to be reset, or stacked for the municipality, the castings shall be exposed, care being taken that they are not damaged by excavating or other machinery, the joints shall then be opened and the castings carefully removed.

Any materials damaged during this work due to the Contractor's negligence shall be replaced by the Contractor at his own expense.

G. Laying Pipe.

Proper tools and equipment for the safe and convenient handling and laying of the pipes shall be used. The Contractor shall exercise reasonable caution during his operations in order to avoid damaging the pipes, castings, or fittings and any which are damaged shall be replaced by him at his own expense.

The Contractor shall furnish the necessary pumps and tools to handle any water encountered in the pipe trench, and shall maintain the trench in a satisfactory condition, free from water, during the laying of the pipe. The pipe, after being laid in place, shall not under any circumstances be used as a drain pipe for the trench.

Cast iron pipe sections shall be laid with the bell on the upgrade end, unless otherwise directed. Before laying the pipe, the outside of the spigot and the inside of the bell shall be wire brushed and wiped clean and dry. When placing a length of pipe, the yarning material for the joint shall be held around the bottom of spigot so that it will enter the bell as the pipe is shoved into position.

H. Setting Gates and Hydrants.

Gates and gate boxes shall be set in the pipe lines as directed. Care shall be taken to see that the spigot ends are securely seated in the bell ends. Blocking or supports of a permanent nature shall be placed under each valve to insure against settlement. The blocking or permanent supports shall conform to Owner's Specifications. Each gate shall be tightly closed before being placed in the line and shall remain so until the joints on each side are completely made. Gate boxes shall be set for all gates. They shall be carefully fitted together and to the gate and securely held during backfilling. The earth around them shall be thoroughly tamped in place and the cover set to the finished grade.

New gate and service boxes, and existing gate and service boxes that are designated to be removed and reset or adjusted to line or grade, which are located in roadway pavement areas shall have concrete collars

constructed around them. The concrete collars shall conform to the details of design shown in the Department's Standards for Concrete Collars.

Hydrants shall be properly supported and held plumb while the joints are being made and during backfilling. One cubic foot of crushed stone or screened gravel stone shall be placed as directed to drain each hydrant drip. The hydrants shall be satisfactorily braced near the bottom of the stem.

I. Yarning.

The strands of yarn for cast iron bell-and-spigot joints shall be cut longer than the circumference of the pipe so that the ends will overlap a maximum of 2 inches.

The yarning material shall be thoroughly packed into the bell leaving a depth of not less than 2½ inches for the sealing compound. Loose or frayed ends shall be left to protrude into the space left for the compound.

J. Jointing.

For cast iron bell-and-spigot joints the melting furnace shall be kept reasonably close to the point where the joints are being made. The joint material shall be melted in a pot, the top or flange of which will fit snugly into a furnace, so designed that heat from a low fire will completely surround the bottom of the melting pot.

The melting pot, ladle and pouring pot shall be thoroughly cleaned before melting the joint material. No dirt or foreign material of any kind shall be allowed to enter the melting pot while in use.

The joint material shall be brought to such temperature that when stirred it will show a rapid change of color and when poured into the joint space will insure a perfect joint. Before pouring, all scum shall be removed from the molten material.

The joint space shall be free from all dirt, water, mud, oil, grease or other deleterious material before placing the joint runner.

The joint runner, soaked in water and rubbed with clay to prevent adherence to the molten joint material shall be placed snugly against the face of the bell and the outside of the pipe. The joint runner and the pouring gate shall be clayed to prevent the material from breaking out.

The molten material shall be poured slowly but continuously through the gate until the joint is completely filled to the top of the gate.

After cooling, the filled joints shall be caulked with pneumatic tools, or hand tools, until thoroughly compacted to form watertight joints without overstraining the bells.

K. Thrust Blocks and Pipe Anchors.

Reaction or thrust blocks of concrete shall be constructed at all tees, plugs, and bends as directed or as detailed on the drawings with 3,000 psi, 1½", 470 Cement Concrete Masonry. The blocks shall be poured against undisturbed original ground and shall be so placed that pipe joints will be accessible for any possible future repairs. Yokes and tie-rods shall be installed in addition to or in lieu of thrust blocks. Pipe anchors shall be used when and as directed.

L. Testing.

After completion, the trenches shall be partially backfilled leaving the joints exposed for examination, and the pipe line then subjected to a hydrostatic pressure of 50 percent above the normal operating pressure. The pipe shall be tested between points as designated by the Engineer by slowly filling the test section with water by means of a pump connected to the pipe but not before the pipe has been relieved of air through taps made where required. Any defects in the pipe or joints revealed by this pressure test shall be repaired or replaced and the pipe line again subjected to a hydrostatic pressure test as described above for possible leakage over the allowable limits. Pump, connections, gauges and a measuring device shall be furnished by the Contractor. The pressure test shall be maintained for at least 2 hours during which time all exposed joints, fittings, valves and hydrants will be carefully examined.

No pipe installation will be accepted until the leakage during a 2 hour test period measured by pumping at the specified test pressure from a calibrated container into the section of pipe being tested is less than that determined by the formula

$$L = \frac{ND\sqrt{P}}{1850}$$

L = Allowable Leakage in gallons per hour.
N = Number of joints.
D = Nominal pipe diameter in inches.
P = Average test pressure in pounds per square inch.

Any defective joints, and any defects in new pipe fittings, valves or hydrants revealed during the leakage

test or before final acceptance of the project shall be removed and replaced with other new material and again tested until the work is satisfactory, with no additional compensation.

M. Disinfection.

After the testing has been successfully completed, the water mains shall be disinfected in accordance with the AWWA Standard Procedure C601.

N. Adjusting Boxes

Gate boxes and service boxes shall be adjusted to required grades and shall be securely held during backfilling — See Subsection 301.60H.

O. Backfilling.

Subsection 150.64.

P. Installing Insulation and Jacket

1. General.

Where water pipe is installed or hung on structures, the insulating material shall be fiber glass, cellular glass, expanded polystyrene, or urethane. Section lengths and thickness shall depend on the pipe size and the recommendations of the insulation manufacturers. When urethane insulating material is used the total thickness shall be not less than 2 inches; when any other type of insulating material is used the total thickness shall be not less than 3 inches.

2. Construction Requirements.

a. Cellular glass pipe insulation for use on water pipes shall be applied as follows: Insulation shall cover all fittings, flanges and pipe clamps. The pipe shall be covered with the required thickness of cellular glass insulation of the premolded rigid type. It shall be molded and cut to conform to the size and shape of the pipe. All joints shall be tightly butted and sealed with adhesive as recommended by the manufacturer. The cellular glass insulation shall be applied to clean dry pipe surfaces and secured with 3/4″ x .015 stainless steel strapping spaced 9″ on center. After insulation is in place, a tack coat of fibrated adhesive mastic shall be applied at the rate of 2 gallons per 100 square feet. Into this, a layer of asphalt coated 20 x 20 mesh glass fabric overlapping all edges at least 3 inches shall be embedded. A second layer of the same fabric shall then be applied together with additional adhesive mastic to completely embed the layer of fabric. Finally, apply another coating of mastic at the rate of four gallons per 100 square feet. A weathrproof seal shall be provided at the ends of the insulation. Insulation covering flanges, fittings, and pipe clamps shall be cut to make a tight fit with the pipe insulation overlapping 3″ on each end.

b. Fiber glass insulation for use on water pipes shall be premolded with an integral vapor barrier jacket and applied as follows: The fiber glass insulation shall be applied to the clean, dry pipe surface. Adjoining sections shall be butted firmly together and taped. The tape shall be composed of a three-ply system consisting of 1 layer of creped kraft paper, 1 layer of aluminum foil and 1 layer of asphalt impregnated creped kraft paper. The three layers shall be tightly bonded together with an asphalt adhesive. The tape shall be applied so that it overlaps the butt joint a minimum of 2 inches on each side. The longitudinal seam of the vapor barrier shall be sealed with a suitable adhesive. All flanges, fittings and pipe clamps shall be insulated with cement applied to the same total thickness as the pipe insulation and covered with 1 inch galvanized wire netting stretched tightly over the surface and wired in place with 16 gage galvanized wire. A weather-proof jacket of .020 inch thick corrugated aluminum shall be placed over the insulation, all edges to lap a minimum of two inches. Longitudinal joints shall be placed in the most suitable direction for shedding water. An adhesive mastic cement shall be applied to all joints and seams, making them completely water tight. The aluminum jacket shall be secured with 3/4″ x .015 stainless steel strapping and stainless steel clips spaced 12 inches on center.

c. Expanded polystyrene or urethane insulation for use on water pipes shall be premolded and applied as follows: The polystyrene or urethane insulation shall be applied to clean dry pipe surfaces. All joints shall be tightly butted and sealed with a suitable polystyrene or urethane adhesive. The insulation shall be secured with 3/4″ x .015 stainless steel strapping and corrugated aluminum with integral vapor barrier shall be applied over the insulation, all edges to lap a minimum of two inches. Longitudinal joints shall be placed in the most suitable direction for shedding water. The jacket shall be secured with 3/4″ x .015 stainless steel strapping and stainless steel clips spaced 12 inches on center. A suitable adhesive that is compatible with polystyrene or urethane shall be applied to all joints and seams of the aluminum jacket making them completely watertight. All flanges, fittings and pipe clamps shall be covered with the same insulating material remolded and sized to make a tight fit with the pipe insulation and overlapping the pipe insulation three inches on each end. Prior to the application of the aluminum jacket all open ends of insulation covering flanges, fittings and pipe clamps shall be covered with a layer of 20 x 20 mesh, asphalt coated glass fabric embedded in suitable adhesive mastic cement.

COMPENSATION

301.80 Method of Measurement.

Water pipe will be measured in place along the axis of the pipe without deduction for the space occupied by valves, excluding however, the length occupied by new fittings. Where two pipes join, measurement will be made to the intersection of the axes, excluding the length occupied by new cast iron fittings.

Fittings, consisting of bends, tees, caps, wyes, sleeves, reducers, increasers, blow-off fittings and other specials, applies only when new materials are necessary and which are not specifically provided for under other items in the Proposal. Fittings other than new will not be paid separately but only under the applicable linear foot items. When new fittings are measured for payment under the pound price for Item 308, the length occupied by the fittings will not be measured for payment under the linear foot items.

The fittings (excluding accessories comprising of Rings, Gaskets, Bolts, Nuts, Washers and Clamps) will be measured by the pound and the quantity to be paid for shall be the weight stated on the invoice of the supplier or the manufacturer's rated weight as listed in the catalog whichever is the lesser.

For new special fittings not listed in the catalog the weight payable will be the invoice weight. The Contractor shall furnish a copy of the Manufacturer's catalog at the start of work. Concrete collars required for gate and service boxes shall be included in the contract unit price for the relevant gate and service box items.

Insulation will be measured by the linear foot under the applicable water pipe insulation item.

Trench excavation in excess of 5 feet in depth and rock excavation shall be measured as specified in Subsection 140.80 for Class B Trench Excavation and Class B Rock Excavation, respectively.

301.81 Basis of Payment.

Water system work will be paid for at the contract unit price under the respective items for the kind of work involved as set forth in the Proposal.

New yokes and tie-rods will be paid for at the contract unit price per pound under Item 308. Payment for fittings other than new will be paid for at the contract unit price per linear foot under the relevant pipe items.

The prices shall also include all excavation (except rock) to a maximum depth of 5 feet (as measured from the top of the trench to the bottom of the pipe barrel).

Trench excavation greater than 5 feet and rock excavation will be paid for a specified in Subsection 140.81 for Class B Trench Excavation and Class B Rock Excavation.

Backfill for trenches 5 feet or less in depth shall be included in the various items of pipe. Backfill for that part of a trench which is more than 5 feet in depth shall be included in the item for Class B Trench Excavation.

If the material for backfill is obtained from borrow, it will be paid for at the contract unit price per cubic yard of the kind of borrow required.

Payment for the restoration of surfaces over trenches shall be made at the contract unit price for the kind of materials used.

Thrust blocks, where required, will be paid for at the contract unit price per cubic yard under Item 903, 3000 psi, 1½", 470 Cement, Concrete Masonry.

Insulation will be paid for at the contract unit price per linear foot under Item 373. Water Pipe Insulation, complete in place.

301.82 Payment Items.

*300.	Cast Iron Water Pipe (Rubber Gasket)	Linear Foot
*302.	Ductile Iron Water Pipe (Rubber Gasket)	Linear Foot
*303.	Ductile Iron Water Pipe (Mechanical Joint)	Linear Foot
*304.	Cast Iron Water Pipe (Cement Lined)	Linear Foot
308	Cast Iron Fittings for Water Pipe	Pound
309.	Ductile Iron Fittings for Water Pipe	Pound
*313.	Cast Iron Water Main Removed and Relaid	Linear Foot
*315.	Cast Iron Water Main Removed and Stacked	Linear Foot
*347.	Copper Tubing Type K	Linear Foot
*349.	Gate Valve	Each
*350.	Gate and Gate Box	Each
*351.	Gate and Gate Box Removed and Reset	Each
*354.	Gate Box Removed and Reset	Each
*355.	Gate and Gate Box Removed and Stacked	Each

*357.	Gate Box	Each
358.	Gate Box Adjusted	Each
*363.	Corporation Cock	Each
*367.	Cast Iron Plug	Each
*373.	Water Pipe Insulation	Linear Foot
376.	Hydrant	Each
376.2	Hydrant Removed and Reset	Each
376.3	Hydrant Removed and Stacked	Each
381.	Service Box	Each
381.1	Service Box Removed and Reset	Each
381.2	Service Box Removed and Stacked	Each
381.3	Service Box Adjusted	Each
384.	Curb Stop	Each
384.1	Curb Stop Removed and Reset	Each
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard
150.	Ordinary Borrow	Cubic Yard
151.	Gravel Borrow	Cubic Yard
156.	Crushed Stone for Drainage.	
	Revetment or Water Work Foundations	Ton
903.	3000 psi, 1½", 470 Cement Concrete Masonry	Cubic Yard

*Pipe or appurtenance size will be included as part of the item number in order to differentiate between he sizes.

SECTION 400

SUB-BASE, BASE COURSES, SHOULDERS, PAVEMENTS, AND BERMS

SECTION 401
GRAVEL SUB-BASE

DESCRIPTION

401.20 General.

The gravel sub-base shall consist of approved gravel placed on the subgrade and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

401.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Gravel Borrow	M1.03.0, Type a or b

CONSTRUCTION METHODS

401.60 Gravel Sub-base.

The gravel shall be spread and compacted in layers not exceeding 8 inches in depth, compacted measurement, except the last layer of gravel Sub-base course (conforming to M1.03.0. Type b) will be 4″ in depth compacted measurement and all layers shall be compacted to not less than 95 percent of the maximum dry density of the material as determined by the Standard AASHTO Test Designation T99 compaction test Method C at optimum moisture content as determined by the Engineer. If the material retained on the #4 sieves is 50% or more of the total sample this test shall not apply and the material shall be compacted to the satisfaction of the Engineer. The specific density of the Gravel Sub-base shall be maintained by determining the number of passes of a roller required to produce a constant and uniform density, after conducting a series of tests either using the sand/volume or the nuclear device.

Any stone with a dimension greater than that permitted for the type of gravel specified shall be removed from the sub-base before the gravel is compacted. Compaction shall continue until the surface is even and true to the proposed lines and grades within a tolerance of 3/8 inch above or below the required cross sectional elevations and to a maximum irregularity not exceeding 3/8 inch under a 10 foot line longitudinally. In locations when the 8″ of gravel is used as a base for Item 405 this tolerance shall be 3/4″ under a 10′ line. Any specific area of gravel sub-base which, after being rolled, does not form a satisfactory, solid, stable foundation shall be removed, replaced and recompacted by the Contractor without extra compensation. The gravel foundation for cement concrete surfacing shall be conditioned in accordance with the provisions of Subsection 476.61.

COMPENSATION

401.80 Method of Measurement.

Gravel for sub-base shall be measured as specified in Subsection 150.80.

401.81 Basis of Payment.

Gravel for the sub-base will be paid for at the contract unit price per cubic yard for Gravel Borrow.

Payment for shaping and compacting of the sub-base as specified herein shall be included in the item of Gravel Borrow.

401.82 Payment Items.

151. Gravel Borrow	Cubic Yard

SECTION 402
DENSE GRADED CRUSHED STONE FOR SUB-BASE

DESCRIPTION

402.20 General.

Dense Graded Crushed Stone for Sub-base consist of crusher-run coarse aggregates of crushed stone or gravel and fine aggregates of natural sand or stone screenings uniformly pre-mixed and placed on the sub-grade or sub-base in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

402.40 General.

Material shall meet the requirements specified in the following Subsection of Division III, Materials:

Dense Graded Crushed Stone for Sub-base	M2.01.7

CONSTRUCTION METHODS

402.60 General.

Grade control survey shall conform to Subsection 5.07. The Contractor shall furnish, set, and maintain all line and grade stakes.

402.61 Spreading and Compacting.

The Dense Graded Crushed Stone shall be spread in layers from self spreading vehicles equipped with automated grade controlled equipment. Power graders or conventional self spreading vehicles may be used only with prior written approval of the Engineer. The Dense Graded Crushed Stone shall be placed to the tolerance as stipulated in Section 401, Gravel Sub-base. Suitable watering devices shall be available at the source of supply and on the project for use as directed by the Engineer to prevent segregation in transit and during spreading and to obtain proper density and stability of the mixture. The specified density of the Dense Graded Crushed Stone shall be maintained by determining the number of passes of a roller are required to produce a constant and uniform density, after conducting a series of tests either using the sand/volume method or the nuclear device.

COMPENSATION

402.80 Method of Measurement.

Dense Graded Crushed Stone shall be measured in place, to the limits specified on the plans or as directed by the Engineer, with no percentage added.

402.81 Basis of Payment.

Dense Graded Crushed Stone for sub-base will be paid for at the contract unit price per cubic yard complete in place.

402.82 Payment Items.

402. Dense Graded Crushed Stone for Sub-base — Cubic Yard

SECTION 403
RECLAIMED BASE COURSE

DESCRIPTION

403.20 General.

The work shall consist of scarifying and pulverizing the inplace asphalt pavement and underlying material, mixing and/or blending the material and spreading and compacting the resultant mixture to the lines and grades shown on the plans or established by the Engineer.

MATERIALS

403.40 General.

All scarified and pulverized material shall pass the 3-inch sieve. Material for blending shall conform to the following requirements:

Gravel Borrow, Type b. — M1.03.0.

CONSTRUCTION METHODS

403.60 General.

Prior to scarifying and pulverizing the existing pavement, the Contractor shall locate and protect existing drainage and utility structures and underground pipes, culverts, conduits and other appurtenances. If the upper sections of utilities are removed to facilitate scarifying and pulverizing the existing pavement, the remaining part of the structure shall be immediately covered with a steel plate capable of withstanding a 36.5 ton truck-load with impact.

The Contractor shall submit to the Engineer for approval a description of equipment and the process to be used for scarifying and pulverizing the existing pavement. The pulverizing operation shall be controlled in such a manner that the resultant material will be free from excessive fine material (material passing the No. 200 sieve). The Engineer will determine the acceptable level of fine material.

The bituminous pavement and underlying material shall be scarified to depths shown on the plans or established by the Engineer and pulverized and mixed to produce a consistent homogeneous material, 100 percent passing the 3-inch sieve and without an excess of material passing the No. 200 sieve. If the Engineer directs, Gravel Borrow (Type b) shall be blended with the pulverized material in quantities to be established by the Engineer to produce a uniform blend suitable for use as base course.

Unsuitable material in the subgrade shall be removed to the lines and depths established by the Engineer and replaced with Gravel Borrow conforming to the requirements of Subsection M1.03.0, Type b.

The mixed and/or blended base course material shall be spread and compacted in accordance with the requirements of Subsection 402.61, to the widths, depths and crowns shown on the plans or established by the Engineer.

COMPENSATION

403.80 Method of Measurement.

Reclaimed Base Course shall be measured in place to the limits specified on the plans or as directed by the Engineer. No deductions shall be made for manhole covers, grates or other surface structures.

403.81 Basis of Payment.

The unit price per square yard is for Reclaimed Base Course, complete-in-place including scarifying, pulverizing and mixing the existing pavement, blending with Gravel Borrow, and spreading and compacting the blended material. It shall also include cost of labor, tools, equipment, materials (except as noted herein) and all other work necessary to satisfactorily complete the work.

The unit price per square yard for Reclaimed Base Course shall also include the restoration of all drainage and utility structures to the top of the base course (the surface upon which the bituminous concrete top and binder courses are to be placed).

Removal of unsuitable material in the subgrade shall be paid for at the unit price for Item 120.1, Unclassified Excavation.

Gravel borrow for blending with the pulverized in-place material and gravel borrow for replacing excavated unsuitable material shall be paid for at the unit price for Item 151, Gravel Borrow.

Grading and compacting the subgrade shall be paid for at the unit Price for Item 170, Fine Grading and Compacting Subgrade Areas.

403.82 Payment Items.

403.0	Reclaimed Base Course	Square Yard
120.1	Unclassified Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
170.	Fine Grading and Compacting-Subgrade Areas	Square Yard

SECTION 405
GRAVEL BASE COURSE

DESCRIPTION

405.20 General.

Gravel base course shall consist of approved gravel placed upon the subgrade or sub-base as directed and in accordance with these specifications and in reasonable close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

405.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Gravel Borrow	M1.03.0 Type b

CONSTRUCTION METHODS

405.60 Spreading and Compacting.

The gravel shall be spread in layers upon the prepared sub-base or subgrade from self-spreading vehicles or with power graders of approved types or by hand methods. Gravel shall be spread in layers not more than 4 inches thick, compacted measure. The gravel shall be compacted and placed to the tolerance as stipulated in Section 401, Gravel Sub-base.

COMPENSATION

405.80 Method of Measurement.

Gravel used for base course will be measured as specified in Subsection 150.80.

405.81 Basis of Payment.

Gravel for base course will be paid for at the contract unit price per cubic yard of Gravel for Base Course, complete in place.

405.82 Payment Items.

405. Gravel for Base Course	Cubic Yard

SECTION 420
CLASS I BITUMINOUS CONCRETE BASE COURSE, TYPE I-1

DESCRIPTION

420.20 General.

This type of base course shall be composed of mineral aggregate, mineral filler and bituminous material. The base course shall be constructed in one or more courses as shown on the plans and as directed on the prepared or existing sub-base in accordance with these specifications and in close conformity with the lines, grades, compacted thickness, and typical cross section shown on the plans.

The Engineer may require the Contractor to remove and replace at his own expense, any defective mix not conforming to the specified job mix formula within the stipulated tolerances; on the basis of the Department testing. Samples of the actual mixture in use will be taken as many times daily as necessary and the mixtures shall be maintained uniform for the project as specified herein. The Engineer may suspend further approval for use of the Plant mixtures in Department work if the mixtures are not uniformly furnished as specified; until any necessary changes have been made so that the mixtures do conform to the specified requirements.

420.21 Composition and Compaction Acceptance Tests.

Where plant inspection is maintained, the material will be considered acceptable for use when the specified tests from samples obtained at the production plant indicate conformance to M3.11.09.

Pavement density shall be determined as outlined in M3.11.09.

The bituminous mixture and the labor for obtaining these samples in the field shall be furnished without charge by the Contractor. The samples shall be taken in accordance with AASHTO T230.

MATERIALS

420.40 General.

Material shall meet the requirements specified in Section M3.11.00 of Division III, Materials, and the following Subsections:

Mineral Aggregate	M3.11.04
Mineral Filler	M3.11.05
Bituminous Materials	M3.11.06

Composition of Base Course Mixture (see Table "A"), M3.11.02.

CONSTRUCTION METHODS

420.60 General.

The bituminous concrete base course shall be constructed in accordance with relevant provisions of Section 460 for Class 1 Bituminous Concrete Pavement, Type I-1.

The equipment for spreading and finishing shall be mechanical, self-powered pavers, capable of

spreading and finishing the mixture true to line, grade, width, and crown by means of fully automated controls for both longitudinal and transverse slope. The use of any other type of equipment for spreading and finishing shall require the prior written approval of the Engineer.

COMPENSATION

420.80 Method of Measurement.

Bituminous concrete shall be measured by the ton and shall be the actual and verified tonnage, complete in place and approved. The quantity shall be determined only by weight slips that have been properly countersigned by the Engineer at the time of delivery.

Bitumen used for prime coat, if required by plans or specifications or ordered by the Engineer, will be measured as specified in Subsection 468.80.

420.81 Basis of Payment.

The tonnage of bituminous concrete, determined as provided above, will be paid for at the contract unit price per ton of the kind of bituminous concrete required, complete in place.

Bitumen as specified herein to be paid for as prime coat, if required, will be paid for at the contract unit price per gallon under the item for Bitumen for Prime Coat, complete in place.

480.82 Payment Items.

420.	Class I Bituminous Concrete Base Course, Type I-1	Ton
463.	Bitumen for Prime Coat	Gallon

SECTION 430
CEMENT CONCRETE BASE COURSE

DESCRIPTION

430.20 General.

Cement concrete base course shall be constructed in one course on the prepared sub-base in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

430.40 General

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

*3,000 psi, 1½", 470 Cement Concrete	M4.02.00
Preformed Joint Filler	M9.14.0
Hot Poured Joint Sealer	M3.05.0

*The concrete shall have a slump of 2 inches with a tolerance of plus or minus 1/2 inch.

CONSTRUCTION METHODS

430.60 General.

The cement concrete base course may be constructed by the Slip-Form Method or the Fixed-Form Method.

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition.

Grade control survey and staking shall conform to Subsection 5.07. The Contractor shall furnish, set, and maintain all line and grade stakes for grading and paving.

430.61 Side Forms.

The forms where required shall be an approved wood or metal type, of a width equal to the depth of the concrete, true to line, free from warp and of sufficient strength, when staked, to resist the pressure of the concrete without springing and so designed that the various sections may be fastened together in such a manner as to prevent the vertical or horizontal movement of the ends.

The forms shall be jointed neatly and tight, shall be set true to line and grade, well staked and braced, and shall have uniform bearing on the sub-base through their entire length. In general the setting of forms shall proceed at least 500 feet in advance of the mixing and placing of concrete. The forms shall be thoroughly cleaned before any concrete is placed against them and shall be made tight to prevent the leaking of mortar from the concrete.

430.62 Fine Grading.

The fine grading of the foundation shall conform to Subsection 476.61.

460.63 Joints.

The Contractor shall construct weakened plane transverse contraction joints in the concrete base course every 30 to 50 feet or as shown on the plans. These joints shall consist of surface slots constructed in accordance with the requirements of Subsection 476.68C for transverse contraction joints.

Expansion joints shall be formed about all structures and features projecting through or into the pavement and between the pavement slab and adjacent curbing. Unless otherwise indicated, such joints shall be 1/2 inch in width and shall be filled with preformed joint filler as specified in Subsection M8.14.0 and sealed with joint filler compound as specified in Subsection M3.05.0 in the same manner as specified for transverse expansion joints in Subsection 476.68B. There will be no additional compensation for joints.

430.64 Placing Concrete.

Concrete shall be placed on a moist, firm and smooth sub-base in accordance with the requirements of Subsection 476.64 except that it shall be placed in one layer.

430.65 Finishing Concrete.

The surface of the concrete shall be struck off with a template shaped so as to leave the concrete with a smooth, even contour surface and crown as shown on the plans and in the typical cross section. The template shall be so constructed that it shall have sufficient strength to retain its shape under all working conditions. This template shall be moved with a longitudinal and crosswise motion and always in the direction in which the work is progressing. The surface of the concrete shall be finished to the elevations, contours and crowns required with a tolerance allowance of 1/4 inch in 10 feet.

The surface of the concrete shall be made free of footprints, ruts, depressions or other imperfections and shall then be lightly broomed, as directed, with approved stable or wire brooms.

430.66 Protection and Curing.

The pavement shall be protected and cured as required in Subsection 476.71 except that membrane compounds not compatible with bituminous materials shall not be used.

COMPENSATION

430.80 Method of Measurement.

Cement concrete base course will be measured in place by the square yard conforming to the length, width and depth required by the plans or as directed. The Contractor shall have no claim for extra payment if thickness of pavement exceeds that shown on the plans or as directed.

430.81 Basis of Payment

Standard cement concrete base course will be paid for at the contract unit price per square yard under the item for Cement Concrete Base Course.

High early strength concrete base course will be paid for at the contract unit price per square yard under the item for High Early Strength Cement Concrete Base Course.

The price paid per square yard shall also include all sprinkling or treating the roadway to keep down dust.

480.82 Payment Items.

430.	Cement Concrete Base Course	Square Yard
431.	High Early Strength Cement Concrete Base Course	Square Yard

SECTION 440
ROADWAY DUST CONTROL

DESCRIPTION

440.20 General.

This work shall consist of furnishing and applying approved dust control material to the surface of the subgrade or elsewhere as directed in accordance with these specifications.

MATERIALS

440.40 Materials.

The material for this work shall be of the kind shown on the plans and shall meet the requirements of the following Subsections of Division III, Materials.

Sand	M1.04.0, Type a
Calcium Chloride	M9.01.0
Bituminous Material	
Cut-back Asphalt	M3.02.0
Asphalt Emulsion	M3.03.0

CONSTRUCTION METHODS

440.60 General.

The required material shall be properly applied where directed by the Engineer and distributed uniformly at the rate specified or ordered.The means of distribution shall depend upon the kind of material used, and the method and equipment used shall be satisfactory to the Engineer. The number and frequency of applications shall be as determined by the Engineer.

440.61 Treatment with Calcium Chloride.

Calcium chloride shall be uniformly applied at the rate of 1 ½ pounds per square yard or at any other rate as directed by means of a mechanical spreader, or other approved methods.

440.62 Treatment with Bitumen.

Bituminous material shall be applied by means of an approved pressure distributor of a type that will distribute the material uniformly under a pressure of not less than 30 pounds per square inch without streaks or spots. it shall be so designed as to enable its operator to "cut out" any portion of the roadway, to control the flow, and to avoid any surplus deposit of the material on the roadway or elsewhere. The bitumen shall be applied at the rate specified on the plans or as directed by the Engineer.

440.63 Sand Cover.

When and if directed by the Engineer, the bitumen shall be covered with a sufficient quantity of sand to absorb all surplus bitumen.

440.64 Treatment with Water.

Water shall be applied at locations at such times, and in the amount as directed by the Engineer. Quantities of water wasted or applied without authorization will not be paid for.

Watering equipment shall consist of pipelines, tanks, tank trucks, or other devices, approved by the Engineer, which are capable of applying a uniform spread of water over the surface. A suitable device for a positive shut-off and for regulating the flow of water shall be located so as to permit positive operator control.

COMPENSATION

440.80 Method of Measurement.

Calcium chloride will be measured by the pound.

Bituminous material will be measured by volume in gallons in accordance with the provisions of Section 468.

Sand will be measured by the cubic yard by load measurement. The quantity shall be the volume of the load, as measured, divided by 1.15.

Water will be measured for payment by the number of M gallons (1000 gallons). The water will be measured in tanks or tank trucks of predetermined capacity, or by means of satisfactorily installed meters. Any and all measuring devices shall be furnished by the Contractor.

440.81 Basis of Payment.

Calcium chloride will be paid for at the contract unit price per pound under the item for Calcium Chloride for Roadway Dust Control, complete in place.

Bituminous material will be paid for at the contract unit price per gallon of Bitumen for Roadway Dust Control, complete in place.

Sand will be paid for at the contract unit price per cubic yard under the item for Sand Borrow (Cover), complete in place as specified.

Water will be paid for at the contract price per "M" gallons for Water for Roadway Dust Control which price shall include all water, labor, tools and equipment required to furnish and measure the water applied to surfaces designated by the Engineer and at the times specified.

440.82 Payment Items.

440.	Calcium Chloride for Roadway Dust Control	Pound
441.	Bitumen for Roadway Dust Control	Gallon
443.	Water for Roadway Dust Control	M. Gallons
154.1	Sand Borrow (Cover)	Cubic Yard

SECTION 445
SHOULDERS

DESCRIPTION

445.20 General.

Shoulders shall be constructed of approved materials in accordance with these specifications and in conformity with the lines, grades and typical cross sections shown on the plans.

Shoulders shall be composed of excavated material or borrow of the kind required or as shown on the plan.

Where shown on the plans, the top portions of shoulders shall be paved with surfacing material of the kind specified.

MATERIALS

445.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials.

Ordinary Borrow	M1.01.0
Gravel Borrow	M1.03.0, Type c
Loam Borrow	M1.05.0
Sodding (Field)	M6.05.0
Seed	M6.03.0

445.41 Surfacing Materials.

The surfacing materials for paving the top portion of shoulders shall conform to the requirements of the particular sections of these specifications relating to the kind of pavement or surfacing required.

CONSTRUCTION METHODS

445.60 General.

The subgrade for shoulders, if required, shall be prepared as required in Section 170 (Subgrade).

Portions of the shoulders, of sufficient width to hold the pavement in its proper place, shall be built in conjunction with the pavement and shall be rolled to a width of at least 12 inches with each rolling of the roadway base course or surface course.

Whenever the plan shows that sodding, loaming, paving or other similar work affecting shoulder construction adjacent to the roadway pavement is required, the Contractor will be required to construct temporary shoulders of suitable material to support the roadway pavement adequately during rolling operations. After the pavement is constructed, the temporary shoulders shall be carefully removed and satisfactorily disposed of by the Contractor prior to construction of the permanent shoulders.

Where necessary, temporary shoulders shall be constructed in conjunction with the construction of paved shoulders in the same manner as prescribed above for roadway pavement.

When shoulders are to be loamed and seeded, the construction method shall be as specified in Section 765 for such work.

Sodding of shoulders shall be done in conformity with the requirements of Section 770 for Field Sodding.

Ordinary borrow, gravel borrow and loam shall be furnished, placed and rolled in accordance with the requirements of Section 150 and as specified herein.

Paving of shoulders shall be done in the manner specified in the particular section of these specifications relating to the kind of pavement or surfacing to be used in this work.

At all times construction shall be so carried on that effective and adequate drainage will be provided.

The full widths of all shoulders except paved or sodded areas shall be reformed, trimmed, raked and rolled before the final completion of the work and the surface when finished shall conform to the proposed grade and cross section.

COMPENSATION

445.80 Method of Measurement.

All borrow materials for shoulders will be measured by the cubic yard in accordance with the provision of Subsection 150.80.

Surfacing materials for paving shoulders will be measured as specified in the particular section for the kind of pavement required.

Sodding will be measured by the square yard as specified in Subsection 770.80.

445.81 Basis of Payment.

Payment for grading of shoulders composed of material obtained from excavation will be included in the price paid for removal and disposal of the type of excavation used.

When composed of borrow, shoulders will be paid for at the contract unit price per cubic yard of borrow, of the kind required as specified in Subsection 150.81.

Compensation for the removal and disposal of temporary shoulder material will be included in the contract unit price under the item for the kind of material used in the roadway pavement or permanent shoulder.

When shoulders are paved with surfacing materials, such materials will be paid for at the contract unit prices for the kinds of materials used in the pavement as specified in the particular section relating to the kind of pavement or surface ordered.

When sodding is used on shoulders, it will be paid for at the contract unit price per square yard under Item for Field Sodding, complete in place, as specified in Subsection 770.81.

The fine-grading and rolling of the subgrade upon which shoulders are constructed will be paid for at the contract unit price per square yard under Item 170. Fine Grading and Compacting (In Subgrade Areas).

SECTION 460
CLASS I BITUMINOUS CONCRETE PAVEMENT
TYPE I-1

DESCRIPTION

460.20 General.

This type of pavement shall be composed of mineral aggregate, mineral filler and bituminous material. The pavement shall be constructed in courses as shown on the plans and as directed on the prepared or existing base in accordance with these specifications and in close conformity with the lines, grades, compacted thickness and typical cross section shown on the plans.

460.21 Composition and Compaction Acceptance Tests.

Where plant inspection is maintained, the material will be considered acceptable for use when the specified tests from samples obtained at the production plant indicate conformance to M3.11.09.

The densities of the completed pavement shall not be less than 95% of the density obtained from Laboratory compaction of a mixture composed of the same materials in like proportions. Laboratory compaction will be performed by Department Standard Methods as outlined in M3.11.00.

The bituminous mixture and the labor for obtaining these samples in the field shall be furnished without charge by the Contractor. The samples shall be taken in accordance with AASHTO T230.

MATERIALS

460.40 General.

Materials shall meet the requirements in the following Subsection of Division III, Materials:

Mineral Aggregate	M3.11.04
Mineral Filler	M3.11.05
Bituminous Materials	M3.11.06

CONSTRUCTION METHODS

460.60 General.

The Engineer may require the Contractor to remove and replace at his own expense, any defective mix not conforming to the specified job mix formula within the stipulated tolerances; on the basis of the Department testing. Samples of the actual mixture in use will be taken as many times daily as necessary and the mixtures shall be maintained uniform for the project as specified herein. The Engineer may suspend further approval for use of the Plant mixtures in Department work if the mixtures are not uniformly furnished as specified; until any necessary changes have been made so that the mixtures do conform to the specified requirements.

If, at any time before the final acceptance of the work, any soft, imperfect places or spots shall develop

in the surface all such places shall be removed and replaced with new materials and then compacted until the edges at which the new work connects with the old become invisible.

Grade control survey shall conform to Subsection 5.07. The Contractor shall furnish, set, and maintain all line and grade stakes necessary to guide the automated grade control equipment. Where required these control stakes shall be maintained by the Contractor and used throughout the operations, from the grading of the subbase material up to and including the final layers of the pavement.

With prior approval of the Engineer and with no increase in cost, a plant may substitute a limited amount (up to 1000 tons per project) of binder mix for black base. The substitution will be only within the station limits, locations, depths and tonnage as permitted by the Engineer.

The Contractor will supply an approved DIAL TYPE ASPHALT THERMOMETER (Range of 50 °F to 500 °F) for each paving machine in operation on the project. The thermometers will remain the property of the Contractor upon completion of the project.

Under normal conditions, where more than one course of bituminous concrete is to be constructed, the use of the stringline for grade control may be eliminated or discontinued after the construction of the initial layer of bituminous concrete. For resurfacing projects, where only one course of bituminous concrete is to be constructed, the use of the stringline for grade control may be eliminated. The use of an approved "ski" may then be substituted for the stringline where lines and grades are found to be satisfactory by the Engineer.

On each contract specifying 5,000 tons of pavement or more, the Contractor shall submit for approval a schedule of proposed paving and compaction equipment. The schedule shall project approximate daily production for the "paving train" and provide sufficient data for proper evaluation of paving and compaction procedures.

460.61 Transportation and Delivery of Mixtures.

The mixtures shall be transported from the plant to the work in vehicles previously cleaned of all foreign materials. During transportation of the mixture from the plant to the spreader on the work, each load shall be fully covered at all times, without exception, with canvas or other suitable material of sufficient size and thickness to furnish complete protection. The mixture shall not be transported such a distance that segregation of the ingredients takes place or that any crust is formed on the surface, bottom or sides of said mixture which will not crumble or flatten out when the mixture is dumped or shall otherwise be deleterious to the mixture in place on the roadway.

The vehicles for transporting the mixture shall be tight and inside of the bodies shall be evenly and lightly coated with a suitable thin oil or approved soap solution, but no excess of lubricant shall be allowed to accumulate in low spots in the body.

When necessary, proper insulation of the vehicles transporting the mixture shall be made to insure that the mixture is delivered for placing at the proper temperature.

The dispatching of trucks from the plant shall be so arranged that all material which is to be delivered at or on the road surface during any day may be placed and shall have received final compaction before nightfall of the same day; unless artificial light, satisfactory to the Engineer is provided.

The temperature of the mixture, within a tolerance of plus or minus 15°, when delivered at the project site will be governed by the temperature of the base upon which the mix is placed as follows:

Base Temp °F On Which Mix is Placed	MAT THICKNESS					
	1/2″	3/4″	1″	1½″	2″	3″ or Greater
35-40				305	295	280
40-50			310	300	285	275
50-60		310	300	295	280	270
60-70	310	300	290	285	275	265
70-80	300	290	285	280	270	265
80-90	290	280	275	270	265	260
90+	290	275	270	265	260	255

460.62 Tack Coat.

When it is required that the existing hardened surface shall be utilized as a base for the new pavement, a tack coat of bituminous material of the kind and grade shown on the plans shall be uniformly applied by

mechanical means to the present surface, at the rate of application of either 1/20 gal/s.y. or that and by the method indicated on the plans or as directed by the Engineer, immediately prior to laying the bottom course of the new pavement.

When and if the surface is in a condition which in the Engineer's judgment, is unsatisfactory for the direct placement of the surface course; it shall be sprayed as specified above with tack coat in the amount and by the method directed by the Engineer.

When a tack coat is required and its need is found to be the direct fault of the Contractor the surface shall be treated with a tack coat as directed by the Engineer and the entire cost for such treatment shall be entirely borne by the Contractor.

The existing surface shall be cleaned of all foreign matter and loose material and shall be dry before the tack coat is placed.

460.63 Spreading and Finishing.

The equipment for spreading and finishing shall be mechanical, self powered pavers, capable of spreading and finishing the mixture true to line, grade, width, and crown by means of fully automated controls for both longitudinal and transverse slope.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly in front of adjustable screeds. They shall be equipped with a quick and efficient steering device and shall have reverse as well as forward traveling speeds.

The pavers shall employ mechanical devices such as equalizing runners, straight edge runners, evener arms or other compensating devices to adjust the grade and confine the edges of the mixture to true lines. They shall be capable of spreading the mixture without segregation is layers to the depths and widths required. They shall be equipped with automatic joint matching attachment for use on adjacent mat or curb; automatic grade and slope control with a floating beam mobile reference system with minimum length of beam ("ski") of thirty feet for averaging longitudinal errors in the grade over which paving is being performed. The joint matching attachment and floating beam mobile reference system shall be employed on all paving courses unless otherwise directed by the Engineer.

When extensions are added to the paver, they shall be provided with the same vibrating screed or tamper action as the main unit of the paver, except for paving variable width areas. The extensions shall also be equipped with a continuation of the automatically controlled spreading augers. The screed and any extensions shall be provided with an approved method of heat distribution.

The screed shall be adjustable for profile and shall have an indicating level attached.

An approved device will be required for heating the screed to the temperature required for the laying of the mixtures without pulling or marring.

The term "screed" includes any "strike-off" device operated by cutting, crowding, or other practicable action, which is effective on the mixtures at permissible workable temperatures without tearing, shoving, or gouging and which produces a finished surface of the evenness and texture required.

The pavers employed on projects requiring in excess of 15,000 tons shall be capable of operating by the use of a sensing grid for operation to a stringline and matching shoe for joints.

The pavers shall operate while bituminous mixture is being spread at a speed which will produce a uniform surface texture free of any rippling or unevenness.

The paver employed on deep lift construction shall be capable of satisfactorily feeding the mix without intermittent stopping during the discharge of the mix from the trucks into the paving machine.

If during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas or produces other permanent blemishes in the pavement which are not satisfactorily corrected by the scheduled operations: the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

The mixtures shall be placed and compacted only at such times as to permit the proper inspection and checking by the Engineer.

The mixtures shall only be placed in the work when they can be efficiently and satisfactorily placed by the methods stipulated herein. Unless otherwise permitted by the Engineer for special particular conditions, only machine methods of placing shall be used.

The construction of bituminous concrete pavement shall terminate November 15 and shall not be resumed prior to April 1 except as determined and directed in writing by the Engineer depending upon the necessity and emergency of attendant conditions: weather conditions, and location of the project.

When the air temperature falls below 50 °F, extra precautions shall be taken in drying the aggregates, controlling the temperatures of the materials, placing, and compacting the mixtures.

No mixture shall be placed unless the breakdown and intermediate rolling can be completed by the time the material has cooled to 170 °F, and provided that the density of the completed pavement attains at least 95% of the laboratory compacted density.

The mixtures shall be placed only upon approved surfaces that are clean from foreign materials and dry; and when weather conditions are suitable. The Engineer may however, at the entire responsibility of the Contractor, permit work to continue when overtaken by sudden rain, but only with material which may be in transit from the plant at the time, and then only when the temperature of the mixture is within the temperature limits specified and the existing surface on the roadway is not excessively wet.

A tack coat shall be applied where required as per Subsection 460.62.

The bituminous concrete shall be placed in courses as shown on the plans, as specified and as directed by the Engineer.

When an existing surface or new base upon which the bottom course is to be placed contains unsatisfactory irregularities, in the Engineer's judgment, such irregularities shall be eliminated by an adequate placing and compaction of mixture so as to furnish a surface with true contour and grade before placing any specified course of mixture.

The contact surfaces of bridge curbings, manholes, catch basins or other appurtenant structures in pavement shall be painted thoroughly with a thin uniform coating of bitumen (Specification RS-1) just before any mixture is placed against them.

Special attention shall be given to proper testing of the surface of each course with a straightedge. The finished surfaces shall be even and uniform throughout. (See Subsection 460.67 for "Testing Surfaces").

Any mixture which becomes loose or broken, mixed with dirt, or in any way defective shall be removed and replaced with new mixture which shall be compacted to conform with the surrounding area. Areas of one square foot or more showing an excess of bitumen shall be removed and replaced.

The methods of spreading the bituminous concrete mixtures shall be as follows:

A. Machine Spreading.

All mixtures shall be deposited in an approved mechanical spreader and immediately spread thereby; and then struck off in a uniform layer to the full width required and of such depth that each course, when compacted, shall have the required thickness and shall conform to the grade and cross section contour specified.

The mixture shall be deposited in the center of the hoppers and care exercised to avoid overloading and spilling. The pavers shall operate, while the mixture is being spread, at a speed which will produce a uniform surface texture.

Immediately after any course is screeded and before roller compaction is started, the surface shall be checked, any irregularities adjusted, any accumulation from the screed removed by rake or lute, and all fat spots in any course removed and replaced with satisfactory material. Irregularities in alignment and grade along outside edges shall be corrected by the addition or removal of mixture before the edges are rolled. Indiscriminate casting of mix on the new screeded surface, where irregularities are not evident, shall not be permitted.

All edges shall be true and uniform.

B. Hand Spreading.

Spreading by hand methods will be permitted only for particular locations in the work which because of irregularity, inaccessibility or other unavoidable obstacles do not allow mechanical spreading and finishing.

460.64 Compaction.

After the paving mixture has been properly spread, initial compaction shall be obtained by the use of power rollers of approved design and weight per inch width of roller. The rollers shall be steel wheeled supplemented with pneumatic-tired rollers where required, or where permitted by the specifications, vibratory rollers.

Steel wheel rollers for initial and intermediate rolling shall have a weight of not less than 240 pounds per inch width of tread.

Pneumatic-tired rollers, when conditions warrant, shall be provided with devices capable of varying tire pressures. When the mixture being spread by each paver requires more than the minimum number of steel wheel rollers, at least one (1) of the additional rollers for each paver shall be a pneumatic-tired roller, except where the use of a vibratory roller is permitted. When using a pneumatic-tired roller, care shall be taken in that initial rolling by the steel wheel roller be restricted to one pass where upon the pneumatic-tired roller shall immediately follow the initial steel wheel rolling.

Vibratory rollers may be used on base, binder and surface courses subject to the conditions set forth herein. Vibratory rollers to be used may be of the single drum type with pneumatic tired drive wheels or the double steel drum type with vibratory mechanism in one or both drums. All vibratory rollers shall have a static weight

of at least eight tons and shall be equipped with an automatic disconnect device to disconnect the vibratory mechanism when the roller is not in motion. They shall also be equipped with a manual over-ride device to disconnect the vibratory mechanism if the automatic device should fail.

All vibratory rollers shall also be equipped with the following equipment: a large and clearly visible speed indicator; an amplitude setting indicator and a frequency setting indicator. They shall also have instructional plates attached which shall include operational instructions and recommended amplitude and frequency settings. A vibratory tachometer shall also be provided with each roller for use by the Engineer.

Vibratory rollers shall not be used on bridges or other structures and their use in urban areas may be restricted. They shall not be used on thin overlays one (1") or less in thickness, except that vibratory rollers of the double drum type may be used in a static condition to compact such overlays, provided that when so operated they shall be able to obtain the degree of density and smoothness required to conform to the specifications.

When vibratory rollers are used for the compaction of base and binder material they shall be operated at a high amplitude setting and a low frequency setting in the range of 1500 to 1700 VPM. When used for the compaction of surface courses they shall be operated at a low amplitude setting at a minimum frequency setting of at least 2200 VPM or higher, if a higher frequency setting is recommended by the manufacturer of the roller. The use of a vibratory roller incapable of being operated at a frequency setting of at least 2200 VPM will not be permitted on surface courses. No deviation from this latter requirement will be allowed. In compacting surface courses a vibratory roller shall not be operated at a speed in excess of three (3) miles per hour.

A vibratory roller shall be operated with the vibration drum or drums in the direction of the paver and the vibrating action of the roller shall be completely shut off during change of direction. Due care shall be exercised to start the vibratory action only when the roller is in motion. During the rolling of layered pavement, in order to prevent creeping and aggregate crushing, care shall be taken not to exceed two passes with the vibrator in action. For deep lift pavements, these passes shall normally not exceed two in each direction, except that the number of vibratory passes in either direction may be varied in order to obtain the required density.

The final rolling of all courses shall be performed with a steel wheeled roller of sufficient weight for final smoothing of the surface.

The use of a vibratory roller may be suspended by the Engineer if, in his opinion, satisfactory results are not being obtained and no further amount of mix shall be spread in such case until a sufficient number of approved rollers are on the project site to satisfy compaction requirements.

A plate shall be attached to each conventional roller which shall show the ballasted and unballasted weight per inch of tread.

The number of rollers required shall be governed by the tonnage of hot-mix being placed daily. A sufficient number shall be provided to compact the mixture in accordance with the specifications. The number of passes required may be varied and shall be governed by compaction results. The Engineer may require that a stand-by roller be provided if in his opinion it is necessary in the event of a breakdown.

Each roller shall be operated by a competent, experienced roller operator and shall be kept in as nearly continuous operation as practicable while work is underway. The mixture shall be rolled longitudinally, diagonally and transversely as may be necessary to produce the required contour for surface. Longitudinal rolling shall start at the side and proceed toward the center of the pavement, except on superelevated curves where the rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least 12 inches. The rolling shall be continued and so executed that all roller marks, ridges, porous spots and impressions are eliminated and the resulting surface has the required grade and contour. The motion of the rollers shall at all times be slow enough to avoid any displacement of the hot mixture. Any displacement or marring of the surface occurring as a result of reversing the direction of the rollers, or from any other cause, shall be corrected. To prevent adhesion with the mixture, the wheels of the steel rollers shall be kept lightly moistened with water but excess water will not be permitted. The use of oil for this purpose will not be allowed.

To prevent "rolloff" of the pavement edges and longitudinal joints on deep lift paving, the outer 8" ± of the deep lift mixture shall be left unrolled until the temperature of the mix ranges between 150 °F and 180 °F, whereupon it shall be compacted by the steel roller.

Along curbs, structures and all places not accessible with a roller, the mixture shall be thoroughly compacted with mechanical tamping devices. The surface of the mixture after compaction shall be smooth and true to the established line and grade.

The densities of the completed pavement shall not be less than 95% of the density obtained from Laboratory compaction of a mixture composed of the same materials in like proportions. Laboratory compaction will be performed by Department Standard Methods.

460.65 Joints.

Placing of the mixture shall be as nearly continuous as possible and the roller shall pass over the unprotected end of the newly placed mixture only when the placing of the course is to be discontinued for such length of time as would permit the mixture to attain initial stability. In all such cases, including the formation of joints as herein specified, provision shall be made for proper bond with the new surface for the full specified depths of the courses.

The maximum length of longitudinal joint shall be such that the temperature of the mixture of the joint shall be not less than 200 °F, when abutting mixture is placed.

If the paving sequence or other conditions cause the joint temperature to fall below 200 °F, the joint shall be treated prior to laying the next lane of bituminous concrete as follows:

The joint shall be coated with a hot poured rubberized asphalt sealant meeting the requirements of Federal Specification SS-S-1401 or SS-S-164.

The hot poured rubberized asphalt shall be applied to the joint from a double jacketed heating kettle with a positive drive gear pump that is connected to a suitable applicator. The nozzle of the applicator shall be set to deliver sufficient sealant to effectively bond and seal the longitudinal paving joint between two adjacent lanes of bituminous concrete.

Longitudinal and transverse joints shall be made in a careful manner, well bonded and sealed, and true to line and grade. Where and as directed, longitudinal and transverse joints for both top and bottom courses placed under this or previous contracts shall be cut back to expose the full depth of the course and, when the laying of the course is resumed, the exposed edge of the joint shall be treated as above.

The above temperature requirements do not apply to open graded mixtures.

In making joints along any adjoining edge such as curb, gutter or an adjoining pavement, and after the mixture is placed by the mechanical spreader, just enough of the hot material shall be placed by hand method to fill any space left open. These joints shall be properly "set-up" with the back of a rake at the proper height and level to receive the maximum compaction. The work of "setting-up" these joints shall be performed only by competent workmen.

Where and as directed, the first width of any course shall be placed not less than one foot wider than the first width of top course, and successive widths of top and as any other courses shall be so placed that there will be at least a one foot overlap between the joints in the top course and the other course.

The rolling of the successive widths of courses shall overlap and shall be performed so as to leave smooth, uniform joints and cross sections.

460.66 Pavement on Bridges.

The bituminous concrete mixtures for protective course paving on bridges shall consist of "Dense Binder Course" as specified hereinbefore for such mix and work performance requirements. The mixtures shall be treated with an approved antistripping compound as specified under M3.10.0.

The protective course over any area shall be placed within 24 hours after the membrane waterproofing over the area has been placed unless exception is granted by the Engineer.

The use of smaller rollers may be permitted, with the approval of the Engineer for compaction of the protective course only.

No vehicular traffic shall be permitted over any bare membrane waterproofing except as provided for under Subsection 965.62.

The top course of pavement on bridges shall consist of "Top Course" and be placed only after the curbing and edging are in place in the work.

460.67 Testing Surfaces.

The plane of the finished surfaces of the base courses and/or binder course and the top course of compacted mixtures, shall be tested with a 16-foot straightedge, except that a 10-foot straightedge may be used on vertical curves. The straightedge shall be carefully applied immediately after first compaction by rolling and, from then on, as may be necessary until and after the final compaction of the material in place. The straightedge shall be held in successive positions parallel to the road centerline and in contact with the road surface; and the entire area checked from one side to the other of the pavement. Any irregularities which vary 1/4" from a true surface in base or binder course shall be corrected.

The top course of resurfaced streets which contain manhole covers, water gate boxes, etc., shall be tested as specified hereinbefore except that a ten (10) foot straightedge shall be used. Any irregularities which vary more than 1/4 of an inch from a true finished surface shall be corrected.

Irregularities which may develop before the completion of rolling and while the material is still workable, may be remedied by loosening the surface mixture and removing or adding material as necessary. Should any irregularities or surface defects remain after final compaction the defective work shall be corrected by removing and replacing the new material, as specified to form a true and even surface of regular texture. All minor surface projections, joints and minor honeycombed surfaces shall be ironed out smoothly to grade, as may be directed.

Adequate and approved straightedges shall be furnished and used by the Contractor with supervision and inspection by the Engineer. The Contractor shall provide or designate a competent employee whose duty shall be to carefully use the straightedge to check the compacted surfaces.

The entire cost for furnishing adequate and approved straightedges with the use of same and the repair or removal and replacement of pavement, as may be required by the Engineer, shall be borne by the Contractor as part of the payment made to him for the relevant contract items.

460.68 Opening to Traffic.

No vehicular traffic or loads shall be permitted on the newly completed pavement until adequate stability has been attained and the material has cooled sufficiently to prevent distortion or loss of fines. If the climatic or other conditions warrant it, the period of time before opening to traffic may be extended at the discretion of the Engineer.

COMPENSATION

460.80 Method of Measurement.

Bituminous concrete shall be measured by the ton and shall be the actual and verified tonnage, complete in place and approved. The quantity shall be determined only by weight slips that have been properly countersigned by the Engineer at the time of delivery.

Bitumen used for tack coat, if required by plans or specifications or ordered by the Engineer, will be measured as specified in Subsection 468.80.

460.81 Basis of Payment.

The tonnage of bituminous concrete, determined as provided above, will be paid for at the contract unit price per ton of the kind of bituminous concrete required, complete in place including butt joint sealant, if required.

Bitumen as specified herein to be paid for as tack coat, if required, will be paid for at the contract unit price per gallon under the item for Bitumen for Tack Coat, complete in place.

460.82 Payment Items.

460.	Class I Bituminous Concrete Pavement, Type I-1	Ton
460.2	Class I Bituminous Concrete Pavement Type I-1 Open Graded	Ton
461.	Class I Dense Bituminous Concrete, Type ST	Ton
462.	Class I Dense Binder Course for Bridges	Ton
464.	Bitumen for Tack Coat	Gallon

SECTION 466
STRESS ABSORBING MEMBRANE INTERLAYER

DESCRIPTION

466.20 General.

This work consists of the application of hot, rubberized asphalt to a paved surface and immediately embedding aggregate therein by spreading and rolling in accordance with these specifications. This item may also be referred to as SAMI.

MATERIALS

466.40 General.

Asphalt: Asphalt cement for the asphalt rubber mixture shall be AC-10 or AC-20, complying with the requirements of M3.01.0. If AC-10 is used, the SAMI shall be overlayed within ten (10) days.

Rubber: The granulated rubber shall be a vulcanized rubber product from the ambient temperature processing of pneumatic tires.

The granulated rubber type shall meet the following gradations:

Sieve Designation	Percent Passing
#8	100
#10	95-100
#16	—
#30	0-10
#50	0-5

Aggregate shall conform to the requirements of M2.01.0 for crushed stone. Crushed gravel stone *will not* be permitted. Gradation requirements will conform to M2.01.6. Percentage of wear as determined by the Los Angeles Abrasion Test (AASHTO-T96) shall be a maximum of 30.

CONSTRUCTION METHODS

466.60 General.

Preparation of Existing Surface.

Prior to application of the rubberized asphalt, the entire paved surface to be treated shall be cleaned by sweeping, blowing and other methods until free of dirt and loose particles. Pot holes, depressions, cracks larger than 3/4" and other irregularities will be patched with hot bituminous mix and compacted. No water shall be present on the surface. A levelling course shall be placed on planed, milled or existing surface if required.

Seasonal and Weather Limitations.

Construction shall not proceed when the ambient temperature has been below 50 °F within the previous 12 hours,when rain is falling, or when conditions are unfavorable to obtaining a uniform spread.

466.61 Asphalt Rubber Mixing and Reaction

The percent of rubber shall be 23 ± 2% as indicated by the mixture design for specific project requirements by weight of total mixture, that is, by total weight of asphalt cement, plus granulated rubber.

The temperature of the asphalt shall be between 350 °F and 425 °F at the time of addition of the vulcanized rubber. The asphalt and rubber shall be combined and mixed together in a blender unit and reacted in the distributor for a period of time as required by the Engineer which shall be based on laboratory testing by the rubberized asphalt supplier. The temperature of the rubberized asphalt mixture shall be above 325 °F during the reaction period.

After the reaction between asphalt and rubber has occurred, the viscosity of the hot rubberized asphalt mixture may be adjusted for spraying and/or better "wetting" of the cover material by the addition of a diluent. The diluent shall comply with the requirements of ASTM - D 369, Grade #1 Fuel Oil and shall not exceed 7.5 percent by volume of the hot asphalt rubber mixture.

When a job delay occurs after full reaction, the rubberized asphalt may be allowed to cool. The rubberized asphalt shall be reheated slowly just prior to application, but not to a temperature exceeding 325 °F. An additional quantity of diluent not exceeding 3 percent by volume of the hot rubberized asphalt mixture may be added after reheating.

Viscosities shall be run, by the applicator, on each blended load of rubberized asphalt rubber using a Haake Field viscometer. One viscosity prior to the induction of the diluent and one after the induction of the diluent blended into the asphalt and rubber mixture. The viscosity of the final product shall be in the range of 2000 to 5000 centipoise.

466.62 Equipment.

1. Distributor Truck.

At least two pressure-type bituminous semi-distributor trucks in good condition will be required. The distributor shall be equipped with an internal heating device capable of heating the material evenly up to 425 °F; have adequate pump capacity to maintain a high rate of circulation in the tank; have adequate pressure devices and suitable manifolds to provide constant positive cut off to prevent dripping from the nozzles. The distribution bar on the distributor shall be fully circulating. Any distributor that produces a streaked or irregular distribution of the material shall be promptly repaired or removed from the project.

Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, a thermometer for reading temperature of tank contents, and an internal auger to maintain proper mixture and blending of asphalt and rubber. Controls for spray bar shall be located in cab of truck, for controlling width and rate of spray of product.

It shall be so constructed that uniform applications may be made at the specified rate per square yard within a tolerance of plus or minus 0.05 gal./sq. yd.

2. Brooms.

Revolving brooms shall be so constructed as to sweep clean or redistribute aggregate without damage to the rubberized-asphalt membrane or surface treatment.

3. Pneumatic-Tired Roller.

There shall be at least two multiple wheel self-propelled pneumatic-tired rollers with provisions for loading eight to twelve tons as deemed necessary. Pneumatic-tired rollers shall have a total compacting width of at least 60 inches and shall have a minimum tire pressure of 60 pounds per square inch. A minimum of three rollers are required, two pneumatic and one steel.

4. Power Rollers.

Shall be self-propelled steel rollers weighing between 1.5 ton and 5 ton.

5. Asphalt Heating Tank.

To heat the asphalt cement to the necessary temperature for blending with the rubber, tank shall be a minimum 3000 gallon capacity and capable of heating product at a minimum rate of 60 °F per hour.

6. Mechanical Blender.

For proper proportioning and thorough mixing of the asphalt and rubber together to produce the specified rubber content material. This unit shall have both an asphalt totalizing meter (gallons) and a flow rate meter (gallons per minute), positive placement auger to feed rubber properly to mix chamber at the specified rate, and an auger in mixing chamber running through a static motionless mixer.

7. Distributor.

Shall include a tachometer, pressure gauges, volume measuring devices, a thermometer, a 12″ auger capable of blending and maintaining proper blending of material and an 8″ dual positive placement gear head pump capable of spraying the rubberized asphalt at a viscosity of 2000 to 5000 centipoise.

A "bootman" shall accompany the distributor and ride in a position so that all spray bar nozzles are in his full view and readily accessible for unplugging.

8. Chip Spreader.

This equipment shall be self-propelled and be adjustable to control and spread accurately the given amounts of cover aggregate per square yard. It shall have a width of spread of not less than twelve (12) feet. Cut off plates shall be provided to permit the width of spread to be reduced in increments of six (6) inches or one (1) foot from the maximum width specified. The spreader shall be equipped with a hitch at the rear so it can lock onto the hauling trucks while they are discharging into the spreader. Two (2) conveyor belts shall supply aggregate from the hopper to the element which spreads the cover aggregate over the road surface. Screen below screw auger at bottom of hopper shall be in place.

466.63 Construction Requirements.

The rubberized asphalt mixture shall be applied at a temperature of 290 °F to 340° F. at a rate of 0.60 ± 0.050 gal./sq. yd. Transverse joints shall be constructed by placing building paper across and over the end of the previous rubberized asphalt application. Once the spraying has progressed beyond the paper, the paper shall be removed immediately and disposed of as directed by the Engineer. Longitudinal joints shall be overlapped from 4 to 6 inches.

If rubberized asphalt is applied directly to an old existing Portland Cement Concrete pavement; band-aid strips shall be placed prior to the rubberized asphalt treatment on all transverse and longitudinal joints. The strips shall be Pave-Prep, Polygard, Rol-Glas or equal and shall be placed 18″ wide. The SAMI shall be applied within four days of the placement of the band-aid strips.

1. Application.

No application shall be made to any area which cannot immediately be covered with aggregate.

The application from the distributor shall be stopped before the tank is empty to be sure the application loes not run light. At all starts, intersections, junctions at transverse joints with previous spreads or other pave-nents, provision shall be made to ensure that the distributor nozzles are operated at full force when the appli-:ation begins. Building paper or other suitable devices shall be used to receive the initial application from the ıozzle before any material reaches the surface at the transverse joint. The paper shall be removed immedi-ıtely after use without spilling surplus material on the surface. Longitudinal joints shall be reasonably true o line and parallel to centerline. The overlap in application of asphalt-rubber material shall be minimum to ıssure complete coverage. Where any construction joint occurs, the edges shall be broomed back and blended :o there are no gaps and the elevations are the same, and free from ridges and depressions.

During application, adequate provision shall be made to prevent marring and discoloration of adjacent ıavements, structures, vehicles, foliage or personal property.

2. Aggregate Application.

The application of aggregate shall follow as close as possible behind the application of the hot rubberized ısphalt which shall not be spread further in advance of the aggregate spread that can be immediately covered. Construction equipment or other vehicles shall not drive on the uncovered rubberized asphalt.

The dry aggregate, pre-coated with 0.5 to 1.0% of AC-20, shall be spread uniformly by a self-propelled preader at a rate of spread directed by the Engineer, generally between 30 and 40 pounds per square yard.

Any deficient areas shall be covered with additional material.

Prior to application, the aggregate shall be pre-heated to a temperature between 250°–300°F and coated vith 0.5 to 1.0% of asphalt, grade AC-20.

3. Rolling.

Rolling shall commence immediately following spread of aggregate. There shall be at least three com-ılete passes by the pneumatic tired rollers to embed the aggregate particles firmly into the rubberized asphalt, ollowed by an additional pass of the steel roller.

4. Sweeping.

When the maximum of aggregate has been embedded into the rubberized asphalt and the pavement has :ooled, all loose material shall be swept or otherwise removed at such time and in such a manner as will not lisplace any embedded aggregate or damage the rubberized asphalt.

5. Curing.

The rubberized asphalt surface treatment should be overlaid immediately following completion of sweeping. f traffic must travel over the surface treatment, it shall be allowed to cool and speed controlled so as not to :xceed 25 miles per hour.

COMPENSATION

66.80 Method of Measurement.

Stress Absorbing Membrane Interlayer will be measured by the square yard and shall be the actual num-ıer of square yards applied as directed by the Engineer.

66.81 Basis of Payment.

Stress Absorbing Membrane Interlayer shall be paid at the contract unit price per square yard and pay-nent shall be full compensation for all labor, materials and equipment required to complete the work to the atisfaction of the Engineer.

66.82 Payment Items.

460.	Class I Bituminous Concrete Pavement Type I-1	Ton
466.	Stress Absorbing Membrane Interlayer	Square Yard

SECTION 468
PEASTONE COVER FOR BITUMINOUS CONCRETE PAVED SHOULDERS

DESCRIPTION

468.20 General.

Peastone cover for bituminous concrete paved shoulders will consist of an application of bitumen on the finished surface of the shoulder and then a cover of peastone spread and rolled in accordance with these specifications.

MATERIALS

468.40 General.

Materials shall meet the requirements of the following Subsections of Division III, Materials:

Crushed Stone Aggregate	M2.01.0
Peastone Cover (Gradation)	M2.01.6
Bituminous Material	
Asphalt Cement	M2.01.0
Asphalt Emulsion	M3.03.0
Cationic Emulsified Asphalt	M3.03.1
Cutback Asphalts	M3.02.0

CONSTRUCTION METHODS

468.60 General.

The width of the treatment shall be as shown on the plans and as directed. The surface to be treated shall be clean and cleared of all leaves, twigs, and other foreign or objectionable material with brooms or other approved method.

468.61 Applying Bitumen.

The bitumen shall be applied uniformly at the specified rate with a pressure distributor. Distributors shall be in good mechanical condition, with an accurate tachometer, and capable of spraying satisfactorily for a width of not less than 15 feet at a pressure of between 40 and 60 pounds per square inch. The distributor shall be equipped with a system for heating evenly the entire volume of the bitumen under efficient and positive control at all times.

Distributors shall also be equipped with satisfactory thermometers for measuring the temperature of the material to be applied and shall have either a steam or air-kerosene system for the clearing of the lines and pumps. Evidence of fluxing with kerosene or emulsification by steam will be sufficient cause for rejection of the delivery.

Deliveries of bitumen will be refused when the above conditions are not fulfilled.

A hose attachment on the distributor shall be used to apply bitumen wherever necessary to touch up any areas missed or inaccessible to the distributor.

The bitumen shall be applied at the temperature recommended in the Department Specifications for Bituminous and Allied Materials for the type of asphaltic material being used.

No bituminous work shall be done during rainy weather or when weather conditions as to temperature or otherwise are, in the Engineer's judgment, unfavorable for obtaining satisfactory results.

468.62 Spreading and Rolling Stone.

The bitumen shall be immediately covered with a sufficient amount of 3/8 inch peastone to take up the excess bitumen and then thoroughly rolled. The peastone shall be spread evenly by means of a mechanical or box type chip spreader. Spreading shall not be done with a power grader or directly from trucks. The

application of peastone shall be performed in conjunction with the application of the bitumen and a rate to assure proper bonding before cooling takes place.

Rolling shall be performed with a steel wheel roller weighing not less than 240 pounds per inch of tread or an approved pneumatic tired roller. The surfaces of the wheels of the roller shall be kept clean at all times. Precautions shall be taken to prevent the depositing of dirt or other foreign material on the shoulders. Only enough rolling will be done to set the stone and bond it to the shoulder. Excess rolling that will crush the stone will not be permitted.

The stone shall be free of all deleterious materials and if, in the opinion of the Engineer, it is deemed necessary for the proper bonding to the bitumen, the stone shall be lightly treated at the plant with a cut back asphalt or other suitable vehicle.

No trucks or other vehicles shall be allowed to pass over a section for at least 12 hours after the stone has been placed.

COMPENSATION

468.80 Method of Measurement.

Peastone for cover will be measured by the ton.

The weight slips shall be countersigned on delivery by the Engineer, and no weight slip not so countersigned shall be included for any payment under the contract.

Bitumen delivered in tank trucks or tank feeders shall be weighted on scales and the volume computed on the basis of the current tabulation of Weights per Gallon of Bituminous Materials, as approved by the Department.

Scales used in weighing shall be standard scales furnished by and at the expense of the Contractor. Such scales shall be sealed as often as necessary to insure their accuracy, at the expense of the Contractor. A sworn weigher to be compensated by the contractor shall weigh all bitumen required to be weighed. The weighing of such materials may be witnessed by the Engineer.

Bitumen delivered in tank cars, when not actually weighed shall be measured by volume at the loading temperature, and this quantity converted to the volume at the applying temperature. The coefficient of expansion or contraction per degree F, shall be .00035 for asphalt, .00025 for asphaltic emulsions, .0004 for cutback asphalt and .0003 for tar.

In no case shall the total number of gallons of bituminous material for any car be in excess of the United States Interstate Commerce Commission's rating for the car, plus the expansion based on the volumetric change between the loading and the specific application temperature.

468.81 Basis of Payment.

Peastone for Cover will be paid for at the contract unit price per ton under the item for Crushed Stone for Peastone Cover.

Bitumen for Peastone Cover will be paid for at the contract unit price per gallon, under the item for Bitumen for Peastone Cover, applied, complete in place.

468.82 Payment Items.

468.	Crushed Stone for Peastone Cover	Ton
469.	Bitumen for Peastone Cover	Gallon

SECTION 470
CLASS I BITUMINOUS CONCRETE BERMS

DESCRIPTION

470.20 General.

Bituminous concrete berms shall consist of Class I Bituminous Concrete, Type I-1, in accordance with the details of design as shown on the plans.

MATERIALS

470.40 Composition of Mix.

The materials to be incorporated in the mix and the composition of the mix shall conform to the relative requirements of Section M3.11.00 for either top course or dense mix.

CONSTRUCTION METHODS

470.60 Foundation.

The foundation for bituminous concrete berms shall be as shown on the plans or as directed, conforming to the requirements for the particular type of berm specified.

470.61 Placing of Mixture.

The mixture shall be placed and compacted with a machine acceptable and approved by the Engineer for type of berm required.

COMPENSATION

470.80 Method of Measurement.

The quantity of bituminous concrete berms will be measured by the ton complete in place. The quantity shall be determined only by weight slips that have been properly countersigned by the Engineer at the time of delivery.

470.81 Basis of Payment.

Class I Bituminous Concrete Berms will be paid for at the contract unit price per ton under the item for Class I Bituminous Concrete Berms, complete in place.

470.82 Payment Items.

470.	Class I Bituminous Concrete Berm, Type A	Ton

SECTION 472
BITUMINOUS CONCRETE FOR PATCHING

DESCRIPTION

472.20 General.

This type of pavement shall be composed of mineral aggregate, mineral filler and bituminous material.

MATERIALS

472.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

General Composition of Mixture	M3.11.02
Mineral Aggregate	M3.11.04
Bitumen (MC-250 or MC-800)	M3.02.0
Hydrated Lime	M9.13.0
Plant Requirements	M3.11.07
*Curing of Mixture	

*This bituminous concrete mixture for patching shall be cured by placing in a stock pile for a period of 1 week or more prior to delivery.

CONSTRUCTION METHODS

472.60 General.

When directed by the Engineer to use bituminous concrete for patching; the Contractor shall obtain Class I Bituminous Concrete material as required under Section 460. If this material is not available, the Contractor may then use the material specified hereof in Section 472.

The bituminous concrete shall be laid to the thickness directed and compacted to the satisfaction of the Engineer.

COMPENSATION

472.80 Method of Measurement.

Bituminous Concrete for Patching will be measured as required in Section 460.

472.81 Basis of Payment.

Bituminous Concrete for Patching will be paid for at the contract unit price per ton complete in place. This price will include full compensation for the satisfactory removal and disposal of the material at a later date, if required; except as follows:

When the required bituminous concrete patching material is placed in areas of proposed roadway excavation, the removal and satisfactory disposal of the patching material will be paid for under the item of Roadway Earth Excavation.

472.82 Payment Item.

472. Bituminous Concrete for Patching	Ton

SECTION 476
CEMENT CONCRETE PAVEMENT

DESCRIPTION

476.20 General.

This work shall consist of a pavement composed of air entrained Portland cement concrete, plain or reinforced as specified, constructed on an approved foundation in accordance with these specifications and in close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

MATERIALS

476.40 General.

Materials shall meet the requirements of the following Subsections of Division III, Materials:

Concrete, (Air Entrained) 5,000 psi, 1½" 660	M4.02.00
Steel Reinforcement	
Reinforcing Bars	M8.01.0
Welded Steel Fabric	M8.01.2
Steel Bar Mats	M8.01.3
Tie Bars and Bolts	M8.01.4
Load Transfer Assembly	M8.14.0
Preformed Joint Filler	M9.14.0

Joint Filler Compound	M3.05.0
Polyurethane Joint Sealer	M9.14.3
Asphaltic Paint	
RC-70	M3.02.0
RS-1	M3.03.0
Curing Materials	
Impervious Liquid Membrane	M9.06.5
Waterproof Paper	M9.06.0
Burlap	M9.06.3
Polyethylene Coated Burlap	M9.06.4
White Polyethylene	M9.06.1B
Base Stabilization Materials	
Portland Cement	M4.01.0
Bitumen	M3.02.0

Fine aggregate for use in concrete to be placed with a slip-form paver shall meet the grading requirements as specified for fine aggregate for cement concrete except that the maximum passing the #100 sieve may be increased to 10% and a maximum of 4% passing the #200 sieve may be established in order to increase the cohesiveness of the cement concrete. Also, the concrete when tested in accordance with AASHTO Designation T-119 shall have a slump of not more than 2 inches nor less than 1 inch.

CONSTRUCTION METHODS

476.60 General.

The cement concrete pavement may be constructed by the Slip-Form Method or the Fixed-Form Method.

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly and approved. Any equipment or tools which are not maintained in full working order or which, as used by the Contractor, prove inadequate to obtain the results prescribed, shall be improved or new equipment or tools substituted or added as directed.

Grade control survey and staking shall conform to Subsection 5.07. The Contractor shall furnish, set, and maintain all line and grade stakes for grading and paving.

476.61 Preparation of Grade.

The sub-base shall consist of gravel or dense graded crushed stone conforming to Section 401 or Section 402, or of soil cement, and shall be as specified on the plans. The sub-base shall be conditioned and perfected not less than 500 ft. in advance of the placing of the concrete. If any traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately ahead of the placing of the concrete.

Sub-base prepared for the slip-form method shall be placed to a compacted depth approximately one inch higher than the grade called for on the plans to allow for planing by approved mechanical means to the proper profile. It shall also be placed to a width 3 ft. greater (18 in. on each side) than the required pavement slab width. After the sub-base has been placed and compacted to the required density, and will adequately support the subgrade machine and the slip-form paver, the track areas shall be cut to the proper elevation by the use of a mechanical form grading machine.

Behind the form grading machine the track areas shall be rolled to a smooth, firm, and uniform surface.

The grade on which the pavement is to be constructed shall then be brought to the proper profile by means of a track mounted subgrade machine operation on the prepared track line or by other mechanical means approved by the Engineer. When concrete is placed, the surface of the sub-base shall not be above, nor more than 3/4 inch below the plan subgrade elevation. If the density of the subgrade is disturbed by the subgrade machine, it shall be corrected by additional compaction before concrete is placed.

The sub-base, after being conditioned, shall provide a firm unyielding support which will not be displaced under the movement of the paver. If the sub-base is displaced by the movement of the paver to the extent that the finished pavement will be affected, the two areas that will support the slip-form paver tracks shall be stabilized as provided herein. The areas to be stabilized will be immediately outside the edge lines of the pavement slab on both sides and are each to be not less than 18 in. in width, measured from the exterior edges of the proposed pavement slab.

If cement is used for stabilization, the material to be stabilized shall be loosened and pulverized before any cement is added. Cement shall be uniformly spread on the loosened and pulverized material at the rate of approximately 4.5 lb. per square foot. The final depth of stabilization shall be not less than 3½ in. in the completed track area after it is brought to proper elevation. The exact amount of cement to be used to adequately harden the mixture of cement and subgrade material will be determined by the Engineer.

The cement and subgrade material shall be thoroughly mixed by means of a power driven mixer until the mixture is of a uniform color throughout the full required depth.

After the cement and subgrade material have been mixed, water shall be added to the mixture and mixing continued until the water is uniformly distributed throughout the mixture. The amount of water to be added will be determined by the Engineer. The moist mixture when ready for compaction shall be near its optimum moisture content.

The mixture shall be uniformly compacted for the full depth until it is firm and unyielding, and within 2 hours after the addition of the water. Compaction shall be with a 10-ton three wheeled or tandem roller, approved rubber-tired roller or approved mechanical vibrator.

After compaction, the surface of the area that will support the paver tracks shall be cut to true profile and elevation by approved mechanical equipment and then rolled to obtain a smooth, true surface.

The stabilization shall be protected from drying by the application of approved bituminous material (approximately 0.2 gal. per sq. yd.) or cover of straw, sand or earth. If straw, sand or earth is used for cover, it must be broomed off before the area is used in further operations. The curing material shall be applied immediately after final rolling and maintained for at least 2 days.

In lieu of the above method and procedure for stabilization of the track area, other proven methods and materials will be considered subject to equivalent and acceptable performance.

Regardless of the method, materials and procedures used, the burden or responsibility for the acceptability of work shall rest with the Contractor.

If stabilization of the track areas is required such stabilization will not be paid for separately, but will be included under Item 476., Cement Concrete Pavement.

Where fixed-form construction is specified, the use of a subgrade machine may follow form setting.

When side forms have been securely set to grade, the sub-base shall be brought to proper cross section. The fine grading shall be compacted by means of approved equipment to a condition similar to that of surrounding grade. A sub-base check template shall be used as a final check. The surface of the sub-base shall not be above nor more than 3/8 inch below the plan sub-base elevation. Any deviation from the required sub-base surface exceeding this tolerance shall be corrected.

The template shall span the width being paved and be supported on the side forms. It may be power or hand operated, with scratch teeth or pins which can be adjusted readily to the required cross section and supported in a frame of sufficient weight and strength to withstand the loads. The points of the teeth or pins shall be adjusted to be at the plan sub-base elevation. High areas shall be trimmed to proper elevation. Low areas shall be filled and compacted to a condition similar to that of surrounding grade except that areas which are not more than 3/4 inch below sub-base elevation may be filled with concrete integral with the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

The sub-base shall be uniformly moist when the concrete is placed. When the sub-base is dry, it shall be sprinkled with as much water as can be readily absorbed immediately in advance of placing concrete. It shall also have been similarly sprinkled not less than 8 hours or more than 24 hours before concrete is placed thereon.

76.62 Forms and Form Setting.

Where fixed-form construction is specified, the straight side forms shall be made of metal and shall be furnished in sections not less than 10 ft. in length. Forms shall have a depth equal to the prescribed edge thickness of the concrete without horizontal joint and a base width equal to the depth of the forms but not less than inches. Flange braces shall extend outward on the base not less than 2/3 the height of the form. Flexible or curved forms of proper radius shall be used for curves of 200-ft. radius or less and be of a design acceptable to the Engineer. Satisfactory wooden forms, as approved by the Engineer, may be used for curves of 200-ft. radius or less or where the design of pavement is such that metal forms cannot be used. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved by the Engineer. The top face of the form shall not vary from a true plane by more than 1/8 inch in 10 feet, and the upstanding leg shall not vary from a true plane by more than 1/8 inch in 10 feet. The forms shall contain provisions for locking the ends of abutting form sections together

tightly and for secure setting. Forms to be used for concrete which is to be furnished by hand shall have a base not less than 6 inches in width.

The foundation under the forms shall be hard and true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. Any grade which at the form line is found below established grade shall be filled to grade with granular material in lifts of 1/2 inch or less for a distance of 18 inches on each side of the base of the form, and thoroughly compacted. Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be joined neatly and tightly and staked securely with not less than 3 pins for each 10 ft. section. A pin shall be placed at each side of every joint. Form sections shall be tightly locked free from play or movement in any direction. If any play or movement of the forms occurs, additional pins shall be required by the Engineer. The entire base of forms shall be directly in contact with the finished sub-base. If a form does not have satisfactory bearing area for its full length, it shall be removed, the bearing area of sub-base reshaped and compacted, and the form replaced. Building of pedestals of earth or other materials upon which to reset the forms in order to bring them to the required grade is not permitted. Forms shall be set at least 500 ft. in advance of the point of placing concrete. They shall be thoroughly cleaned and greased or soaped before concrete is placed against them. No excessive settlement or springing of forms under the finishing machine will be tolerated.

The forms shall be set to correct line and grade. Smooth alignment and grade shall be checked by sighting and with an approved 10 foot straight edge. The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked. Use of a straight-edge will not be required on vertical curves. A mechanical tamper of approved type and design will be permitted for use in the preparation of a firm, even sub-base for form installation.

476.63 Batching and Mixing Concrete.

The materials shall be batched at a central plant. The batch plant site, layout, equipment, and provisions for transporting material shall be such as to assure a continuous operation of the paver employed on the project. The work shall be done in accordance with the relevant provisions of Subsection M4.02.08.

Concrete may be mixed at the site of construction or at a central point. Mixers shall conform to the applicable requirements of Subsection M4.02.09.

Concrete mixed at a central plant shall be hauled to the paving site by agitation trucks or other approved haul units in accordance with the relevant provisions of Subsection M4.02.10.

Concrete mixed completely in truck mixers in accordance with Subsection M4.02.10 (A-1), may be allowed when approved by the Engineer.

The Contractor shall obtain approval of his proposed central mix plant site, its capacity, concrete materials sources, hauling equipment, proposed haul routes, etc. prior to moving said equipment onto project.

Concrete mixed in pavers at the site shall be mixed for a period of not less than 60 seconds including transfer time but no less than 50 seconds, exclusive of transfer time, but no less than 50 seconds, exclusive of transfer time, after all materials, except water, are in the drum. The mixer shall be operated at drum speed shown on the manufacturer's name plate. The manufacturer's guaranteed capacity of the mixer shall not be less than 27 cubic feet. Except by written permission of the Engineer, the mixer shall not be operated in excess of its guaranteed capacity nor by more than 10% above its rated capacity as shown on the standard rating plate on the machine, when operating on grades not exceeding 6%.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 20 seconds of the mixing period. The entire contents shall be removed from the drum before the succeeding batch is introduced. The inside of the drum shall be kept free from hardened concrete. The skip and throat of the mixer drum shall be kept clean and free of accumulation or encrustations of inert materials and the admission of these materials to the mixer shall be cause for rejection of the batch in which they are included. The concrete, as discharged from the mixer, shall be uniform in composition and consistency. If this condition is not produced with the maximum size of batch, the size of the batch shall be reduced or the mixing time increased, or both, until an acceptable mixture is obtained.

As required above, all materials except water shall be admitted to the mixer simultaneously and thereafter no additional amount of any ingredient shall be admitted to the mixer, except on specific instructions of the Engineer or his representative, for each individual batch. Such instructions shall not be given for more

than three consecutive batches after which the proportions of the mix shall be correct prior to the initial charging of the mixer, and further, such instructions shall not relax the following restrictions concerning the retempering of concrete.

Retempering of concrete by the addition of water will not be permitted. The addition of water to the batch in the mixer after 10 minutes have elapsed after the initial charging, or the addition of water to the concrete after removal from the mixer, shall be construed as retempering. Batches of concrete prepared contrary to these restrictions shall be rejected and immediately removed from the site. The concrete shall be mixed only in the quantity required for immediate use and concrete not in place within 30 minutes from the time the ingredients were charged into the mixing drum, or that has developed initial set, shall not be used.

The concrete shall have a slump of between 1½ and 3 inches if not vibrated, or between 1 and 2 inches if vibrated throughout, as measured in accordance with AASHTO Designation T119.

Batches shall be discharged in a manner to facilitate placing the concrete in its final position with a minimum of rehandling and without damage to forms, concrete previously placed, or other parts of the work.

The interval between loads shall be controlled in order that concrete in place will not become partially hardened prior to placing succeeding batches and in no case shall it exceed 30 minutes. Plant capacity and transportation facilities shall be sufficient to insure delivery of concrete at the rate required.

Samples of concrete for test and test specimens will be taken from transportation units at the point of discharge or from the concrete in place as determined by the Engineer.

When cement concrete paving operations are done during cold weather, the stipulations as outlined in Subsection 901.72 shall apply.

476.64 Placing Concrete.

Concrete shall be placed only on an approved sub-base.

The Contractor shall notify the Engineer at least 24 hours in advance of placing the concrete. In the event he desires to operate after the daylight hours, the Contractor shall provide a lighting system sufficiently adequate to illuminate all of the operations to the satisfaction of the Engineer.

No finishing of the concrete will be permitted after daylight hours unless an adequate and approved lighting system is provided by the Contractor and operated in a satisfactory manner. Approval of the lighting system by the Engineer must be obtained prior to its use.

At least 500 ft. of foundation shall have been prepared ahead of the mixer or concrete operations at all times. The depositing of concrete on excessively wet subgrades or sub-bases or a frozen foundation will not be permitted. No concrete shall be placed around manholes or other structures until they have been installed to the required grade and alignment.

During dry weather, when traffic on the foundation or adjacent roadways would deposit wind-blown dust and dirt on the freshly placed concrete before it can be protected, the Contractor shall sprinkle the foundation or adjacent roadways with water or otherwise apply satisfactory treatment to keep down the dust.

Unless otherwise permitted by the Engineer, all equipment used for mixing, hauling and placing the concrete shall be operated outside of the area being paved. Should operation of such equipment be permitted on the prepared foundation, suitable planks or platforms shall be provided and used for the equipment to run on, so that the foundation will be maintained in an approved condition.

The concrete shall be deposited on the grade in such a manner as to require as little handling as possible. Concrete shall be distributed in such a manner that when consolidated and finished, the slab thickness and surface grade required by the plans will be obtained at all points. Unless truck-mixers, truck-agitators, or nonagitating hauling equipment demonstrate that they will discharge concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade in such a manner as to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads except as specified under Subsection 476.68 for construction joints. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

The concrete shall be deposited carefully at and around contraction and expansion joints. It shall be shoveled against both sides of expansion joints simultaneously, maintaining equal pressure on both sides. Care shall be taken that the concrete is worked under all metal parts of the load transfer assemblies. The concrete shall not be dumped directly upon or against the joints in any manner which displaces the load transfer assemblies or joint material from the true position.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods.

Where concrete is to be placed adjoining a previously constructed lane of pavement and mechanical equipment will be operated upon the existing lane of pavement, that lane may be opened to traffic when curing operations have been completed provided that beam tests show that the concrete has attained a modulus of rupture of at least 550 lb. per square inch. Curing operations will not be considered completed unless a curing period of at least 7 days has elapsed since the concrete was placed. However, the pavement may be used at the end of 5 days if only rubber-tired finishing equipment is permitted to operate upon it and the concrete has attained a modulus of rupture of at least 550 lb. per square inch.

When high early strength concrete is used, mechanical equipment may be operated upon the pavement after a shorter period of curing or as beam tests show that the concrete has attained a modulus of rupture of at least 550 lb. per square inch.

Pavers will not be permitted to operate on the finished pavement unless permission is given by the Engineer.

Gaps in the pavement for crossovers will not be permitted. Should crossings be necessary, suitable bridging of slabs or sand cushioning will be provided, as approved by the Engineer.

476.65 Spreading and Strike-Off of Concrete.

As soon as concrete has been placed on the sub-base, it shall be immediately struck-off accurately, by means of an approved mechanical spreading device, leaving a surface uniform in texture, true to grade, elevation and contour. The strike-off shall be so adjusted for elevation that when the concrete is consolidated, as herein designated, sufficient material remains above grade as is required for the final finished surface of the pavement.

When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be struck-off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck-off and screeded. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense.

A. Slip-Form Method.

The slip-form paver shall be an approved machine designed to spread, consolidate, screed, and float finish the freshly placed concrete in one complete pass of the machine in such manner that a minimum of hand finish will be necessary to provide a dense and homogeneous pavement in conformance with the plans and specifications.

The slip-form paver shall be of the self-propelled type, equipped with crawler type tracks not less than 22 feet in length.

The machine shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibration shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The forms shall trail behind the paver for such a distance that no appreciable slumping of the concrete will occur, and that necessary final finishing can be accomplished while the concrete is still within the forms.

The slip-form paver shall be adjustable as to crown and super-elevation and shall shape and compact the concrete to the required cross section as shown on the plans. Such adjustments shall be readily controllable for accuracy in transitions. No tractive force shall be applied to the machine except that which is controlled from the machine.

The concrete shall be of uniform consistency such that there will be no appreciable slumping at the edge of the pavement after the slip-forms have passed. The following tolerances on edge slump shall apply: Edge slump, exclusive of edge rounding, shall not exceed 1/4 inch within 6 inches of the edge at the extreme outside limits of the concrete pavement: at the longitudinal joint along the pavement crown and along the longitudinal joint between the travel lanes and speed change lanes. The edges along the longitudinal joint between the two travel lanes of the same cross-slope shall be at true finish grade. Any deviation from these tolerances shall be corrected while the concrete is plastic.

The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

For reinforced pavement and where necessary, more than one machine and/or complimentary equipment will be allowed, subject to the Engineers approval.

B. Fixed-Form Method.

The spreading machine shall be mechanical, self-propelled, and of an approved type. It shall be capable of spreading the concrete evenly between the side forms, without segregation, and without introducing thrust on the side form. It shall be equipped with a spreading device, adjustable in height for distributing the concrete longitudinally and transversely, and a blade adjustable in height to strike-off the concrete at the required elevation above or below the top of the side form.

Immediately after the concrete has been struck off, it shall be thoroughly consolidated against and along the faces of all forms and along the full length and around all parts of joint assemblies, by means of vibrators inserted in the concrete.

Vibrators, for full width vibration of concrete paving slabs, may be either the surface pan type or the internal type with either immersed tube or multiple spuds. They may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, load transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 impulses per minute and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and not less than 7,000 impulses per minute for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

Vibrators shall not cause the displacement of the side forms nor cause undue delay due to mechanical difficulties. Should these problems arise, they shall be removed from the work and be replaced by equipment meeting these specifications.

Surface vibrating apparatus shall be used only on the top course or layer of the pavement and must be completely out of use when moving over transverse joints or when spreading the bottom course of concrete in two-course construction. It shall not be operated where the surface of the concrete, as spread, is below the elevation of the finished surface of the pavement.

476.66 Placing Steel Reinforcement.

All reinforcing metal must be kept clean and free from dirt, oil, paint, grease, mill scale, loose or thick rust or any foreign material which could impair bond of the steel with the concrete. Welded sheet fabric and clipped bar mats shall be furnished in flat sheets and shall be handled carefully during the placing, and kept straight until installed.

The reinforcement shall be placed as shown on the plans. The reinforcement shall be placed so that the extreme longitudinal member will be located not more than 4 in. from the edge of the slab section and the ends of all longitudinal members shall extend to within 3 in. of the ends of the slab sections. Adjacent sheets of welded fabric and clipped bar mats shall be lapped as shown on the plans.

Mats or sheets of reinforcement shall be preformed in accordance with the schedule shown on the plans, and placed in the concrete by the strike-off method without chairs or other supporting devices. Laps between adjacent mats or sheets and positions of same with respect to longitudinal joints, transverse joints and edges of pavement shall be as shown on the plans.

Concreting operations shall be performed in a manner so that the mats and sheets will be left in required position.

When reinforced concrete is specified, or permitted by the Engineer, to be placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means immediately after the concrete has been spread and struck-off.

476.67 Finishing Concrete.

Immediately after placement, concrete shall be properly finished. The sequence of operations shall be as follows: strike-off, consolidation, transverse screeding, longitudinal floating, straightedging, texturing and finally edging of formed joints. The machine method of finishing shall be employed, except that odd widths or shapes of slab may be finished by hand method.

The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

A. Machine Finishing.

When the concrete paver is not designed to screed and float finish the freshly placed concrete, the surface shall be struck-off and screeded by an approved finishing machine.

The transverse finishing machine for the pavement shall be mechanical, self-propelled, and of an approved type. It shall be equipped with at least two oscillating screeds. It shall have an independent screed and traction

speeds to permit the operator to choose a combination of speeds that will produce the required finish with the consistency of concrete being used. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish.

The transverse finishing machine shall consolidate and screed the concrete with no more than two passages over the slab, except with the special permission of the Engineer. The operation of the machine shall be controlled so as to prevent excess mortar and water from being worked to the top of the slab, and from forming a watery mortar in the roll of concrete in front of the screeds.

If excess mortar does form, it shall be removed from the site and wasted. It shall not, under any circumstances, be placed on the sub-base or shovelled ahead on top of the slab. Segregated particles of coarse aggregate which may collect in front of the screed shall be wasted outside the forms.

A uniform depth roll of concrete shall be maintained in front of the screeds at all times, in order to secure uniform consolidation and to prevent lifting of the screed by irregular amount or overload of concrete.

When vibration is permitted vibrators for full width vibration of concrete paving slabs shall meet the requirement herein of Subsection 476.65 (B). If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor shall furnish equipment and methods which will produce pavement conforming to the Specifications.

B. Longitudinal Finishing.

As soon as possible after the transverse finishing has been completed as specified above, the surface of the concrete shall be further smoothed and finished by use of an approved longitudinal float.

Mechanical Method — The float in contact with the pavement shall be at least 12 ft. in length and at least 12 in. wide. The type of float and details of its construction shall be approved by the Engineer, and it shall be in good working condition.

The tracks from which the float operates shall be accurately adjusted to the required crown. The float shall be accurately adjusted and coordinated with the adjustments of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The forward speed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each area of pavement no more than twice except with the special permission of the Engineer. Any excess water or soupy material shall be wasted over the side forms on each pass.

Hand Method — When strike-off and consolidation are done by hand methods and longitudinal floating by hand is required the float shall be not less than 16 ft. in length, not less than 10 in. in width, suitably stiffened against flexibility and warping and equipped with suitable handles. It shall be operated from bridges spanning the pavement. It shall be operated with a sawing motion parallel to the center line while passing gradually from one side of the pavement to the other. Movement ahead shall be in successive advances of not more than one-half the length of the float. Excess water or soupy material shall be wasted over the side forms of each pass.

C. Alternate Finishing and Floating.

As an alternative to the mechanical finishing and floating method in Subsection 476.67 (A) and (B) preceding, the Contractor may use a long wheel base combination float-finishing machine in lieu of the transverse finishing machine and longitudinal float, providing the combination machine can be adjusted to produce satisfactory results and final finishing is properly timed. Any combination of screeding, floating and finishing machines shall include at least two transverse oscillating screeds.

D. Hand Finishing.

Unless otherwise specified, hand finishing methods will not be permitted except under the following conditions:

> In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs. Narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical may be finished by hand methods.

The surface of the concrete shall be struck-off immediately after it is placed and leveled by means of an adjustable steel template 10 inches wide and 2 feet longer than the width of the pavement. A second adjustable steel template 8 inches wide and 2 feet longer than the width of the pavement shall be used directly behind this template. Both templates shall be constructed to produce pavement of the desired cross section and shall have sufficient strength to retain their shape under all working conditions. The templates shall be moved forward with a combined longitudinal and crosswise motion fully resting at all times on the forms, and during the operation, the distance between the two templates shall at no time exceed 10 ft. The template shall be used until a true surface is obtained. While the concrete is being struck-off with the first template, three or more

men shall be at work leveling, spading and tamping the concrete in front of the template.

Consolidation shall be attained by the use of a suitable vibrator or other approved equipment.

After the concrete has been struck-off with the hand templates described previously, other finishing operations described as following the screeding by the finishing machines shall be carried out.

Straightedging operations following the screeding shall be sufficient to remove surface irregularities or produce a riding surface equivalent to that produced by machine operation.

Experienced skilled operators and concrete finishers shall be employed. Any laxity in this respect shall be cause for immediate suspension of concreting operations.

E. Finishing at Joints.

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Subsection 476.65. After the concrete has been placed and vibrated adjacent to the joints the machine shall be brought forward operating in a manner to avoid damage or misalignment of joints. If uninterrupted operation of the finishing machine, to, over, and beyond the joints causes segregation of concrete, damage to or misalignment of the joints, the finishing machine shall be stopped when the front screed is approximately 8 in. from the joint. Segregated concrete shall be removed from in front of and off the joint: the front screed shall be lifted and set directly on top of the joint and the forward motion of the finishing machine resumed. When the second screed is close enough to permit the excess mortar in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may be run over the joint without lifting the screeds, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

The edges of the slabs on both sides of the transverse expansion joint shall be finished to the same grade. The top transverse edges of formed joints shall then be rounded to a radius of 1/8 of an inch by means of approved edging tools. The transverse edges of formed joints shall be rounded with an edging tool having a vertical leg of sufficient length to contact the vertical side of the preformed filler. The lateral edge adjacent to pavement already in place shall be rounded with an edging tool having a vertical leg 1/4 in. wide and slightly longer than that used on the first slab. Tool marks shall be eliminated.

The finishing of the concrete at joints shall be done from a bridge which shall not rest on the concrete at any point. The finishers shall use a short straightedge not less than 4 ft. in length when finishing transverse formed joints to insure that both slab ends will be at the same elevation or grade.

F. Straightedge Testing and Surface Corrections.

Following the longitudinal finishing operations all remaining irregularities shall be eliminated by use of scraping straightedges 10 ft. in length, equipped with handles 2 ft. longer than the width of one lane. Straightedges shall be made of redwood or aluminum. For wood the cross section shall be 2 in. by 7 in. tapered from 7 in. depth at center to 4 in. depth at ends. For aluminum the preferred shape is the 'T' section with bearing width of not more than 3 in. For both metal and wood the approximate weight should be 30 to 35 lb. for the 10 ft. length exclusive of handle. The handle shall be attached to form an angle of about 10 degrees with the horizontal so as to present a cutting edge when in operation.

The scraping straightedge shall be employed directly after the longitudinal finisher.

The straightedge shall be placed on the form or edge of completed pavement nearest the operator. The handle shall be lowered to knee height and pushed transversely over the pavement surface. When it reaches the opposite form or center of full width paving, the handle shall be raised to shoulder height and the straightedge drawn back across the pavement in the same path. Additional passes shall be made if all irregularities are not removed by these two passes. Each pass shall be lapped one-half of the length of the straightedge as the work progresses. Any depressions found shall be immediately filled with freshly mixed concrete struck-off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness.

Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

Where a wood straightedge is used, the Contractor shall maintain a master straightedge on the job. Wood straightedges are required to be checked on the master straightedge twice a day, once in the morning before use and again at noon. Any variation from a true plane shall be corrected before further use.

G. Final Finish.

Following the scraping straightedges, the final surface texture shall be developed by use of a wet burlap strip dragged longitudinally over the pavement. The burlap shall be not less than 3 ft. nor more than 6 ft. wide without seams and the leading edge fastened to a wood pole for purpose of keeping burlap in proper position.

The burlap shall be a minimum of 2 ft. longer than the pavement width being dragged. At least 2 ft. of the burlap drag shall be in contact with the surface when dragging the pavement. Generally, two such drags should be used so that the complete operation may be in a forward direction without backing up.

The drags shall be cleaned of mortar when necessary so as to maintain uniform and satisfactory surface texture. Drags that cannot be cleaned shall be discarded and new drags substituted. When not in use, the drag shall be removed from the pavement surface.

The surface of the concrete, after burlap drag operation, shall be uniform in appearance with a gritty texture, shall have the required grade and contour, shall be free from surplus water, rough and porous spots, irregularities, depressions and other objectionable surface features resulting from the improper handling of the tools. The entire operation shall be executed to the satisfaction of the Engineer.

Mechanically operated wire or plastic bristle brooms shall be used where specified to provide an adequate skid resistant surface.

H. Edging at Forms and Joints.

After the final finish has been completed, but before the concrete has taken its initial set, the edges of slabs along forms and at formed joints shall be carefully finished and tooled to form a smooth rounded surface of the radius required on the plans. Corners or edges of slabs which have crumbled and any areas which lack sufficient mortar for proper finishing shall be cleaned by removing all loose fragments and soupy mortar, and shall be solidly filled and finished with a mixture of correct proportions and appropriate consistence. Tool marks shall be eliminated and all edges shall be smooth and true to line.

The surface of the slab shall not be unduly disturbed by tilting of the tool during use. All concrete on top of the joint filler shall be completely removed.

476.68 Joints.

Joints shall be constructed of the types and dimensions and at the locations required by the plans, or specifications, or as directed by the Engineer. They shall be placed to a true alignment as shown on the plans or as directed. The sides of joints shall be protected during the curing period. Joint spaces shall be protected against infiltration of foreign materials before the time of sealing. All joints shall be sealed before the pavement is opened to any kind of traffic. Dowels, tie-bars and tie-bolts shall be prepared and placed across joints where indicated on the plans.

If joints become adulterated with dirt, sand, gravel, or other foreign material during the construction period, they shall be reopened, cleaned and resealed prior to opening the job to traffic. This shall be done in conjunction with final clean-up. The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing with a water-cooled diamond edge saw blade or an abrasive wheel to the required dimensions and at the required rate, and he shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete placement.

The Contractor shall submit for approval by the Engineer his proposed equipment for lighting and sawing prior to commencing work on the project.

A. Longitudinal Joints.

Longitudinal joints shall consist of construction joints between adjacent lanes and surface groove joints when the paving is placed more than one lane wide. They shall be located as shown on the plans or as directed.

Deformed steel bars or tie-bolts of specified length, size, spacing and material shall be placed perpendicular to the longitudinal joints; they shall be placed by approved hand or mechanical methods or rigidly secured by chairs or other approved supports to prevent displacement. Tie-bars and tie-bolts shall not be painted or coated with asphalt or other material or enclosed in tubes or sleeves.

When fixed-forms are used, tie-bolts shall be placed across longitudinal construction joints as shown on the plans or as directed. Tie-bolts shall be installed in two major parts to form an integral tie-bolt unit. Such device, as approved, shall result in proper installation as specified, and shall conform to all standard requirements specified herein for strength and design.

Tie-bars in full width paving shall be of the size and length shown on the plans and placed at right angle to and across the locations of the longitudinal joint. The mid-point of the tie-bar shall be at the longitudinal joint. When supported above the fine grade before placing concrete, the tie-bars shall be at the mid-depth of the pavement. Tie-bars may be placed under the distributed reinforcement by approved hand or mechanical methods before the reinforcement is placed and before the top layer of concrete is placed. If placed under the distributed reinforcement, the tie-bars shall be not less than 2¾ inches nor more than 4½ inches below the finished pavement surface.

Longitudinal construction joints shall extend for the full depth of the pavement, be perpendicular to the pavement surface and keyed and tied as shown on the plans. The upper edges of the slab shall be rounded as shown on the plans. The slab placed second shall be edged with a tool having a vertical leg 1/4 inch thick and longer than that used in the first slab. The joint shall be filled with sealing material.

All honeycombed areas on the vertical faces of longitudinal joints shall be cleaned with a wire brush and thoroughly wetted and patched with mortar of the same composition as that used in the pavement.

The faces of the concrete slabs at the longitudinal joints shall be painted with asphaltic material specified in Subsection 476.40 before the adjacent slab is placed against it.

Longitudinal surface groove joints shall be constructed by sawing with an approved concrete saw to the depth, width and line shown on the plans. The width of the cut shall not be less than 1/4 of an inch and the depth shall not be less than one-fourth of the pavement thickness plus 1/4 in. Suitable guide lines or devices shall be used to assure cutting the joint on the true line as shown on the plans. The joint shall be sawed before any equipment or vehicles are allowed on the pavement. If sawing is done before the end of the curing period, the faces of the joint shall be cured as provided for transverse sawed joints. The joints shall be filled with joint sealer compound as specified under Subsection 476.40.

Where there is more than one longitudinal joint, the cutting of this joint shall be done by tandem sawing, which saws shall be fixed to assure lines parallel and true, as shown on the plans.

B. Transverse Expansion Joints.

Transverse expansion joints shall be constructed where shown on the plans or directed by the Engineer. They shall consist of a preformed filler 3/4 of an inch thick (476.40), a top sealing cap of poured joint filler compound (476.40), and an approved load transfer assembly (476.40).

The expansion joint filler shall be continuous from edge to edge shaped to the subgrade and to the keyway along the edge. It shall extend from the subgrade to one inch below the pavement surface.

Preformed joint filler shall be furnished in lengths equal to the paving width or equal to the width of one lane. Where more than one section is used in a joint, the sections shall be securely laced or clipped together. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

A removable metal cap shall be placed over the top of the preformed joint during the concreting operations to maintain proper grade and alignment. Concrete shall be placed as specified and shall be carefully spaded against the joint filler. The metal cap shall be removed immediately after the final pass of the finishing machine. A suitable strip of the exact dimensions of the filler shall then be inserted in the joint as a guide and the concrete edged with a 1/8 in. radius edging tool. The strip shall then be removed and any rough or torn places in the concrete shall be corrected.

Particular care shall be taken to keep the concrete in exactly the same plane on the two sides of the joint. No concrete shall extend across the joint. No plugs of concrete shall be permitted anywhere within the expansion space.

C. Transverse Contraction Joints.

These joints shall consist of planes of weakness created by sawing grooves in the surface of the pavement at the locations indicated on the plans.

Approved load transfer assemblies shall be installed at each contraction joint as shown on the plans and in accordance with the Speficiations.

When approved by the Engineer, a vibrating bar may be used to move coarse aggregate off the line of the saw cut. The vibrating bar shall be used only in plastic concrete and so as not to produce areas of segregated mortar.

The Contractor's sawing equipment and method of sawing shall be subject to the approval of the Engineer. The timing and sawing and the order in which joints are sawed shall be subject to such control by the Engineer as in his judgement is necessary to protect the pavement from ravelling, spalling, cracking, or other damage. Normally, contraction joints will be sawed progressively with an approved circular saw at not less than 6 nor more than 24 hours after finishing. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and the night regardless of weather conditions.

The pavement shall be cut for not less than 1/8 inch in width to a depth at least one-fourth of the pavement thickness.

Secondary saw cuts shall be made as necessary so that the final joint width is at least 3/8 of an inch or as shown on the plans. In the event of excessive relief of the joint, care should be taken to secure this minimum opening.

To control random cracking the Engineer may require that initial curing (for the first 24 hours) be done

with wet burlap. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. In general, all joints should be sawed in sequence. All contraction joints in lanes adjacent to previously constructed lanes shall be sawed before uncontrolled cracking occurs.

D. Transverse Construction Joints.

Transverse construction joints shall be placed at the end of each day's work and when placing concrete will be interrupted for more than 30 minutes. No transverse construction joint shall be placed closer than 15 ft. to another transverse joint. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 15 ft. long, the excess concrete back to the last preceding joint shall be removed and disposed as directed.

Substantial temporary wood or metal bulkheads shall be used to form construction joints. Particular care will be taken to provide a good riding joint and hand finishing shall be kept to a minimum. Poor riding joints will be corrected.

When the construction joint is placed at a regular location of an expansion or contraction joint, a standard load transfer assembly will be used. When the construction joint is at other than the regular joint location, deformed bars will be used to create a bonded tie across the joint. Minimum tie steel shall be #8 round deformed bars, 48 in. long at 12 in. center to center.

E. Load Transfer Devices.

Dowels shall be held in position parallel to the surface and center line of the slab by a metal device meeting the requirements of Subsection 476.40 or shall be placed by an approved mechanical placing device.

The sub-base at the locations where expansion, contraction, and construction joint load transfer assemblies are to be installed shall be trimmed accurately to the required cross section and depth of pavement. Where used, the complete joint assembly shall be carefully placed. If the sub-base is trimmed too low or if there are any open spaces beneath the preformed joint filler, the joint assembly shall be removed, the sub-base correctly graded and tamped, and the joint assembly reset.

One-half the length of each slip-dowel bar of load transfer units shall be rendered bondless with a coat of either a graphite lubricant or a wax base grease meeting the requirements of Subsection M8.14.0. The graphite lubricant shall be applied by daubing, mopping or gloved hand to produce a thorough coating approximately 1/16 inch thick. Brushes shall not be used for the application of the graphite lubricant.

The wax base grease shall be pre-heated to temperatures of 170 °F to 190 °F and applied either by dipping or by brush to produce a coating approximately 1/16 inch thick.

Dowels shall be coated at least one hour before the concrete is placed around the dowel assembly.

The assembly shall be held in the required position at line and grade by metal stakes or pins throughout the operation of placing and striking-off the concrete. No concrete shall be placed unless the methods and devices used by the Contractor for installing and securing the joint assembly, including any joint filler required, and finishing the joint meet with the approval of the Engineer. Immediately prior to depositing the concrete, the position of dowels shall be checked and the assemblies tightened if necessary. The installation of dowel assemblies and the placement of the surrounding concrete shall result in dowels tightly encased in concrete and parallel to both the pavement surface and center line at plan locations. In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the plastic concrete by a mechanical device approved by the Engineer.

476.69 Numbering Slabs.

The pavement slabs shall be numbered consecutively as the work progresses, and the last slab placed each day shall be stamped with the date. The marking shall be on the right hand corner at the beginning of each slab, and so placed that it can be read traveling in the direction the pavement was laid. The figures and letters shall be 1½ in. high and plainly and neatly stamped after the final finish of the concrete as directed. When two or more paver mixers are working, the distinguishing letter for each mixer shall be stamped adjacent to the number.

476.70 Surface Test.

The entire surface shall be checked while the concrete is still plastic with an approved metal straightedge 10 ft. in length, and any deviation from the general surface shall be corrected at once. The surface shall be checked again immediately after the removal of the burlap where an initial burlap covering is used, or at the end of 72 hours where 72 hour covering is used. The straightedge shall be placed at several points across the pavement parallel to the centerline and shall be advanced in 5 ft. steps. Areas showing high spots of more than 1/8 in. but not exceeding 1/2 in. in 10 ft. shall be marked and immediately ground or rubbed down with an

approved tool to an elevation where the area or spot will not show surface deviations in excess of 1/8 in. when tested with a 10 ft. straightedge. This grinding or rubbing shall be conducted carefully so as to avoid loosening coarse aggregate or otherwise damaging the slab.

Where the departure from correct cross section exceeds 1/2 inch, the pavement shall be removed and replaced by and at the expense of the Contractor.

Any area or section so removed shall be not less than 15 ft. in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 15 ft. in length, shall also be removed and replaced.

476.71 Curing.

Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be covered and cured in accordance with one of the following methods. In all cases in which curing requires the use of water, the curing shall have prior rights to all water supply or supplies. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or a lack of water adequate to take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 an hour between stages of curing or during the curing period. Whenever fixed-forms are not used, exceptional care shall be taken in the use of paper or burlap to prevent any damage to the unsupported edges of the pavement. The curing media shall be applied at the appropriate time and shall be applied uniformly and completely to all surfaces and edges of the pavement.

A. Moist Curing.

Initial Curing — Strips of burlap saturated with water shall be placed on the fresh concrete surface carefully so as to avoid marring, and the strips shall overlap not less than 3 inches. This burlap shall be kept thoroughly and continuously wet by sprinkling it with a fine spray of until it is removed. Initial curing with wet burlap shall be for a period of not less than 24 hours. Burlap which has been used for any purpose other than curing concrete shall not be used.

Final Curing — Following completion of initial curing the curing shall be continued using an additional layer of burlap or cotton mats. This double layer shall remain in place and shall be kept thoroughly and continuously saturated with water for a period of not less than 5 days.

Cotton mats may be used for final curing if approved by the Engineer. Such covering shall be as effective in preventing evaporation of mixing water and controlling variance in temperature of the concrete as the two thicknesses of wet burlap. If cotton mats are used for final curing, the burlap shall be removed in such a manner that not more than 60 lineal feet of pavement is exposed at one time, followed at once by application of cotton mats.

B. Waterproof Paper Curing.

The top surface and sides of the pavement shall be entirely covered with waterproof paper. Each paper cover shall be not less than 20 or more than 75 ft. in length, and shall be of such width that, when in place, it will extend to at least 18 in. beyond the edges of the slab to be covered.

Paper covers may be furnished in widths corresponding to that of the slab provided supplemental stringer sheets, at least 18 in. wide are used, in which case such sheets shall be placed along the edges of the slab under the paper covers. On removal of forms the paper shall be brought down over the slab side and held with a continuous bank of earth. The junctions between the paper covers shall be lapped approximately 12 in. and held in place with a bank of earth.

All rips or holes occurring in the paper covers while in use shall be immediately repaired with a sealed patch to render them airtight. Covers which have become damaged or soiled to the extent that they will not provide satisfactory curing or will mar the concrete shall not be used.

The paper shall be left in place for a period of 72 hours or longer, if necessary to obtain the required strength. The surface of the pavement shall be moist when the paper is placed.

C. Impervious Membrane Curing.

After finishing operations have been completed, and immediately after the free water has left the surface, the surface of the slab shall be completely coated and sealed with a uniform layer of white pigmented curing compound. The compound shall be applied in a 2-coat continuous operation and at a total coverage of not less than one gallon per 150 sq. ft. of surface.

The compounds shall be applied by means of a mechanical pressure sprayer mounted on a self-propelled carriage. The compound shall form a uniform, continuous, coherent film that shall not check, crack or peel and shall be free from pin holes, or other imperfections. If discontinuities, pin holes or abrasion exist, an additional

coat shall be applied within 30 minutes to the affected areas. The equipment shall provide adequate stirring of the compound during application. Also, wind protection to the spray fog shall be provided by an adequate shield when the compound is applied to the pavement. The equipment for applying the compound shall be approved by the Engineer before work is started. Should the method of applying the compound not produce a uniform film, its use shall be discontinued and the curing shall be done by one of the other approved methods specified herein.

The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause within the required curing period, the damaged portions shall be repaired immediately with additional compound.

Liquid membrane material shall not be placed on the faces of joints. Immediately after the contraction joints are sawed, they shall be protected and moist-cured with strips of waterproof paper or plastic. Ropes made of jute or cotton may also be used. The method used shall insure proper curing of the portion of the slab adjacent to the joints.

Immediately after the forms are removed, the entire area of the sides of the slab shall be coated with the curing compound at the rate specified for the pavement surface. This spraying shall be a continuous process, and waiting until all forms have been removed before making the application will not be permitted. Hand-spray equipment will be permitted for the application of the curing compound over the sides of the slab. Care shall be used to prevent coating the ends of sawed contraction joints. If hair checking develops before the curing compound can be applied, the concrete shall be moist-cured for at least 24 hours before applying any membrane curing compound. If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the Contractor will be required to apply a new coat of material to the affected areas, equal to that specified for the original coat. The treated surface shall be protected by the Contractor from injury for a period of at least 3 days. All traffic, foot or otherwise, will be considered injurious to the film of the applied compound. A minimum of foot traffic will be permitted on the dried film as necessary to carry on the work properly, provided any damage to the film is immediately repaired by the application of an additional coat of compound.

D. White Polyethylene Sheeting.

The general requirements for the use of white polyethylene sheets shall be those for waterproof paper curing in Subsection 476.71B.

E. Curing in Cold Weather.

During cold weather, when the air temperature may be expected to drop below 40 °F, a sufficient supply of loose dry hay or straw or other suitable blanketing material for covering shall be provided along the line of the work, and at any time when the air temperature may be expected to reach the freezing point during the day or night, the material so provided shall be spread to a sufficient depth to prevent freezing of the concrete. The period of time such protection shall be maintained shall be not less than 5 days or until the concrete has hardened thoroughly. The use of such hay or straw does not take the place of the burlap or other covering specified herein, but shall be applied in addition to the covering. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

476.72 Removing Forms.

Forms shall not be removed for 12 hours after the concrete has been placed, or for a longer period if directed. Extreme care shall be taken in removing forms in order that no damage will be done to the concrete. Under no condition shall any bar, pick, or other tool be used which depends upon leverage on the concrete, for removal of the pins or forms.

As soon as side forms are removed and prior to sealing joints, the ends of all joints shall be opened and all mortar or foreign material shall be removed from the joint opening above the filler or other space as provided so that there will be complete freedom for required movement of the joint. After the forms have been removed, the side of the slab shall be cured as outlined in one of the methods indicated previously.

All holes or honeycomb shall be patched promptly with mortar, of the same composition as that used in the pavement, which has been allowed to set for about one-half hour after mixing. Major honeycombed areas will be considered as defective work and shall be removed and replaced. Any area or section so removed shall not be less than 15 ft. in length nor less than full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 15 ft. in length, shall also be removed and replaced.

476.73 Sealing Joints.

Joints shall be sealed after curing and before any kind of traffic is permitted on the pavement.

The sealing of joints shall be undertaken only when the atmospheric temperature is above 40 °F, and when the weather is not foggy or rainy.

Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, including curing compound, by means of a mechanical, power-operated concrete grooving machine or a power wire brush. The concrete grooving machine or wire brush shall be operated in such a manner that the vertical faces of the concrete in the joint opening will present thoroughly clean concrete surfaces for application of the joint sealing compound. Following this operation, each joint shall then be further cleaned by means of a powerful jet of compressed air.

No joints shall be filled when there is any free water in or adjacent to the joints. Joint walls and all surfaces to which the sealing compound is to be applied shall be surface dry for at least 3 hours prior to placing. No joints shall be sealed until the joints have been approved by the Engineer as being clean and dry in accordance with the foregoing provisions.

Joints shall be sealed with an approved joint sealing compound conforming to Federal Specifications for Sealer, Hot-Poured Type for Joints in Concrete (SS-S-164), or an approved elastic open-cell compression seal (M9.14.3).

The melting devices used for heating the joint sealing material shall be of the double boiler, indirect heating type using high flash oil for heat transfer. Constant mechanical agitation during the entire melting period shall be provided and no material shall be subjected for more than 60 minutes to the high temperature required for melting of the material. Positive temperature control (preferably by thermostat) of the heating medium of the sealing compound shall be provided at all times.

Hot-poured sealing compound shall not be subjected to temperatures in excess of 450 °F at any stage of the melting operation. Sealing material that has remained in the kettle in a molten state overnight will not be acceptable for use.

Hot-poured filler for use in sealing all joints, except expansion joints, shall be applied under pressure. When hot-poured filler is applied under pressure, the material shall be applied by means of a heavy duty air operated pump, or other approved device. The material shall be discharged through a suitable nozzle in such a way as to fill the joint opening solid and uniformly in a neat and workmanlike manner.

When the atmospheric temperature at the time of sealing is below 50 °F, the surface of the sealing compound in the finished joint shall be not less than 3/16 in. below the level of the pavement surface. Otherwise, the surface of the finished joint shall be within 1/4 of the pavement surface.

The sealing shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

In the event paving and construction operations must close down in the Fall because of cold weather and the contract cannot be completed until the following year, the Engineer shall require the Contractor to clean and seal all joints in the part of the pavement completed at the time of the shut-down, in the manner prescribed in this Specification. Under no circumstances shall any joint remain unsealed between the period of shut-down in the Fall and resumption of construction in the Spring.

476.74 Protection of Pavement.

The Contractor shall erect and maintain suitable barricades and employ watchmen to exclude traffic from the newly constructed pavement for the period herein prescribed. These barriers shall be so arranged as not in any way to interfere with or impede public traffic on any lane intended to be kept open. Necessary signs shall be maintained by the Contractor clearly indicating the open lanes to the public. When it is necessary to provide for traffic across the pavement, the Contractor shall construct at his entire expense, immediately after the finishing of the concrete, the necessary bridges over the pavement clear of the forms and at least 3 in. clear of the concrete and sufficiently strong to carry the traffic. He shall maintain these bridges until the concrete has attained the strength required in these Specifications for opening to traffic.

Prior approval shall be obtained from the Engineer for crossing of existing structures with the paving train.

When fixed-forms are not used, the Contractor shall be required to have available at all times, materials for the protection of the edges and surface of the unhardened concrete in order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened. Such protective materials shall consist of standard metal forms or wood plank having a nominal thickness of not less than 2 inches and a nominal width of not less than the thickness of the pavement at its edge for the protection of the pavement edges,

and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement.

An adequate quantity of the materials described above shall be available, loaded on vehicles which can be promptly driven or towed to the scene of paving operations and be located not more than one-half mile from the place where the paving operations are in progress.

When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

The Contractor shall have on hand at the paving site sufficient burlap or paper to cover at least 6,000 square feet of freshly laid pavement as a protection against sudden thunder showers or heavy downpours of rain.

Any part of the pavement damaged by traffic or other causes occurring prior to its final acceptance shall be repaired or replaced by and at the expense of the Contractor in a manner satisfactory to the Engineer. The Contractor shall protect the pavement against both public traffic and the traffic caused by his own employees and agents. The pavement shall be so protected until the beam test shows a strength of at least 550 lb. per square inch.

476.75 Opening to Traffic.

Upon completion of curing operations as specified, the pavement may be opened to traffic provided that beam tests show that the concrete has attained a modulus of rupture of at least 550 lb. per square inch. However, curing operations will not be considered completed unless a curing period of at least 7 days has elapsed since the concrete was placed.

Where high-early strength concrete is used, the pavement may be opened to traffic after a shorter period of curing or as beam tests show that the concrete has attained a modulus of rupture of at least 550 lb. per square inch.

476.76 Test Specimens.

Test specimens shall conform to the requirements of Subsection M4.02.13. They will be taken in the field from batches used in the pavement to determine the adequacy of control of the materials, the proportioning and mixing of the concrete and compliance with the minimum strength requirements. Test beams shall be 6" x 6" x 36" in length and shall be made, cured, and used in accordance with AASHTO Designations T-23 and T-97. At least two beams shall be made for each 2,000 sq. yd. or fraction thereof of pavement placed.

Payment for the forms, material and assistance as the Engineer may require to make, cure and test the field specimens will not be paid for directly but shall be included in the contract unit price for the pavement.

476.77 Tolerance in Pavement Thickness.

It is the intent of these Specifications that the pavement shall be constructed in accordance with the thickness shown on the plans. Before final acceptance of the work or during the progress of the work, as may be advisable or necessary, the thickness or depth of concrete pavement will be determined by cores taken by the Contractor under the direction of the Engineer or his designee, and unsatisfactory work shall be repaired, replaced, or will be paid for at an adjusted unit price. Where any pavement is found deficient in thickness, the following rules relative to replacement of the faulty pavement and adjustment of unit price shall govern.

The thickness of the pavement will be determined by average caliper measurement of cores tested in accordance with AASHTO Designation T-148.

For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined as not more than 1,000 linear feet of pavement in each traffic lane starting at the end of the pavement bearing the smaller station number. A traffic lane is defined as being between longitudinal joints or between a longitudinal joint and a pavement edge. The last unit in each lane shall be 1,000 ft. plus the fractional part of 1,000 ft. remaining.

One core will be taken at random in each unit by the Contractor.

When the measurement of the core from a unit is not deficient by more than 1/4" from the plan thickness, the pavement in the unit represented will be paid for at full unit price.

When such measurement is deficient by more than 1/4" but less than 1/2", two additional cores at intervals of not less than 300 ft. will be taken. The thickness of the unit will be considered to be the average of the three cores provided none is deficient by 1/2" or more. Payment for the pavement in the unit will be at an adjusted unit price as provided in Subsection 476.81.

In calculating the average thickness of the pavement, measurements in excess of the specified thickness will be considered as the specified thickness. Measurements which are less than the specified thickness by 1/2" or more will not be included in the average.

When any core is deficient by 1/2" or more, additional cores will be taken at 25 ft. intervals in each direction until a core is found in each direction that is deficient by less than 1/2". Each such exploratory core will represent the depth of 25 lineal feet of pavement one traffic lane in width. The pavement so represented will be deducted from the unit of pavement being measured and the remaining area cored and measured as described previously.

Pavement deficient by 1/2" or more but less than 3/4" may be accepted by the Engineer at no payment to the Contractor. However, the Contractor may, at his own expense, remove and replace the pavement, which will then be cored and measured for payment as herein provided.

Pavement deficient by 3/4" or more shall be removed and replaced by the Contractor at his own expense. Payment for such replaced pavement will be as provided herein.

Other areas such as intersections, entrances, crossovers, ramps, etc., will be considered as one unit and the thickness of each unit will be determined separately. Small irregular unit areas may be included as part of another unit. At such points as the Engineer may select in each unit, one core will be taken for each 2,000 sq. yd. of pavement, or fraction thereof, in the unit. Thickness of each unit will be determined as described previously except that when additional cores in any unit are required, they will be taken at locations as directed by the Engineer.

COMPENSATION

476.80 Method of Measurement.

Cement concrete pavement will be measured by the square yard and the quantity paid for shall be the number of square yards as determined by the actual area of the finished pavement, complete in place and accepted, but subject to adjusted proportional payment or non-payment as stated in Subsection 476.81 for all pavement areas found deficient in depth.

The width for measurement of the pavement shall be as shown on the typical cross sections, including additional widening where called for, or as otherwise directed in writing by the Engineer. The length will be measured *horizontally* along the center line of each roadway or ramp.

476.81 Basis of Payment.

Standard cement concrete pavement will be paid for at the contract unit price per square yard complete in place subject to price adjustments as set forth below. No additional payment over the unit contract price will be made for any pavement having an average thickness in excess of that shown on the plans. Average thickness shall be calculated as stated in Subsection 476.77. Where the average thickness of pavement is deficient in thickness by more than 1/4 inch, but less than 1/2 inch, payment will be made as follows:

CONCRETE PAVEMENT DEFICIENCY

Deficiency in Thickness, Determined by Cores	Proportional Part of Contract Prices Allowed
1/4 inch or less	100 percent
More than 1/4 inch. but less than 3/8 inch	80 percent
3/8 inch or more. but less than 1/2 inch	70 percent

Where core measurements indicate that the pavement is deficient in thickness by 1/2" but less than 3/4" the pavement may be accepted without any payment being made to the Contractor, or it may be replaced at the option of the Contractor with pavement of the specified thickness at his entire expense. If the deficiency in thickness is 3/4" or more, the Contractor shall be required to remove such deficient areas and replace them with cement concrete pavement conforming with all requirements of these Specifications and to the thickness shown on the plans. Such areas when accepted will then be duly included in the yardage for which payment shall be made at the contract unit price. The Contractor shall receive no compensation for materials or labor involved in removing and replacing deficient areas.

When high early strength concrete is specified at the direction of the Engineer, in order to expedite the opening of pavement to traffic, the high early strength will be obtained by means of an increase in the cement factor and a reduction of the water-cement ratio. The extra cement will be paid for at the actual unit cost per

barrel to the Contractor for the extra quantity of cement actually incorporated in the pavement, plus an allowance of 5 % of the cost per barrel, which cost shall include all equipment, labor storage, transportation and work incidental to its inclusion in the concrete and incorporation in the finished pavement.

476.82 Payment Items.

476. Cement Concrete Pavement	Square Yard

SECTION 485
GRANITE RUBBLE BLOCK PAVEMENT

DESCRIPTION

485.20 General.

This item of work shall consist of furnishing and setting granite rubble block pavement on a sand cushion on a concrete base course in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

485.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III. Materials:

Granite Rubble Block	M2.03.0
3,000 psi, 1½", 470 Cement Concrete	M4.02.00
Expansion and Contraction Joints	
Preformed Filler	M9.14.0
Hot Poured Joint Sealer	M3.05.0
Mortar	M4.02.15
Sand Borrow	M1.04.0. Type b

CONSTRUCTION METHODS

485.60 General.

The sub-base below the concrete base course shall be fine graded and thoroughly compacted after forms are in place: it shall be placed on compacted fill as required under Section 401.

485.61 Forms

Forms shall be placed if directed to the full depth of the combined granite rubble block, sand cushion, and concrete base. They shall be of wood, not less than nominal 2-inch thickness and dressed on all four sides. Forms shall be securely staked and braced and shall be constructed and set so as to resist the pressure of the concrete without springing out of alignment. They shall be oiled before use.

485.62 Placing Concrete.

Concrete shall be deposited with minimum rehandling and in one layer. Hand spreading and spading shall be done adjacent to forms and joints.

The concrete shall be struck off and float-finished. Protection and curing shall be done as required in Section 901. Placing of sand cushion and laying of granite rubble blocks shall not be done until at least 24 hours after the final curing period of the concrete base course.

The forms shall remain in place until the granite rubble blocks are laid, in order to confine the sand cushion and mortar.

485.63 Joints in Concrete.

Weakened plane transverse contraction joints shall be constructed in the concrete base course every 40 feet or as shown on the plans. These joints shall consist of surface slats 2 inches deep, varying in width from 3/8 inch at top to 1/4 inch at bottom.

Expansion joints shall be formed at all existing expansion joints of existing reinforced concrete surface where this surface is to be used as the base. Joints shall be 1/2 inch in width and shall be filled with preformed joint filler. All joints shall be sealed with joint filler compound.

485.64 Laying Blocks.

Blocks shall be carefully laid on a sand cushion over the concrete foundation as shown on the plans and as directed, and shall be solidly rammed in position. Joints between blocks shall be a maximum of 1 ½ inches and a minimum of 1-inch in width. Blocks shall be kept perfectly clean and joints between stones hall be clean and open to the full depth of blocks until the joint is filled with mortar.

After a sufficient area of block pavement has been laid the surface shall be tested with a 10 foot straight-edge laid parallel with the centerline and any variation exceeding 3/8 inch shall be corrected and brought to proper grade.

Stones disturbed in making replacements or correcting variations shall be settled into place by carefully ramming or tampering to grade by use of a hand tamper applied upon a 2-inch plank.

Each section of block surfacing must be acceptable to the Engineer before joints in that section are filled with mortar.

485.65 Filling Joints

Mortar shall be placed and worked in such a manner as to fill the joint to a depth ½" below the surface. The top surface of blocks shall be kept clean of mortar stains. Immediately after the mortar joints have set sufficiently the granite block pavement shall be swept clean and any marks on the top surface removed.

COMPENSATION

485.80 Method of Measurement

Granite rubble block pavement will be measured by the square yard for the work, complete in place.

485.81 Basis of Payment.

This work will be paid for at the contract unit price per square yard for Granite Rubble Block Pavement, complete in place.

485.82 Payment Items.

485.	Granite Rubble Block Pavement	Square Yard

SECTION 500
CURB AND EDGING

SECTION 501
CURB, CURB INLETS, CURB CORNERS AND EDGING

DESCRIPTION

501.20 General.

This item of work shall consist of furnishing and setting curb, curb inlets, curb corners and edging on a gravel foundation except for bridge curb which is set in full mortar bed and bituminous concrete curb which is placed on a bituminous concrete base, in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

501.40 General.

Materials shall conform to the requirements specified in the following Subsection of Division III, Materials:

Granite Curb	M9.04.1
Granite Curb Inlets	M9.04.5
Granite Curb Corners	M9.04.6
Granite Edging	M9.04.2
Mortar	M4.02.15
Gravel	M1.03.0 Type c
Anchors	M8.01.0
Cement Concrete Precast Units	M4.02.14
Joint Material	
Tar Impregnated Felted Paper	M9.06.2
Preformed Expansion Joint Filler	M9.14.0
Bituminous Concrete Curb, Types 1, 2 & 3	M3.12.0
Cement Concrete Curb	M4.02.00
Liquid Concrete Penetrant/Sealer	M9.15.0

CONSTRUCTION METHODS

501.60 Excavating Trench.

The trench for the curb shall be excavated to a width of 18 inches. The subgrade of the trench shall be a depth below the proposed finished grade of the curb equal to 6 inches plus the depth of the curbstone.

501.61 Preparing Foundation.

The foundation for the curb shall consist of gravel spread upon the subgrade and after being thoroughly compacted by tamping shall be 6 inches in depth.

The gravel foundation for edging shall be as shown on the plans and shall be thoroughly rammed or tamped until firm and unyielding.

The foundation for the curb inlet shall consist of a full bed of Portland cement mortar on the supporting back wall of the catch basin or gutter inlet and sufficient gravel on each side to support the overhang. The trench for the gravel foundation shall be at least 6 inches in depth and 18 inches in width. This trench shall be filled

vith gravel thoroughly tamped to the required grade.

The trench for the curb corner shall be excavated so that there shall be constructed a foundation of gravel vhich when thoroughly compacted will be 6 inches in depth, and extending 6 inches beyond the front and back of curb corner to the full depth of foundation. Other acceptable material may be used for backing.

501.62 Setting Curb and Edging.

Curbing, curb corners or edging shall be set on additional gravel spread upon the foundation.

All spaces under the curb, curb corners or edging shall be filled with gravel thoroughly compacted so hat the curb, curb corners or edging will be completely supported throughout their length. The curb shall be set at the line and grade required as shown on the plans unless otherwise directed.

Curb, curb corners or edging shall be fitted together as closely as possible except for VA5 curb which shall not fit closer to each other than 1/4 inch.

If curb, curb corners, curb inlets or edging of different quarries is used on the same project, curbing of each particular quarry shall be segregated and set to give uniform appearance.

501.63 Concrete Curb, Corners, and Edging.

A. General.

The curb shall consist of concrete castings moulded in place in sections 6 feet long, 24 inches in depth, 5 inches in width at the top, and 7 inches in width at the bottom and with front vertical face. The top front edge of curb shall be rounded to 3/4 inch radius. The ends of curb sections shall be chamfered 1/4 inch.

The edging shall consist of concrete castings conforming to the size and dimensions shown on plans. Straight-edging shall be cast in lengths of 4 feet. Edging for curves with radii-300 feet or less shall be straight edging but shall be cast in lengths less than 4 feet in order to avoid angles at joints. The ends of all edging shall be normal to the line of face. The edges of edging face shall be chamfered 1/4 inch.

Corners shall match the adjacent curb in size, color and finish. The front arris line shall extend through 1/4 of a circle having a radius of 2 feet or 3 feet respectively for Type A or Type B curb corner. The back arris line shall be straight. The plan of the back shall be normal to the top.

All forms shall be set true to lines and grades indicated on plans and as directed and held rigidly in proper position. They shall be either of metal or of acceptable planed and matched lumber of such construction that a smooth surface will be provided.

Expansion joints shall be formed at the intervals shown on the plans using preformed expansion joint filler having a thickness of 1/2 inch. When curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite or at expansion joints in the pavement.

B. Mixing and Placing Concrete.

The concrete shall be of such consistency and be so spaded and worked that a smooth mortar face will be produced.

C. Protection, Curing and Finishing of Concrete.

1. Protection. The forms shall be left in place for 24 hours or as directed until the concrete has set sufficiently so that they can be removed without injury to the castings. Particular care will be required to prevent any discoloration of the exposed surface.

2. Curing. When the concrete has hardened sufficiently the concrete shall be covered with acceptable burlap or other approved material and kept wet for 3 days or longer. Under extreme weather or other particular conditions proper curing shall be carried out as directed.

3. Finishing. The castings shall, immediately upon removal of the forms, be rubbed down to a smooth and uniform surface, but no plastering will be allowed. For this work a competent and skillful finisher shall be employed.

4. Protective Coating.. The Concrete Penetrant/Sealer shall conform to the requirements of M9.15.0. After the concrete is at least 14 days old and after a 48-hour minimum drying period (a longer period shall be required if castings do not appear dry) just prior to the time of treatment, the exposed surface shall be cleaned to remove all oil, grime and loose particles which would prevent the mixture from penetrating the concrete. Immediately before the application of the mixture, an air blast shall be directed over the surface to be treated so that all dust will be removed. Unless otherwise directed, the temperature of the concrete and air shall be 50°F. or higher at the time of application. 'For rate of application see Section M4.02.14D.

The second application of the surface treatment mixture shall not be made until the concrete, in the judgement of the Engineer, has regained its dry appearance.

Traffic shall be prohibited from the area until the concrete has regained its dry appearance.

501.64 Bituminous Concrete Curb.

The bituminous concrete mixture shall be placed and compacted with a machine acceptable and approved by the Engineer. The machine shall be capable of spreading the mixture true to line and grade and to the shape stipulated.

The bituminous concrete curb shall be placed as shown in the current Department Standards.

If at any time before the acceptance of the work any soft or imperfect spots develop in the exposed surface of the curb, such material placed shall be removed and replaced with new material and compacted, without additional compensation.

501.65 Filling About Trench.

After the curb, curb corners, curb inlets, and edging is set, the space between it and the wall of the trench shall be filled with gravel thoroughly tamped to the depth directed, care being taken not to affect the line or grade of the curb, curb corners, curb inlets and edging.

501.66 Bridge Curb.

On bridges, after the concrete base has set and before the concrete in back of the curb is placed, Type VA5 curb shall be set to line and grade in full mortar beds and full mortar end joints with the anchors in the stone grouted in place.

Each curb shall be brushed clean and free from loose particles, and thoroughly wetted with clean, fresh water before setting. The stone shall be carefully bedded in a full bed of mortar and in such a way as not to slide the stone on the mortar bed.

Each stone shall be held securely in position by 2 steel anchors. The anchors shall be of the required dimensions and shapes and shall extend 3 inches into the curb and 6 inches into the concrete. Care shall be taken in placing the concrete in back of the curb to avoid disturbing the line or grade of the curb.

Wherever plans indicate a construction joint in the sidewalk, or paraffin joint in coping, the curb shall be laid out so that a joint in the curb will be opposite the joint in the sidewalk, or coping.

501.67 Pointing.

The joints between curbstones (both front and back) or edging shall be carefully filled with cement mortar and neatly pointed on the top and front exposed portions. After pointing, the curbstones or edging shall be satisfactorily cleaned of all excess mortar that may have been forced out of the joints.

501.68 Transition Curb for Wheelchair Ramps

Transitions from normal curb settings to wheelchair ramps shall be accomplished with transition curb as directed. Transitions shall be of the same type curb and similar to that abutting and, if on a curve, of the same radius.

COMPENSATION

501.80 Method of Measurement.

The length of curb (except bituminous concrete curb) and edging shall be as measured along the front arris of the curb and edging, except that where the edging is set on a curve having a radius of 10 feet or less, the measurement will be made along the edging at the lowest exposed level after completion of shoulder or pavement.

The quantity of bituminous concrete curb to be paid for will be the length actually measured along curb at its lowest exposed edge or by tonnage actually used, complete in place.

Weight slips shall be countersigned upon delivery by the Engineer and slips not countersigned shall not be included for payment.

Each curb corner and curb inlet set, complete in place, will be considered one unit.

501.81 Basis of Payment.

Curb will be paid for at the contract unit price per linear foot under the item for the particular type of curb, complete in place.

Curved granite curb shall include all curb (except curb corners), cut to specified radius and set on curve.

The steel anchors used with Type VA5 curb will be paid for under the Item for VA5 curb.

Edging will be paid for at the contract unit price per linear feet for the particular type of edging, complete in place.

Where granite edging is set on a curve having a radius of 10 feet or less the work will be paid for at the contract unit price per linear foot, complete in place, under the respective item for the particular type of edging required.

Curb inlets will be paid for at the contract unit price each under the respective item for the particular type of inlet, either straight or curved, complete in place.

All curb corners will be paid for at the contract unit price for each, under the item for the particular type of corner required, complete in place.

The initial excavation, except Class "A" Rock, when done in conjunction with excavation for sub-base will be paid for under the item for Roadway Earth Excavation. The price of the curbing will include compensation for any other required excavation.

Gravel borrow for the foundations and backfilling will be paid for at the contract unit price per cubic yard under the item for Gravel Borrow.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic yard under the item for Class A Rock Excavation.

501.82 Payment Terms.

501.	Granite Curb Type VA1-Straight	Linear Foot
501.1	Granite Curb Type VA1-Curved	Linear Foot
502.	Granite Curb Type VA2-Straight	Linear Foot
502.1	Granite Curb Type VA2-Curved	Linear Foot
503.	Granite Curb Type VA3-Straight	Linear Foot
503.1	Granite Curb Type VA3-Curved	Linear Foot
504.	Granite Curb Type VA4-Straight	Linear Foot
504.1	Granite Curb Type VA4-Curved	Linear Foot
505.	Granite Curb Type VA5-Straight	Linear Foot
505.1	Granite Curb Type VA5-Curved	Linear Foot
506.	Granite Curb Type VB-Straight	Linear Foot
506.1	Granite Curb Type VB-Curved	Linear Foot
509.	Granite Transition Curb for Wheelchair Ramps-Straight	Linear Foot
509.1	Granite Transition Curb for Wheelchair Ramps-Curved	Linear Foot
510.	Granite Edging Type SA	Linear Foot
510.1	Granite Edging Type SA (Radius 10 Feet or less)	Linear Foot
511.1	Granite Edging Type SB-Straight	Linear Foot
512.1	Granite Edging Type SB (Radius 10 Feet or less)	Linear Foot
513.	Granite Edging Type SC	Linear Foot
513.1	Granite Edging Type SC (Radius 10 Feet or less)	Linear Foot
514.	Granite Curb Inlet-Straight	Each
515.	Granite Curb Inlet-Curved	Each
516.	Granite Curb Corner Type A	Each
517.	Granite Curb Corner Type B	Each
520.	Concrete Curb Type VA	Linear Foot
521.	Concrete Curb Corner Type A	Each
521.1	Concrete Curb Corner Type B	Each
522.	Concrete Edging Type SA	Linear Foot
570.1	Bituminous Concrete Curb Type 1	Linear Foot
570.2	Bituminous Concrete Curb Type 2	Linear Foot
570.3	Bituminous Concrete Curb Type 3	Linear Foot
572.1	Bituminous Concrete Curb Type 1	Ton
572.2	Bituminous Concrete Curb Type 2	Ton
572.3	Bituminous Concrete Curb Type 3	Ton
121.	Class A Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard

SECTION 580
CURB OR EDGING REMOVED AND RESET; REMOVED AND STACKED OR REMOVED AND DISCARDED

DESCRIPTION

580.20 General.

This work shall consist of removing the present curb, edging, curb corners and curb inlets of every type and cross section made of granite, concrete or granite-faced and resetting or stacking them or discarding them in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

580.40 Curb Edging, Curb Inlets and Curb Corners.

Curb, edging, curb inlets and curb corners shall consist of so much of the same as is suitable, in the Engineer's judgment to be reset or stacked.

580.41 Gravel.

Gravel shall conform to the requirements of Subsection M1.03.0 Type c of Division III, Materials.

CONSTRUCTION METHODS

580.60 Removal.

A trench of sufficient width and depth shall be excavated so that the present curb, edging, curb corners and curb inlets can be removed without damage.

580.61 Protection.

The Contractor shall protect all curb or edging and keep it in satisfactory condition until the acceptance of the entire contract. Particular care will be required to prevent any unsatisfactory discoloration of the curb or edging. The Contractor shall replace any existing curb, edging, curb corners and curb inlets that is to be reset, which is lost or damaged as a result of his operations, or because of his failure to store and protect it in a manner that would eliminate its loss or damage.

580.62 Adjustment.

The length of any section of curb or edging, shall be altered by cutting in order to fit closures as necessary. The ends of all stones shall be square with the planes of the top and face so that when the stones are placed end-to-end as closely as possible no space shall show in the joint at the top and face of more than 3/4 inch for the full width of the top and for 8 inches down on the face.

580.63 Relaying.

The Construction methods for resetting all curbing or edging, in the final location shall conform to the requirements of Subsections 501.60 to 501.62, 501.65 and 501.67.

580.64 Stacking.

The Contractor shall accept and hold entire responsibility for the removal, handling, stacking at a location convenient for removal by owner, and protection of all curbing or edging until its final removal as designated in accordance with the following:

Any curbing or edging damaged through lack of protection or carelessness by the Contractor shall

be replaced at his expense. The Contractor's responsibility will cease upon final acceptance of the work or 60 days from the time a certified notice, with copy to the Engineer, is sent by Contractor to owner of material that all material is available for removal.

580.65 Discarding.

Any curb, edging, curb corners and curb inlets not damaged through lack of protection or carelessness by the Contractor but deemed by the Engineer as unsatisfactory for relaying or stacking, will be discarded. It will be the Contractor's responsibility to dispose of any discarded curb, edging, curb corners and curb inlets without additional compensation.

COMPENSATION

580.80 Method of Measurement.

The quantity of curb and edging to be paid for will be the length actually removed and reset, and measured as specified in Subsection 501.80.

The quantity of curb or edging measured will be the length actually removed and stacked, and measured along the front arris line at the location stacked.

The quantity of curb or edging removed and discarded will be the length ordered to be removed and actually removed, but not included for payment under the items of Removed and Reset or Removed and Stacked.

Each curb inlet or curb corner removed and stacked or discarded will be considered as 1 unit.

Any remaining curb or edging removed which is not included for payment under the items listed above shall be classified as Earth Excavation (See Subsection 120.21).

580.81 Basis of Payment.

Removing and resetting curb and edging will be paid for at the contract unit price per linear foot of Curb Removed and Reset or Edging Removed and Reset at new location.

Removing and resetting curb inlets will be paid for at the contract unit price each for Curb Inlets Removed and Reset.

Removing and resetting curb corners will be paid for at the contract unit price each, Curb Corners Removed and Reset.

Removing and stacking curb or edging will be paid for at the contract unit price per linear foot under the respective item.

Removing and stacking of curb inlets and curb corners will be paid for under the items for Curb Inlets Removed and Stacked, and Curb Corners Removed and Stacked, respectively.

Removing and discarding curb or edging will be paid for at the contract unit price per linear foot under the respective item.

Removing and discarding of curb inlets and curb corners will be paid for under the items for Curb Inlets Removed and Discarded, and Curb Corners Removed and Discarded, respectively.

580.82 Payment Items.

580.	Curb Removed and Reset	Linear Foot
581.	Curb Inlet Removed and Reset	Each
582.	Curb Corner Removed and Reset	Each
583.	Edging Removed and Reset	Linear Foot
590.	Curb Removed and Stacked	Linear Foot
591.	Curb Inlet Removed and Stacked	Each
592.	Curb Corner Removed and Stacked	Each
593.	Edging Removed and Stacked	Linear Foot
594.	Curb Removed and Discarded	Linear Foot
595.	Curb Inlet Removed and Discarded	Each
596.	Curb Corner Removed and Discarded	Each
597.	Edging Removed and Discarded	Linear Foot
121.	Class A Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard

SECTION 600
HIGHWAY GUARD, FENCES AND WALLS

SECTION 601
HIGHWAY GUARD

DESCRIPTION

601.20 General.

This work shall consist of the construction of guard rail in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

The type of guard rail is designated as follows:

Highway Guard Steel Beam Type SS.

The construction of guard rail shall include the assembly and erection of all components parts and materials complete at the locations shown on the plans or as directed.

MATERIALS

601.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Steel Beam Highway Guard Type SS	M8.07.0

CONSTRUCTION METHODS

601.60 Posts.

Posts shall be set plumb, in hand or mechanically dug holes, or driven, then backfilled with acceptable material placed in layers and thoroughly compacted.

If driven the post shall be provided with suitable driving caps and equipment used which will prevent battering or injury of posts. Posts damaged or distorted as a result of driving shall be removed and replaced with approved posts.

Guard posts to be set in areas of proposed bituminous concrete surfacing shall be erected prior to laying the surrounding finished surface unless otherwise permitted by the Engineer.

601.61 Spacing of Posts.

Posts shall be spaced as shown on the plans.

601.62 Steel Beam Rail.

The rail shall be erected so as to form a smooth continuous rail conforming to the required line and grade. The rail element shall be spliced by lapping in the direction of the traffic or by other approved methods. The holes in the rail element nearer the posts shall be slotted to facilitate erection and to permit expansion. The rail shall make full contact at each splice.

All bolts, except where otherwise required at expansion joints shall be drawn tight. Bolts through expansion joints shall be drawn up as tightly as possible without being too tight to prevent the rail elements from sliding past one another longitudinally.

COMPENSATION

601.80 Method of Measurement.

Steel beam highway guard will be measured along the top edge of the rail element from center to center of end posts.

The unit of measurement of individual posts will be each post set complete in place.

Single faced steel beam terminal sections and double faced steel beam terminal sections will each be considered as a unit.

Buried ends will be measured as a unit for installation of the 37.5 feet of highway guard as directed.

Leading and Trailing ends will be measured as units for the 25 feet of highway guard, hardware and necessary work to complete installation as directed.

601.81 Basis of Payment.

Highway guard will be paid for at the contract unit price per linear foot.

Single faced and double faced steel beam terminal sections will be paid for at the contract unit price each under the items for Steel Beam Terminal Section (Single Faced) and Steel Beam Terminal Section (Double Faced) respectively.

Buried ends will be paid for at the contract unit price each.

Leading and trailing ends will be paid for at the contract unit price each.

Where posts occur in waterway aprons the cutting of holes and replacement of aprons shall be done without additional compensation.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic yard under the item for Class B Rock Excavation.

601.82 Payment Items.

602.	Individual Post	Each
620.1	St. Bm. Hwy. Guard-Type SS (Single Faced)	Linear Foot
620.3	St. Bm. Hwy. Guard-Type SS (Single Faced) (Curved)	Linear Foot
620.4	St. Bm. Hwy. Guard-Type SS Buried End (Single Faced)	Each
621.1	St. Bm. Hwy. Guard-Type SS (Double Faced)	Linear Foot
621.3	St. Bm. Hwy. Guard-Type SS (Double Faced) (Curved)	Linear Foot
621.4	St. Bm. Hwy. Guard-Type SS Buried End (Double Faced)	Each
622.1	St. Bm. Hwy. Guard-Type SS (Single Faced/Wood Posts)	Linear Foot
622.3	St. Bm. Hwy. Guard-Type SS (Single Faced/Wood Posts) (Curved)	Linear Foot
622.5	St. Bm. Hwy. Guard-Type SS Buried End (Single Faced/Wood Posts)	Each
624.1	St. Thrie Bm. Hwy. Guard-Type SS (Single Faced)	Linear Foot
624.3	St. Thrie Bm. Hwy. Guard-Type SS (Single Faced) (Curved)	Linear Foot
624.4	St. Thrie Bm. Hwy. Guard-Type SS Buried End (Single Faced)	Each
625.1	St. Thrie Bm. Hwy. Guard-Type SS (Double Faced)	Linear Foot
625.3	St. Thrie Bm. Hwy. Guard-Type SS (Double Faced) (Curved)	Linear Foot
625.4	St. Thrie Bm. Hwy. Guard-Type SS Buried End (Double Faced)	Each
626.1	St. Bm. Hwy. Guard-Type SS (Single Faced/SP Base Anch.)	Linear Foot
626.2	St. Bm. Hwy. Guard-Type SS (Double Faced/SP Base Anch.)	Linear Foot
626.3	St. Thrie Bm. Hwy. Guard-Type SS (Single Faced/SP Base Anch.)	Linear Foot
626.4	St. Thrie Bm. Hwy. Guard-Type SS (Double Faced/SP Base Anch.)	Linear Foot
627.1	St. Bm. Terminal Section (Single Faced)	Each
627.2	St. Bm. Terminal Section (Double Faced)	Each
627.3	St. Thrie Bm. Terminal Section (Single Faced)	Each
627.4	St. Thrie Bm. Terminal Section (Double Faced)	Each
627.5	Special St. Bm. Terminal Section (Single Faced)	Each
628.1	Leading End for St. Bm. Hwy. Guard at Bridge	Each
628.2	Trailing End for St. Bm. Hwy. Guard at Bridge	Each
628.	Leading End for St. Thrie Bm. Hwy. Guard at Bridge	Each
628.4	Trailing End for St. Thrie Bm. Hwy. Guard at Bridge	Each
144.	Class B Rock Excavation	Cubic Yard

SECTION 629
CONCRETE BARRIER

DESCRIPTION

629.20 General.

This item shall consist of furnishing and placing Portland cement concrete barrier on an accepted prepared subgrade or sub-base in accordance with these specifications and in reasonable close conformity with the lines, grades and dimensions shown on the plans.

MATERIALS

629.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Cement Concrete, 4000 psi, 3/4" 610	M4.02.00
Steel Reinforcement	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Preformed Joint Filler	M9.14.0
Concrete Penetrant/Sealer	M9.15.0
Demountable Reflectorized Delineators	M9.30.7

CONSTRUCTION METHODS

629.60 General.

Concrete barriers shall be either precast or cast-in-place and conform to Section M4 for 4000 psi, 3/4", 610 cement concrete masonry. Excavation for concrete barriers shall be made to the required depth and to a width that will permit the installation and bracing of forms where necessary. All soft and unsuitable material shall be removed and replaced with gravel borrow.

The subgrade shall be properly shaped and compacted as specified in Section 170.

The barrier shall be cured according to the relevant requirements of Subsection 476.71 and M4.02.14 as herein amended. If the water method is utilized, the units shall be kept moist for a period of seven days.

Under no condition will the use of a curing compound be permitted.

629.61 Precast Barrier.

The precast concrete barriers and transition pieces shall be in lengths of 10 feet and shall be subject to the approval of the Engineer for method of casting, handling and setting of the sections.

The reinforcing steel shall be in conformance with Subsection 901.61 and Subsection M8.01.7 of Division III — Materials, as modified to conform to ASTM Designation A615, Grade 60.

The 1 inch plain dowel bars shall conform to ASTM A36 and shall be galvanized according to AASHTO M111.

The units shall be manufactured in a plant approved by the Engineer and subject to his inspection and control.

The forms shall be constructed of steel or other approved material and are to conform to the design shown on the plans; wood forms will not be allowed. Reuse of old, worn or misshapen forms will not be allowed.

The form release material is to be applied to the forms in an approved manner and of a type that will not reduce the adhesive and or penetrating qualities of the protective coating (Concrete Penetrant/Sealer) to the concrete.

The dowel bars shall be accurately set true to a plane at right angles to the plane of the end of the unit.

Lifting holes or devices shall be as indicated on Construction Standards so that no undue stresses are transmitted to the units.

The units shall be cast with the forms in a 180 degree inverted position and compacted with an approved vibrator. Air holes are to be filled immediately after form removal to the satisfaction of the Engineer.

629.62 Cast-in-Place Barrier.

A. Conventionally Formed Barrier.

Forms shall be accurately set to the required line and grade, secured by a method not detrimental to the roadway pavement and maintained in a true position during concrete placement. Forms may be removed no sooner than 24 hours after placement of concrete.

A. Slipformed Barrier.

Concrete traffic barriers may be constructed by the use of slipform equipment provided that the finished barrier is true to the specified line and grade within a tolerance of ± 1/4 inch in 10 feet.

The barrier shall present a smooth, uniform appearance in its final position, and shall conform to the horizontal and vertical lines shown on the plans or as directed by the Engineer. Any unsatisfactory section of the barrier shall be removed and replaced at the Contractor's expense.

The concrete shall be vibrated and worked until adequately consolidated and free of honeycomb. The concrete shall be of such consistency after slipforming that it will maintain the shape of the barrier without support. Prior to the beginning of operations, the Contractor shall insure that a continuous supply of concrete is available to the slipform machine to minimize starting and stopping. The slump of concrete shall not exceed 1½ inches unless directed otherwise by the Engineer.

The slipform machine shall be guided by vertical and horizontal sensors that ride along a wire line. A grade line gauge or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line. The slipform machine shall not exceed the speed recommended by the manufacturer. In lieu of sensor controls, the slipform machine may be operated on rails or supports set at the required grade.

629.63 Concrete Median Barrier Cap.

The work consists of constructing a four (4) inch thick cast-in-place cap between the single face median barriers as shown on the plans.

The cap shall be cast in place on a gravel foundation with the length of each section being 30 feet. A 1/2 inch premolded joint filler will be placed between these 30 foot sections. A 1/2 inch premolded joint filler will be placed around bridge pier columns and along the joints between the barrier and the cap where required.

629.64 Placement of Barriers.

Precast concrete barrier units shall be placed on a previously compacted gravel foundation utilizing two (2) 4″ by 8″ by 24″ concrete leveling blocks set flush with the top of the gravel to control setting of the unit to the proper grade.

The Contractor shall schedule his operation and sequence of installation of the barriers so that a minimum amount of closure pieces will be required.

Expansion and construction joints shall be as shown on the Construction Standards.

Any units showing cracks or other damages due to curing, transportation, installation or other acts of the Contractor shall be removed and replaced by the Contractor at no additional compensation.

629.65 Concrete Penetrant/Sealer.

Concrete Penetrant/Sealer shall be applied to the exposed faces of the cement concrete barriers and concrete median barrier cap by the method described below and as directed by the Engineer.

The compound shall conform to the provisions of Subsection M9.15.0 and shall not be applied sooner than 28 days after the concrete has been poured and finished. The compound shall not be applied when the air temperature is below 50 °F. unless otherwise directed; the compound is not to be heated.

All of the surfaces that are to be treated shall be dry and cleaned of all dust, dirt, form oil, and debris by sweeping, sand blasting or air blasting.

All joints that are to be filled with a joint sealer are to be shielded from contact with the concrete penetrant/sealer with tape or other suitable protective measures approved by the Engineer.

The compound is to be applied in accordance with the manufacturers specifications.

629.66 Delineators.

Delineators shall be installed in conformance with manufacturer's recommendations at beginnings and ends of each continuous run of barrier with intermediate placement at 80 foot intervals.

Two sided amber reflectors shall be mounted on top of double faced median barriers.

Single faced barriers shall have side mounted installation with amber color delineating left edge, white

color delineating right edge and red color backing on each.

Delineators shall be mounted at appropriate angles which provide maximum reflectorization.

COMPENSATION

629.80 Method of Measurement.

Concrete Barrier — Single Faced will be measured by the linear foot along the face of the barrier at the gutter line.

Concrete Median Barrier — Double Faced will be measured by the linear foot along the center line of top of barrier.

Cast-in-place median barrier cap concrete will be measured by the cubic yard in place.

629.81 Basis of Payment.

Concrete Barrier will be paid for at the contract unit price per linear foot which includes full compensation for all labor, equipment; materials including concrete penetrant/sealer, delineators, reinforcing steel, premoulded filler, concrete leveling blocks and all incidental work necessary to complete the work as specified.

Cast-in-place Concrete Median Barrier Cap will be paid for at the contract unit bid price per cubic yard. This unit price shall include full compensation for all labor, tools, equipment, materials, including concrete penetrant/sealer, reinforcing steel and premoulded joint filler and all incidental work necessary to complete the work as specified.

Gravel borrow for the foundation of the barriers and between the sections will be paid for under Item 151; Gravel Borrow.

629.82 Payment Items.

629.1	Precast Concrete Barrier — Single Faced	Linear Foot
629.2	Precast Concrete Median Barrier — Double Faced	Linear Foot
629.3	Cast-in-Place Concrete Barrier — Single Faced	Linear Foot
629.4	Cast-in-Place Concrete Median Barrier — Double Faced	Linear Foot
629.5	Cast-in-Place Median Barrier Cap	Cubic Yard
151.	Gravel Borrow	Cubic Yard

SECTION 630
HIGHWAY GUARD REMOVED AND RESET: REMOVED AND STACKED

DESCRIPTION

630.20 General.

This work consists of removing present highway guard (including individual post), resetting in accordance with these specifications and in close conformity with established lines and grades, or stacking them as directed.

MATERIALS

630.40 General.

The materials removed shall be utilized in the highway guard as reset except, where necessary, new posts shall be furnished by the Contractor. Any posts removed and found unsuitable for use in resetting shall be

replaced with new posts and paid for under the item of New Posts in Highway Guard Removed and Reset. Any materials damaged or lost during or subsequent to removal shall be replaced by the Contractor without compensation.

All new materials required shall be equal in all respects to the materials in the present highway guard.

CONSTRUCTION METHODS

630.60 Removal.

The present highway guard shall be carefully removed together with all fittings, anchors and appurtenances and stacked and preserved safe from damage or loss. Old post holes shall be backfilled with suitable material and satisfactorily compacted.

630.61 Erection.

Before resetting, the portion of the posts below the ground surface shall be cleaned. The highway guard shall be reset plumb on the new location lines and to the grades required. Backfilling around the highway guard posts shall consist of suitable material satisfactorily compacted. If the highway guard posts were originally set in concrete they shall be reset in their new locations in concrete.

630.63 Stacking.

The Contractor shall accept and hold the responsibility for the removal, handling, stacking at a location convenient for removal by owner and protection of all anchors, posts, cables, fittings, etc. until final removal by others as designated and in accordance with the following:

Any anchors, posts, cables, fittings, etc., lost or damaged through lack of protection or carelessness by the Contractor shall be replaced with satisfactory material in kind at his expense.

Materials stacked shall be stored in neat piles that will be convenient for removal by the owner. The Engineer will determine the size and location of the piles of stacked material.

The Contractor's responsibility will cease upon final acceptance of the work, or 60 days from the time a certified notice (with copy to Engineer) is sent by Contractor to owner of material that all material is available for removal.

COMPENSATION

630.80 Method of Measurement.

The measurement of Highway Guard Removed and Reset will be made in its final position from center to center of end post to which the guard is attached, along the top edge of rail element. Any remaining Highway Guard not required to be stacked shall become the property of the Contractor and shall be removed from the work without additional compensation.

Highway Guard Removed and Stacked will be measured in its original position and the quantity to be paid for will be the length actually removed and stacked. Measurement will be from center to center of end posts to which guard is attached, along the scale or the top edge of rail elements.

630.81 Basis of Payment.

Removing and resetting highway guard will be paid for at the contract unit price per linear foot of Highway Guard Removed and Reset, complete in its final position.

New posts will be paid for at the contract unit price each for New Posts in Highway Guard Removed and Reset in addition to the payment for Highway Guard Removed and Reset.

Removing and resetting individual posts will be paid for at the contract unit price each for Individual Posts Removed and Reset, complete in place.

Removing and stacking of highway guard will be paid for at the contract unit price per linear foot of Highway Guard Removed and Stacked.

Removing and stacking of anchors will be paid for at the contract unit price each for Anchors Removed and Stacked.

Removing and stacking individual posts will be paid for at the contract unit price each for Individual Posts Removed and Stacked, except when such posts are included in payment for Anchors Removed and Stacked.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic yard under the item for Class B Rock Excavation.

630.82 Payment Items.

*630.	Highway Guard Removed and Reset	Linear Foot
632.	Individual Post Removed and Reset	Each
633.	New Post in Highway Guard Removed and Reset	Each
635.	Highway Guard Removed and Stacked	Linear Foot
636.	Anchor Removed and Stacked	Each
637.	Individual Post Removed and Stacked	Each
144.	Class B Rock Excavation	Cubic Yard

*Where more than one type of Highway Guard Removed and Stacked are included in the Contract, a decimal will be added to the item number to distinguish between the different types.

SECTION 639
WOVEN WIRE FENCE AND GATES

DESCRIPTION

639.20 General.

This work consists of the construction of woven wire fence and/or gates of the height stipulated in accordance with these specifications and in close conformity with the lines and grades shown on the plan or as established by the Engineer.

MATERIALS

639.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Woven Wire Fence	M8.09.1

CONSTRUCTION METHODS

639.60 Posts.

At the beginning and end of all sections of woven wire fence, at all gates and at intermediate brace posts, not more than 600 feet apart, the post shall be firmly and securely braced in a concrete base.

Line posts shall be driven or set to the required depth and the tops shall be cut off at uniform height.

Line posts that would be unstable due to soil conditions, shall be set in a concrete base. The concrete base, when required for Line Posts, will be paid for under Item 901.3 4000 psi, 1½", 565 Cement Concrete Masonry for Post Foundation per cubic yard and shall include all excavation necessary except Class B Rock Excavation.

Where solid rock is encountered without an overburden of soil, line posts shall be set a minimum depth of 8 inches, and end, corner, gate and intermediate brace posts a minimum of 12 inches into the solid rock. The hole shall have a minimum width or diameter of one inch greater than the largest dimension of the post section to be set. The posts shall be cut, before installation to lengths which will give the required length of post above ground, or if the Contractor so elects he may use an even length of post above ground, or if the Contractor so plans, he may use an even length at post set at greater depth into the solid rock.

After the post is set and plumbed the hole shall be filled with grout consisting of one part Portland cement and one part clean, well graded sand. The grout shall be thoroughly worked into the hole so as to leave no

voids. Where posts are set in the above manner, concrete footings will not be required.
Where solid rock is covered by an overburden of soil or loose rock, the posts shall be set to the full depth shown on the standard drawing unless the penetration into solid rock reaches the minimum depths specified above, in which case the depth of penetration may be terminated. Concrete footings shall be constructed from the solid rock to the top of the ground as designated. Grouting will be required on the portion of the posts in solid rock.

Intermediate Brace Posts are used in these specifications shall be braced in the manner shown on the standard drawing and spaced at 600-foot maximum intervals.

Gate, end, corner and intermediate brace posts shall be braced in the manner shown on the standard drawing. Changes in line of 30 degrees or more shall be considered as corners.

Forms for placing concrete bases will not be required. Chamfer or bevel edges will not be required.

639.61 Fence Fabric.

The fence fabric shall be strung taut upon the posts so set and fastened in an approved manner. All line wires are to be spliced in conformance with approved standards.

639.62 Gate.

Opening for the installation of gate shall be left as directed. Gate shall be erected as shown on the plans or as directed.

COMPENSATION

639.80 Method of Measurement.

Woven wire fences will be measured in place from outside to outside of end posts and shall be the length of fence actually constructed.

Woven wire fence gate with gate posts, complete in place, will be considered as one unit.

639.81 Basis of Payment.

All woven wire fence will be paid for at the contract unit price per linear foot of Woven Wire Fence, complete in place, which shall include all line posts, fasteners and/or clips and necessary materials and equipment to complete the work in a satisfactory manner.

Gates will be paid for at the contract unit price per linear foot for Woven Wire Fence Gates with Gate Posts, complete in place.

End posts, including brace and concrete base, will be paid for at the contract unit price each under the Item for Woven Wire Fence End Post, complete in place. Corner and intermediate brace posts, including braces and concrete bases, will be paid for at the contract unit price each for Woven Wire Fence Corner or Intermediate Brace post, complete in place.

Rock excavation, if required, will be paid for at the contract unit price per cubic yard under the item for Class B Rock Excavation.

4000 psi, 1½", 565 Cement Concrete Masonry for Post Foundation, if required, will be paid for at the contract unit price per cubic yard under Item 901.3.

639.82 Payment Items.

*639.	— —In. Woven Wire Fence (Line Post-Option)	Linear Foot
*639.1	— —In. Woven Wire Fence (Steel Line Post)	Linear Foot
*639.2	— —In. Woven Wire Fence (Alum. Line Post)	Linear Foot
*639.3	— —In. Woven Wire Fence End Post	Each
*639.4	— —In. Woven Wire Fence Gate/Gate Posts	Linear Foot
*639.5	— —In. Woven Wire Fence Corner or Intermediate Brace Post	Each
144.	— —Cl. B Rock Excavation	Cubic Yard
901.3	— —4000 psi, 1½", 565 Cement Concrete Masonry for Post Foundation	Cubic Yard

*The height of fence or gate shall be added to the whole figure.

SECTION 644
CHAIN LINK FENCE AND GATES

DESCRIPTION

644.20 General.

This work shall consist of the construction of chain link fence and gates in accordance with these specifications, and in close conformity with the lines and grades shown on the plan or established by the Engineer.

Chain link fence shall be either Type 1 Zinc-Coated Steel or Type 2 Aluminum-Coated Steel.

MATERIALS

644.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Chain Link Fences and Gates	M8.09.0
Bonded Vinyl Coated Chain Link Fences, Posts, Rails, Fabric, Gates and Accessories	M8.09.2
4000 psi, 1½", 565 Cement Concrete Bases	M4.02.00
Paint, High Zinc Dust Content — Galvanizing Repair	M7.04.11

CONSTRUCTION METHODS

644.60 General.

The posts shall be set true to the line and grade of the proposed fence.

End, Corner and Intermediate Brace Posts shall be set in concrete bases as shown in the Construction Standards.

The posts in masonry walls shall be set in pipe sleeves or sockets.

All line posts, except those which are unstable due to soil condition as described hereinafter, shall have drive anchor assemblies as shown in the Construction Standards.

Line Posts, which in the opinion of the Engineer are unstable due to soil condition, (such as in swamps or seasonal wet areas) shall be placed in a concrete base as shown in the Construction Standards.

Where solid rock is encountered without an overburden of soil, line posts shall be set a minimum depth of 8 inches, and end, corner, gate and intermediate posts a minimum of 12 inches in the solid rock. The hole shall have a minimum width or diameter of one inch greater than the largest dimension of the post section to be set. The posts shall be cut, before installation to lengths which will give the required length of post above ground, or if the Contractor so elects he may use an even length of post above ground, or if the Contractor so elects he may use an even length of post set at greater depth into the solid rock.

After the post is set and plumbed the hole shall be filled with grout consisting of one part Portland cement and one part clean, well graded sand. The grout shall be thoroughly worked into the hole so as to leave no voids. Where posts are set in the above manner, concrete footings will not be required.

Where solid rock is covered by an overburden of soil or loose rock, the posts shall be set to the full depth shown on the standard drawing unless the penetration into solid rock reaches the minimum depths specified above, in which case the depth of penetration may be terminated. Concrete footings shall be constructed from the solid rock to the top of the ground as designated. Grouting will be required on the portion of the posts in solid rock.

Intermediate Brace Posts as used in these specifications, shall be spaced at 500-foot maximum intervals.

Gate, end, corner, and intermediate brace posts shall be braced as shown on the standard drawing. Changes in line of 30 degrees or more shall be considered as corners.

644.61 Foundation Bases.

Forms for placing concrete bases will not be required. Chamfer or bevel edges will not be required.

Where chain link fences are used to enclose Engineers field office and material buildings, the posts shall be set in ground without concrete bases to facilitate ease in removal later.

644.62 Top Rail.

Top rails shall pass through the ornamental tops of line posts, forming a continuous brace from end to end of each stretch of fence. Lengths of top rail shall be jointed by sleeve type couplings. Top rails shall be securely fastened to terminal posts by pressed steel fittings.

On curves with a radius of less than 500 feet the top rail shall be bent true to the curve.

644.63 Top Tension Cable.

Top tension cable shall pass through the ornamental top of the line posts. One continuous length of cable shall be used between pull posts. The cable shall pass through the pull post top and down to the base of the next line post where it shall be attached to the base of line post with a turnbuckle. Sufficient tension shall be applied to the cable to allow a maximum sag of 1/4 inch between posts after the chain link mesh has been attached to the cable. The Contractor shall provide temporary bracing on intermediate brace posts when applying tension to one length of cable at a time, to prevent undue stresses in the intermediate brace post.

After tension has been applied to the cables, a wire rope clip shall be placed around both cables one on each side of the intermediate brace posts, and the clips securely tightened. Clips shall be placed as close to the posts as possible to minimize the deflection of the post if one of the cables should be parted.

The cable shall be fastened to the top of the end intermediate brace post with an eye bolt through the post and a turn-buckle connecting the eye bolt to the cable. The end intermediate post shall be braced to the bottom of the end post with a short length of cable attached. A length of cable shall connect the end intermediate brace post and the end post at the top.

Eye bolts shall have a shoulder on the eye end and shall be provided with a nut and lock washer. Where the eye bolt is to be installed through a pipe section, 2 lead washers shall be placed against the shoulder of the eye, and a lead washer backed and the nut tightened sufficiently to seal the hole in the pipe.

A galvanized iron strap 1/4 inch in thickness by 2 inches in width, formed as shown on the standard drawing, shall be provided for the attachment of eye bolts to the base of "H" column post in order to take the strain of the cable tension off the web of the "H" column.

All holes drilled in steel post sections shall be cleaned and painted before the eye bolts are installed with 2 coats of paint, High Zinc Dust Content — Galvanizing Repair (M7.04.11).

The ends of all cables shall be seized with annealed iron wire passed around the end of cable and the line cable. The seizing shall be at least 1 inch in width.

644.64 Spring Tension Wire.

Spring tension wires shall be placed ten inches (10″) from the top and bottom of the line posts, corner posts, end posts and intermediate brace posts. The spring tension wire shall be fastened to each line post with No. 6 gauge steel clip.

The wires shall be fastened to end posts, corner posts and intermediate brace posts with an end band and minimum of five (5) turns around the spring tension wire to end the installation. One continuous length of spring tension wire shall be used between intermediate brace posts (500′).

Sufficient tension shall be applied to create a tension in the spring tension wire so that no sag is visible. On completion of the installation the spring tension wire shall be attached to the fence fabric with hog rings of No. 11 gauge placed every twelve (12) inches ± top and bottom.

644.65 Fence Fabric.

Chain link fabric over 5 foot fence shall be placed on the face of the post away from the highway, and for fence 5 feet or less, erect fabric on the face of the posts designated by the Engineer, except that on curves the fabric on all types of fence shall be placed on the face of the post which is on the outside of the curve.

The chain link fabric shall be placed approximately 2 inches above the ground and on a straight grade between posts.

The fabric shall be stretched taut and securely fastened to the posts. Stretching by motor vehicle will not be permitted. Fastening to end, gate, corner, and intermediate brace posts shall be with stretcher bars and fabric bands spaced at one foot intervals. The fabric shall be cut and each span attached independently at all intermediate brace and corner posts. Fastening to post, top rail, top tension cable or spring tension wire shall be with wire, metal bands, hog rings, or by other approved method.

Rolls of wire fabric shall be joined by weaving a single strand into the ends of the rolls to form a continuous mesh.

644.66 Gates.

Chain link fabric shall be fastened to the end bars of the gate frame by stretcher bars and fabric bands, and to the top and bottom bars of the gate frames by tie wires in the same manner as specified for the chain link fence fabric; or by other standard methods if approved by the Engineer.

The height of the gate frame shall be approximately as follows:

6′ Fence 5′6″ 4′ Fence 3′6″
5′ Fence 4′6″ 3′ Fence 2′6″

COMPENSATION

644.80 Method of Measurement.

Chain link fence will be measured, approximately parallel to the ground by the linear foot of completed fence, exclusive of openings from outside of to outside of end posts.

Gates with gate posts will be measured between centers of the gate posts.

644.81 Basis of Payment.

Chain Link Fence will be paid for at the contract unit price per linear foot, complete in place, except for rock excavation, which shall include all drive anchors, line posts, fabric, top rail, cable or wire, fasteners, clips and all material and equipment necessary to complete the work in a satisfactory manner. Allowance for rock excavation will be as specified under Class B Rock Excavation.

Gates with Gate Posts will be paid for at the contract unit price per linear foot of the height specified and the respective widths shown on the plans complete in place. Allowance for rock excavation will be made as specified under Class B Rock Excavation.

End post including brace will be paid for at the contract unit price each under item for Chain Link Fence End Post, complete in place. Corner and intermediate brace post will be paid for at the contract unit price each for Chain Link Fence Corner and Intermediate Brace Post, complete in place. The chain link fence posts shall be of the type used throughout the installation.

Concrete bases for line posts, if required, shall be paid for under Item 901.3 4000 psi, 1½″, 565 Cement Concrete Masonry for Post Foundation, which shall include the excavation, except rock excavation, which shall be paid under Class B Rock Excavation.

644.82 Payment Items.

*644.1	In. Chain Link Fence (Spring Tension Wire) Ty 1 — (Line Post — Option)	Linear Foot
*644.2	In. Chain Link Fence (Spring Tension Wire) Ty 2 — (Line Post — Option)	Linear Foot
644.3	In. Chain Link Fence (Spring Tension Wire) Vinyl Coated — (Line Post — Option)	Linear Foot
*645.1	In. Chain Link Fence (Pipe Top Rail) Ty 1 — (Line Post — Option)	Linear Foot
*645.2	In. Chain Link Fence (Pipe Top Rail) Ty 2 — (Line Post — Option)	Linear Foot
645.3	In. Chain Link Fence (Pipe Top Roll) Vinyl Coated — Line Post — Option)	Linear Foot
*646.1	In. Chain Link Fence (Cable Top) Ty 1 — (Line Post — Option)	Linear Foot
*646.2	In. Chain Link Fence (Cable Top) Ty 2 — (Line Post — Option)	Linear Foot
646.3	In. Chain Link Fence (Cable Top) Vinyl Coated — (Line Post — Options)	Linear Foot
*647.1	In. Chain Link Fence (Pipe Top Rail) With Barbed Wire Ty 1 — (Line Post — Option)	Linear Foot
*647.2	In. Chain Link Fence (Pipe Top Rail) With Barbed Wire Ty 2 — (Line Post — Option)	Linear Foot
*648.1	In. Chain Link Fence (Cable Top) With Barbed Wire Ty 1 — (Line Post — Option)	Linear Foot
*648.2	In. Chain Link Fence (Cable Top) With Barbed Wire Ty 2 (Line Post — Option)	Linear Foot
*649.1	In. Chain Link Fence (Spring Tension Wire) With Barbed Wire Ty 1 (Line Post — Option)	Linear Foot

*649.2	In. Chain Link Fence (Spring Tension Wire) With Barbed Wire Ty 2 (Line Post — Option)	Linear Foot
*650.1	In. Chain Link Gate, Type 1 With Gate Posts	Linear Foot
*650.2	In. Chain Link Gate, Type 2 With Gate Posts	Linear Foot
*651.1	In. Chain Link Gate, Type 1 With Gate Posts and Barbed Wire	Linear Foot
*651.2	In. Chain Link Gate, Type 2 With Gate Posts and Barbed Wire	Linear Foot
*652.	In. Chain Link Fence End Post	Each
*653.	In. Chain Link Corner and Intermediate Brace Post	Each
*654.	In. Chain Link Fence Fabric	Linear Foot
144.	Class B Rock Excavation	Cubic Yard
901.3	4000 psi, 1½", 565 Cement Concrete Masonry for Post Foundation	Cubic Yard

*Insert height of fence or gate at beginning of nomenclature, item number will reflect this height when possible.

When option is stipulated in above items the Contractor will be required to indicate his choice.

SECTION 660
METAL PIPE RAIL

DESCRIPTION

660.20 General.

This work shall consist of the construction of metal pipe rail in accordance with these specifications and in close conformity with the lines and grades shown on the plan or established by the Engineer.

MATERIALS

660.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Rails and Posts	M8.10.0A
Fittings	M8.10.0B
Lead Wood	M8.10.0C
Bitumen	M8.10.0D
Paint (Primer Coat)	
Zinc Dust-Zinc Oxide	M7.04.07
Basic Lead Silico Chromate	
Intermediate Paint	M7.02.06
Paint (Finish Coat)	
Enamel	M7.03.02

CONSTRUCTION METHODS

660.60 Fabrication and Erection.

All posts shall be set vertical. In setting the posts precautions shall be taken to insure proper alignment and leveling to prevent springing or bending the railing in erecting.

All railings shall be straightened as required before setting up. All horizontal pipes shall be provided with approved expansion couplings at intervals of not more than 50 feet.

Welding shall conform to the requirements of Subsection 960.61.

After erection and welding all welds shall be cleaned and coated with a spot coat of M7.04.07 (TT-P-641G,

Type 11 Primer Coating: Zinc Dust-Zinc Oxide).

The fabricator shall be on the Department's approved fabricator's list.

660.61 Painting.

After erection and welding the completed rail shall be painted with one (1) coat of M7.04.07 and a color coat of M7.03.02, Color No. 10075. Painting shall conform to Subsection 960.63.

COMPENSATION

660.80 Method of Measurement.

The pipe rail will be measured in place and the quantity to be paid for will be the length as constructed outside to outside of end posts or top rail whichever is the greater.

660.81 Basis of Payment.

The pipe rail will be paid for at the contract unit price per linear foot under the item for Metal Pipe Rail, complete in place.

660.82 Payment Items.

660.	Metal Pipe Rail	Linear Foot

SECTION 665
FENCES AND GATES REMOVED AND RESET: REMOVED AND STACKED

DESCRIPTION

665.20 General.

This work shall consist of removing present fences and gates and resetting or stacking them in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

665.40 General.

The materials removed shall be utilized in the fence and gates for resetting except, where necessary, new posts and bases shall be furnished by the Contractor. Any materials missing, damaged or lost during or subsequent to removal shall be replaced by the Contractor without additional compensation.

All new materials required shall be equal in quality and design to the materials in the present fence or gates.

CONSTRUCTION METHODS

665.60 Removal.

The present fences and gates together with all appurtenances shall be carefully removed and satisfactorily stored and protected until required for resetting. Old post holes shall be backfilled with suitable material properly compacted.

665.61 Erection.

Fences shall be reset plumb on the new line and grade as required and shall conform to the original fence or as the Engineer directs. Backfilling around the posts shall consist of suitable material satisfactorily compacted. If the fence posts were originally set in concrete bases they shall be reset in their new locations in concrete bases, conforming to M4.02.00 for 4000 psi, 1½", 565 Cement Concrete.

If repainting of fences which have been painted originally is required, such work shall be done as directed.

Gates shall be reset where and as directed. Painting, if required, shall be done as directed.

665.62 Stacking.

The fencing, posts, braces and gates shall be carefully removed from their present locations, transported and stacked neatly on wooden planks at the locations directed on the project, to be available and convenient for final removal from the project by the owner.

The Contractor will be held responsible for the fencing, posts, braces and gates, and any damage to same prior to final removal from the project, but the Contractor's responsibility will cease upon final acceptance of the work, or 60 days from the time a certified notice (with copy to the Engineer) is sent by Contractor to owner of material that all material is available for removal.

COMPENSATION

665.80 Method of Measurement.

The measurement of Fences Removed and Reset, shall be made in the final position from outside to outside of end posts or top rail whichever is the greater. Any remaining fence not required to be stacked shall become the property of the Contractor and shall be removed from the work without additional compensation.

Fences Removed and Stacked will be measured in its original position and the quantity to be paid for will be the length actually removed and stacked, including wooden gates.

Gates with gate posts removed and reset, complete in place, will be considered as a unit.

Chain Link Gates with gate posts removed and stacked will be considered as a unit.

665.81 Basis of Payment.

Removing and resetting fences will be paid for at the contract unit price per linear foot of Fences Removed and Reset, complete in their final positions.

Removal and resetting of gates with gate posts will be paid for at the contract unit price each under the respective item.

Removing and stacking fencing will be paid for at the contract unit price per linear foot of fences removed and stacked.

Removing and stacking of chain link gates with gate posts will be paid for under the item for Chain Link Gates (*inch) with Gate Posts Removed and Stacked.

Allowance for rock, if not already paid for under previous rock excavation, shall be made in accordance with the provisions as stipulated under Class B Rock Excavation.

665.82 Payment Items.

665.	Fence Removed and Reset	Linear Foot
*666.	Inch Chain Link Fence. Removed and Reset	Linear Foot
*667.	In. Chain Link Fence Gate with Gate Posts Removed and Reset	Each
668.	Iron Fence Removed and Reset	Linear Foot
669.	Stock Fence Gate Removed and Reset	Each
670.	Wood Gate Removed and Reset	Each
671.	Fence Removed and Stacked	Linear Foot
*672.	In. Chain Link Fence Removed and Stacked	Linear Foot
*673.	In. Chain Link Gate with Gate Posts Removed and Stacked	Each
144.	Class B Rock Excavation	Cubic Yard

*Height to be inserted.

SECTION 685
FIELD STONE MASONRY

DESCRIPTION

685.20 General.

This work shall consist of the construction of field stone masonry consisting of angular blasted or field stones having straight edges, but with faces not necessarily rectangular in shape, laid either in cement mortar or dry in accordance with these specifications, and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

685.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Stone for Field Stone Masonry	M9.04.4
Mortar	M4.02.15

CONSTRUCTION METHODS

685.60 Shaping Stones.

Selected stone, roughly shaped to provide suitable exposed faces, shall be used at all angles and ends of walls.

All shaping of stone shall be done before the stone is laid in the wall. If a stone is loosened after the mortar has set, it shall be removed, the mortar cleaned off and the stone relaid in fresh mortar.

685.61 Headers.

Headers shall occupy at least 1/4 the face area of the wall and shall be evenly distributed. Headers in walls 2 feet or less in thickness shall extend entirely through the wall.

685.62 Laying Stone.

The masonry shall be laid and the face pattern shall be of uniform appearance throughout. The stones shall decrease in size from bottom to top of wall.

The stones shall be laid on horizontal beds parallel to the natural bed of the stone. Vertical joints shall be broken by at least 6 inches and no vertical joint shall be located directly above or below a headers.

Each stone to be set in mortar shall be cleaned and thoroughly wetted before being set. They shall be set on full beds of mortar, and mortar joints shall be full and the stone settled in place before the mortar has set.

The wall shall be compactly laid having all interior joints completely filled with suitable stones or spalls thoroughly bedded in mortar.

685.63 Tree Wells.

Where directed, dry field stone masonry walls shall be constructed around the trunks of trees in order to support the embankment in conformity with the standard design shown on the plans and as directed.

COMPENSATION

685.80 Method of Measurement.

Field stone masonry will be measured by the cubic yard and the quantity shall be the number of cubic yards in the completed structure, complete in place and accepted. The limiting dimensions shall not exceed those shown on the plan or ordered by the Engineer.

685.81 Basis of Payment.

Field stone masonry will be paid for at the contract unit price per cubic yard under the item for Field Stone Masonry in Cement Mortar or Field Stone Masonry, Dry.

Excavation will be paid for at the contract unit prices per cubic yard under the item for Class A Trench Excavation or Class B Rock Excavation.

685.82 Payment Items.

685.	Field Stone Masonry in Cement Mortar	Cubic Yard
685.1	Field Stone Masonry, Dry	Cubic Yard
141.	Class A Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard

SECTION 690
WALLS REMOVED AND REBUILT

DESCRIPTION

690.20 General.

This work shall consist of the removing and rebuilding of present stone masonry and balance stone walls in accordance with these specifications, and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

690.40 General.

The stone shall consist of those in the present wall and its foundation and such new stones as may be required.

Mortar shall meet the requirement of Subsection M4.02.15 of Division III, Materials.

CONSTRUCTION METHODS

690.60 Stone Masonry Walls.

A. Laying Stone in Mortar.

All the stones from the present walls to be rebuilt, shall be removed and used to rebuild the new walls in addition to furnishing such new stones as may be necessary to provide rebuilt walls of uniform appearance and cross sectional dimensions throughout their length.

The stones shall be laid so as to break joints and in full mortar beds. All vertical spaces shall be flushed with cement mortar and shall be packed full with spalls. No spalls shall be allowed in the beds — except if the bed requires more than 1 inch of mortar. At least 1/4 of the stones in the face shall be headers evenly distributed throughout the walls. Weep holes shall be constructed as directed.

B. Laying Stone Dry.

The stone shall be laid so as to break joints and all vertical spaces shall be packed full with spalls. No spalls shall be allowed in the beds and at least 1/4 of the stones in the face shall be headers evenly distributed throughout the wall.

690.61 Balance Stone Walls.

A trench for rebuilding the balance stone walls shall be excavated to a minimum depth of 12 inches as directed and to a width sufficient to place the largest bottom stones of the present wall.

All the stones from the present walls to be rebuilt, shall be removed and used to rebuild the new wall in addition to furnishing such new stones as may be necessary to provide rebuilt walls of uniform appearances and cross sectional dimensions throughout their length. The open spaces about the base of the wall shall be filled with the materials excavated from the trench and all surplus excavation shall be used as directed on the slopes of the new embankment.

COMPENSATION

690.80 Method of Measurement.

Stone Masonry Walls, Removed and Rebuilt as specified herein will be measured by the cubic yard and the pay quantity shall be only that quantity actually laid and approved.

Balance Stone Walls Removed and Rebuilt will be measured in place and shall be the length of balance stone walls rebuilt.

690.81 Basis of Payment.

Stone Masonry Walls, Removed and Rebuilt will be paid for at the contract unit price per cubic yard for the kind of wall removed and rebuilt, complete in place.

Balance Stone Walls, Removed and Rebuilt, will be paid for at the contract unit price per linear foot, complete in place.

Excavation at the new location will be paid for at the contract unit price per cubic yard under the item for Class A Trench Excavation or Class B Rock Excavation.

690.82 Payment Items.

690.	Stone Masonry Wall Removed and Rebuilt in Cement Mortar	Cubic Yard
690.1	Stone Masonry Wall Removed and Rebuilt Dry	Cubic Yard
691.	Balance Stone Wall Removed and Rebuilt	Linear Foot
141.	Class A Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard

SECTION 700
INCIDENTAL WORK

SECTION 701
SIDEWALKS, WHEELCHAIR RAMPS AND DRIVEWAYS

DESCRIPTION

701.20 General.

This work shall consist of the construction of bituminous concrete or cement concrete sidewalks, wheelchair ramps and driveways in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

701.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Gravel Borrow	M1.03.0 (Type b)
Cement Concrete (Air-Entrained 4000 psi, 3/4", 610)	M4.02.00
Preformed Expansion Joint Filler	M9.14.0
Class I Bituminous Concrete	M3.11.00

CONSTRUCTION METHODS

701.60 General.

A. Subgrade.

The subgrade for the sidewalks, ramps and driveways shall be shaped parallel to the proposed surface of the walks, ramps and driveways and thoroughly compacted. All depressions occurring shall be filled with suitable material and again compacted until the surface is smooth and hard.

B. Foundation.

After the subgrade has been prepared, a foundation of gravel shall be placed upon it. After being compacted thoroughly, the foundation shall be at least 8 inches in thickness and parallel to the proposed surface of the walk.

701.61 Concrete Sidewalks and Wheelchair Ramps.

A. Forms.

Side forms and transverse forms shall be smooth, free from warp, of sufficient strength to resist springing out of shape, of a depth to conform to the thickness of the proposed walk or ramp and of a type satisfactory to the Engineer.

All mortar or dirt shall be completely removed from forms that have been previously used. The forms shall be well staked and thoroughly graded and set to the established lines with their upper edge conforming to the grade of the finished walk or ramp which shall have sufficient pitch to the roadside edge to provide for surface drainage but not to exceed 1/4 of an inch per foot unless otherwise directed.

All forms shall be oiled before placing concrete.

B. Placing and Finishing Concrete.

The concrete shall be placed in alternate slabs 30 feet in length except as otherwise ordered. The slabs shall be separated by transverse preformed expansion joint filler 1/2 inch in thickness.

Preformed expansion joint filler shall be placed adjacent to or around existing structures a directed.

On the foundation as specified above, the concrete shall be placed in such quantity that after being thoroughly consolidated in place it shall be 4 inches in depth. At driveways, the sidewalks shall be 6 inches in depth. No finishing operation shall be performed while free water is present. Finishing operations shall be delayed until all bled water and water sheen has left the surface and the concrete has started to stiffen. After water sheen has disappeared, edging operations, where required, shall be completed. After edging and joining operations, the surface shall be floated. Immediately following floating, the surface shall be steel-trowled. If necessary tooled joints and edges shall be rerun before and after troweling to maintain uniformity. After troweling, the surface shall be brushed by drawing a soft-bristled pushbroom with a long handle over the surface of the concrete to produce a nonslip surface.

In conveying the concrete from the place of mixing to the place of deposit, the operation shall be conducted in such a manner that no mortar will be lost, and the concrete shall be so handled that the concrete will be of uniform composition throughout, showing neither excess nor lack of mortar in any one place.

The surface of all concrete sidewalks shall be uniformly scored into block units of areas not more than 36 square feet. The depth of the scoring shall be at least one quarter of the thickness of the sidewalk.

The application of neat cement to surfaces in order to hasten hardening is prohibited.

The finishing of concrete surface shall be done by experienced and competent cement finishers approved by the Engineer.

When completed the walks shall be kept moist and protected from traffic and weather for at least 3 days in accordance with the applicable provisions of Subsection 476.74.

701.62 Bituminous Concrete Sidewalks and Wheelchair Ramps.

A. Forms.

Where walls, curbing or other suitable permanent supports are not present or where an approved mechanical spreader is not used, satisfactory forms shall be installed to assist in securing proper alignment and adequate compaction of the base and surface courses.

B. Placing Bituminous Concrete.

The bituminous concrete walk surface shall be laid in 2 courses to a depth after rolling of 2½ inches. The bottom course shall be 1¼ inches in thickness, and its surface after rolling shall be 1¼ inches below and parallel to the proposed grade of the finished surfaces. The top course shall be 1¼ inches in thickness after rolling.

Unless otherwise directed, the surface shall have a pitch 3/16 of an inch per foot of width to provide for proper drainage.

The courses shall be constructed in accordance with the applicable requirements of Section 460 and the following provisions:

1. *Spreading Mixture* — The mixture shall be dumped, as needed, in wheelbarrows or on approved steel dump sheets outside the areas on which it is to be placed. It shall then be immediately distributed into place by means of shovels and raked into a uniformly loose layer to the full width required and of such depth that, when the work is completed, it shall conform to the grade and surface contour required. An approved mechanical spreader may be used.

2. *Rolling* — The surface shall be rolled with a self-propelled tandem roller weighing not less than 1½ tons and not more than 5 tons. In places inaccessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers weighing not less than 50 pounds and having a tamping face not exceeding 100 square inches.

3. *Testing Surface* — When tested with a 10-foot straightedge placed parallel to the center line of the courses, there shall be no deviation from a true surface in excess of 1/4 of an inch.

701.63 Bituminous Concrete Driveways.

A. No Forms will be required.

B. Placing Bituminous Concrete.

The Bituminous Concrete driveway surface shall be laid in 2 courses to a depth, after rolling, of 3½ inches unless otherwise designated on the plans. The Bottom Course shall be 2 inches in thickness, and its surface,

after rolling, shall be 1 ½ inches below and parallel to the proposed grade of the finished surface. The top course shall be 1 ½ inches in thickness after rolling.

1. Spreading Mixture — The Mixture shall be spread with an approved spreader. In areas not accessible to a spreader, the mix shall be placed as specified for bituminous concrete sidewalks (Section 701.62 B-1).

2. *Rolling* — The surface shall be rolled with a self-propelled tandem roller weighing not less than 3 tons nor more than 5 tons, or an approved roller as designated by the Engineer.

3. *Testing Surface* — When tested with a 10 foot straightedge placed parallel to the center line of the courses, there shall be no deviation from a free surface in excess of 1/4 inch.

COMPENSATION

701.80 Method of Measurement.

Concrete walks and wheelchair ramps will be measured in square yards.

Bituminous concrete walks, wheelchair ramps and driveways will be measured by the ton.

Gravel borrow will be measured by the cubic yard as specified in Subsection 150.80.

Fine Grading and Compacting (in subgrade areas) will be measured by the square yard.

701.81 Basis of Payment.

Concrete Sidewalks, Wheelchair Ramps and Sidewalks at Driveways will be paid for at the contract unit price per square yard.

Bituminous concrete for the walk surface and wheelchair ramps will be paid for at the contract unit price per ton.

Bituminous Concrete Driveways will be paid for at the contract unit price per ton under the item for Bituminous Concrete Driveways complete in place.

Gravel will be paid for at the contract unit price per cubic yard under Item 151., Gravel Borrow.

Fine Grading and Compacting will be paid for at the contract unit price per square yard under Item 170., Fine Grading and Compacting (in subgrade areas).

Excavation will be paid for at the contract unit price per cubic yard under Item 120., Earth Excavation, or Item 121., Class A Rock Excavation.

701.82 Payment Items.

701.	Concrete Sidewalk	Square Yard
701.1	Concrete Sidewalk at Driveways	Square Yard
701.2	Concrete Wheelchair Ramp	Square Yard
702.	Bituminous Concrete Walk Surface	Ton
702.2	Bituminous Concrete Wheelchair Ramp	Ton
703.	Bituminous Concrete Driveway	Ton
120.	Earth Excavation	Cubic Yard
121.	Class A Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
170.	Fine Grading and Compacting (in subgrade areas)	Square Yard

SECTION 710
BOUNDS

DESCRIPTION

710.20 General.

Bounds shall be of granite as directed and shall be set at points designated by the Engineer and in conformity with these specifications. Drill Steel rods may be used, if directed, where the points fall on exposed rock.

Where and as directed, the stone or concrete bounds now in the ground shall be removed and reset in conformity with these specifications. In instances where these are not to be reset they shall be transported and stacked as directed.

Bounds (Lettered-Granite) and Bounds (Plain Granite) Furnished and Set, shall consist of furnishing and installing highway property bounds as required and in accordance with the plans and the applicable provisions of this Section. Lettering shall be in accordance with the Department Standards and face abutting properties.

MATERIALS

710.40 General.

Material shall meet the requirements specified in the following Subsections of Division III, Materials:

Granite Bounds	M9.04.8
Drill Steel Rods	M8.02.0

CONSTRUCTION METHODS

710.60 General.

The bounds shall be set at the depth and position as directed, and they shall not project above the ground more than 6 inches after final grading.

Bounds located in lawns shall be set with the top of the bound 2 inches below the surface.

Bounds located in sidewalks or drives shall be set with the top of the bound flush with the surface.

Material for backfilling shall consist of suitable excavated material carefully placed about the bound and thoroughly tamped. When the excavation is in earth not suitable for backfilling, the Contractor shall furnish clean gravel or sand for backfill.

When the bound location falls on solid ledge and the use of a drill steel rod is directed by the Engineer, a 1 ½ inch hole shall be drilled to a depth of 18 inches and a drill steel rod as specified under Subsection 710.40 shall be placed in the hole. The rod shall be set so that the hole is on the bound point. The drill steel rod shall project above the ledge from 1 inch to 2 inches, and shall be grouted with a 1:1 mortar mix.

The 1/2" drill holes in the top of the bounds shall be filled to their full depth with lead rope securely compacted in place.

710.61 Bounds Removed and Reset.

Present bounds shall be excavated from the ground, the holes properly backfilled with suitable excavated material, or borrow, and the bounds delivered to the new locations and reset as directed and suitably backfilled, all in accordance with the requirements for setting bounds as stipulated hereinbefore.

When a bound to be reset does not have a drill hole in the top center of the bound, a hole 1 ½ inches in depth and 1/2 inch in diameter with the bottom somewhat flared, shall be drilled and this hole filled with lead rope securely compacted in place.

The Contractor will be held responsible for all bounds removed, and shall replace at his own expense all bounds as may have been broken by his employees, or otherwise, after such removal.

710.62 Bounds Removed and Stacked.

Present bounds shall be excavated from the ground, the holes properly backfilled with suitable excavated material and the bounds carefully stacked, as directed.

The Contractor shall accept and hold entire responsibility for the removal, handling, stacking at a location convenient for removal by owner, and protection of all bounds until the final removal by others as designated and in accordance with the following: Any bound damaged through lack of protection or carelessness by the Contractor shall be replaced with a satisfactory bound at his expense. The Contractor's responsibility will cease upon final acceptance of the work or 60 days from the time a certified notice, with copy to Engineer, is sent by Contractor to owner of material that material is available for removal.

COMPENSATION

710.81 Basis of Payment.

This work will be paid for at the contract unit price each under the item for Bounds Removed and Reset, or Bounds Removed and Stacked, or Bounds (Lettered-Granite) or Bounds (Plain-Granite) or Drill Steel Rods (Set in Solid Ledge) complete in place, and paid for as a bound of the type indicated.

Allowance for rock, if not already paid for under previous rock excavation, shall be based on area 24 inches square multiplied by the depth of the rock to the bottom of the bound plus 6 inches, and will be paid for under the item of Class B Rock Excavation. There will be no rock allowance paid for drill steel rods.

Bounds which are designated to be Removed and Reset and are found to be unsuitable for re-use after excavation through no fault of the Contractor shall be paid for at one half the contract unit price.

Bounds which are designated to be Removed and Stacked and are found to be unsuitable for re-use through no fault of the Contractor will be paid for at the full contract unit price.

Borrow materials, when directed to be used, will be paid for at the contract unit price per cubic yard for the particular type of Borrow.

710.82 Payment Items.

710.3	Bound-Lettered Granite	Each
710.4	Bound-Plain Granite	Each
711.	Bound Removed and Reset	Each
712.	Bound Removed and Stacked	Each
144.	Class B Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
154.	Sand Borrow	Cubic Yard

SECTION 715
RURAL MAIL BOXES REMOVED AND RESET

DESCRIPTION

715.20 General.

This work consists of the removing and resetting present mail boxes in accordance with these specifications and in close conformity with the lines and grades established by the Engineer.

MATERIALS

715.40 General.

Material shall meet the requirements specified on the plans.

CONSTRUCTION METHODS

715.60 General.

The mail boxes indicated shall be removed together with the posts, and the post holes filled with suitable material and properly tamped.

If necessary during the construction the mail boxes shall be set in temporary locations as directed, so that they are easily accessible to the mail carrier.

In their final permanent location the present mail boxes shall be set on new wooden bases and iron pipe posts as shown on the Department's plan for Setting Rural Mail Boxes.

COMPENSATION

715.80 Method of Measurement.

The number of units to be paid for will be determined by the number of sustaining posts installed and not by the number of mail boxes removed and reset.

715.81 Basis of Payment.

Payment for this work will be made at the contract unit price each under the item for Rural Mail Box Removed and Reset which price shall constitute full compensation for setting the boxes in temporary locations.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic yard under the item for Class B Rock Excavation.

715.82 Payment Items.

715.	Rural Mail Box Removed and Reset	Each
144.	Class B Rock Excavation	Cubic Yard

SECTION 717
METAL BIN-TYPE RETAINING WALL

DESCRIPTION

717.20 General.

This item consists of the furnishing and erection of metal retaining wall members consisting of stringer and spacer units, columns, column caps, stiffeners and other accessories meeting the requirements of these specifications. The details of the wall members and other arrangements in the finished wall shall be as shown on the plans.

717.21 Erected Wall.

When erected the walls shall consist of a number of columns in pairs, one column of each pair being in the plane of the front of the wall and the other column being in the plane of the rear of the wall, with the pairs of columns spaced longitudinally with overlapping S-shaped facing and rear members (stringers) and transversely with overlapping U-shaped tie members (spacers). The necessary bolts and appurtenances shall be furnished for complete assembly of the units into a continuous closed face wall of connected bins.

MATERIALS

717.40 General.

Material shall meet the requirements specified in Subsection M8.13.2 of Division III, Materials.

CONSTRUCTION METHODS

717.60 Manufacturer's Responsibility.

All units shall be so fabricated that units of the same nominal size shall be fully interchangeable. No drilling, punching or drifting to correct defects in manufacture shall be permitted. Any units having holes improperly punched shall be promptly replaced at the expense of the Contractor.

Whenever possible in the manufacture of the units a minimum forming radius of one inch shall be maintained. All units that are formed with less than one inch radius shall be hot-dipped galvanized after forming.

717.61 Excavation.

Rough excavation for the site of the wall shall be made to the lines and grades shown on the plans or as directed. The bearing at the corners of the bin shall be firm and true to grade before any wall is erected.

No base plate shall be set on ledge or concrete and, if encountered, the ledge or concrete shall be removed and replaced with a gravel cushion having a minimum thickness of 12 inches between the base plate and the ledge or concrete.

Gravel shall conform to the requirements of Subsection M1.03.0 Type c for Gravel Borrow.

717.62 Erection of Units.

Prior to erection, the gauge of stringers, spacers and columns shall be readily identifiable.

The units shall be erected as shown on the plans. Members shall be handled carefully and any which are damaged as a result of handling, storing or erecting shall be removed and new members substituted at the Contractor's expense. Any and all plain galvanized accessories, excluding bolts, shall be covered prior to erection with an approved paint supplied by the manufacturer.

The units in the wall shall conform to the dimensions and gauges specified on the plans and when assembled, shall be in conformity with the lines, grades and dimensions shown on the plans.

717.63 Construction of Wall on Curve.

In the construction of a wall on a curve the proper curvature for the face shall be obtained by the use of shorter stringers in the front or rear panels of retaining wall as designated on the plans or by the Engineer.

717.64 Height of Wall.

The wall height may be varied but it shall not exceed the maximum height shown for the design selected. Two or more designs of retaining walls may be incorporated in the same wall by the use of special split columns to make the connection on the stepback.

717.65 Backfill.

The filling of the interior of the wall and behind the wall may progress simultaneously with the erection of the units and shall consist of gravel conforming to the requirements of Subsection M1.03.0, Type a. The backfilling shall be made in layers not greater than 6" in thickness, and shall be thoroughly and satisfactorily compacted. The puddling method of backfilling will not be permitted.

COMPENSATION

717.80 Method of Measurement.

The quantity of metal bin-type retaining wall to be paid for under this item shall be the number of square feet of area of the total of all front panels of metal retaining wall complete in place in the accepted work. The area of each front panel shall be determined by multiplying the width of each front panel by its total height.

Excavation shall be measured as specified in Section 120 for Earth Excavation or Class A Rock Excavation, and as indicated on the plan.

Gravel borrow shall be measured as specified in Subsection 150.80.

717.81 Basis of Payment.

The above work will be paid for at the contract unit price per square foot of Metal Bin-Type Retaining Walls, complete in place.

Excavation will be paid for at the contract unit price per cubic yard under the item of Earth Excavation or Class A Rock Excavation.

Gravel for filling in and around the metal bin-type retaining wall will be paid for at the contract unit price per cubic yard for Gravel Borrow.

717.82 Payment Items

717.	Metal Bin-Type Retaining Wall	Square Foot
120.	Earth Excavation	Cubic Yard
121.	Class A Rock Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard

SECTION 740

ENGINEER'S FIELD OFFICE AND MATERIALS LABORATORY (EACH WITH PERTINENT EQUIPMENT)

DESCRIPTION

740.20 General.

Satisfactory office space, trailers, materials laboratory, or the utilization of a suitable existing building or buildings as directed shall be provided when required, in an approved location on the project or in the immediate vicinity thereof, for the exclusive use of the Engineers and Inspectors of the Department; such facilities to be separate from any building or buildings used by the Contractor.

740.21 Requirements.

The trailers or buildings shall be fully equipped and made ready for use prior to the beginning of other work on the project and may remain for a period of approximately 45 days after all work on the project has been completed and accepted by the Department.

All offices and laboratories shall be maintained in good condition and appearance by the Contractor for the designated period, after which all portable buildings or trailers, fencing, surfacing and utilities shall be removed from the location, the areas cleaned, loamed and seeded if required, and left in a neat and acceptable condition.

If existing buildings are utilized, the above mentioned requirements shall apply, unless otherwise indicated in the Special Provisions.

740.22 Building Types and Construction.

Unless particularly specified the building or facilities may consist of any of the following, subject to approval of the Engineer.

a. Moved onto or constructed on the site.

b. A trailer or trailers, each type as stipulated in the Proposal.

c. An existing building, owned or rented by the Contractor, containing floor space equivalent to the type specified.

Buildings or trailers moved onto or constructed on the project shall conform with the following:

A. General.

The work to be done under this section shall consist of furnishing all labor, equipment and materials to construct, furnish and maintain buildings or trailers for the Engineer's use, in accordance with the Department Standards and these Specifications.

The sanitary facilities are not for general use by the Contractor's employees. Sanitary provisions for these employees shall be provided otherwise by the Contractor in accordance with Subsection 7.02F.

The work on buildings and trailers shall be completed before any other construction work is done at the site. Maintenance shall continue until the work at the site under the Contract is completed and the buildings or trailers shall be kept clean, orderly, and in working condition at all times.

The Contractor shall protect the buildings or trailers against theft throughout the 24 hours of the day and night, and be responsible for any loss of property of the Department and the personal property of employees of the Department housed therein, due to either fire, theft or other causes.

B. Plumbing.

Each office shall be equipped with complete sanitary and washroom facilities. All connections shall conform with state and local requirements for venting and other sanitary provisions.

A 3/4 inch copper tubing type L shall be installed for the water service. The water closets shall be provided with sufficient pressure to completely expel the contents in one operation.

Insulation shall be provided on all services where necessary. If directed, the Contractor shall furnish and install an approved electric tape, as directed, together with necessary switches and thermostat for each water pipe to prevent freezing.

If a sanitary sewer is not available, a septic system adequate for the office meeting the requirements of the Department of Environmental Quality Engineering regulations set forth in "The State Environmental Code, Minimum Requirements for the Subsurface Disposal of Sanitary Sewage — Title 5" shall be installed.

The Department will not approve the location of a Field Office until the Contractor has obtained approval for his proposed method of sanitary sewage disposal from a) The Department of Environmental Quality Engineering if the location is on state property or b) The Department of Environmental Quality Engineering and the applicable local Board of Health if the location is on private or municipal property.

The Contractor will be required to furnish personnel, equipment and materials for soil test pits and percolation tests and to furnish plans, prepared by a Registered Professional Engineer skilled in the matter of subsurface sewage disposal, signed and stamped with the Engineer's stamp, for any proposed subsurface sewage disposal system. The plan or plans will meet the requirements of Title 5 of the State Environmental Code or its successor or amendments thereto.

The Contractor will be required to determine, through the appropriate regional office of the Department of Environmental Quality Engineering, whether or not a proposed site is within a watershed area for public water supply.

Every effort will be made *not* to locate temporary Sanitary Facilities on any public water supply watershed. Should there be no alternative, the provisions of any regulations of D.E.Q.E. Division of Water Supply and the above shall apply.

In the event that it can be shown that there is no place reasonably proximate to the job with suitable soil and site conditions that will permit subsurface sewage disposal, the Department of Environmental Quality Engineering will consider approval of a tight tank system. The Contractor will have his engineer submit his tight tank proposal and plans to the appropriate Regional Environmental Engineer of the Department of Environmental Quality Engineering in compliance with their "Sanitary Sewage Tight Tank Policy" for approval.

C. Wiring and Lighting.

48-inch non-glare fluorescent luminaires shall be installed in each office so as to provide a minimum level of illumination at desk height of 100 foot-candles. Two fixtures shall be placed over the drawing table as directed. The master switch shall be near the door and control the desk light. Separate pull chains shall be provided for the lights over the table. Four double convenience outlets shall be installed where directed.

Electric wiring in each building or trailer shall be complete with meter connections, fuse box and switch.

D. Heating and Air Conditioning.

All buildings or trailers shall be heated and air conditioned with equipment capable of maintaining a temperature of 70 °F, the total cost to be borne by the Contractor.

E. Area Enclosures, Surfacing and Maintenance.

The area occupied by the buildings or trailers shall be enclosed with 72″ chain link fence, including a 12′ clear opening double-swing gate, all with 3 strands of barbed wire on extension arms and conforming to the relevant provisions of Section 644. The area to be enclosed will depend on the manner in which the buildings are arranged and shall be satisfactory to the Engineer.

A portion of the area within the enclosure designated by the Engineer for use as walks and parking, shall be graded and paved with 2½″ Class I Bituminous Concrete Pavement Type I-1 over a 6″ gravel foundation.

The Contractor shall maintain the enclosed area by cleaning as required, including the removal of snow from the paved portions.

Toilet tissue, paper towels and soap shall be furnished by the Contractor as required. The office shall be cleaned and floors washed and waxed weekly. The space between the ground and trailer floor shall be completely closed in and insulated.

All of this work shall be included for payment under the contract price for furnishing the specified number and types of buildings.

F. Insurance and Replacement.

At the time the buildings are made available to the Department, the Contractor shall furnish evidence to the Engineer that Insurance in form, coverage and substance satisfactory to the Department in amount of $5,000 (non-deductible) has been obtained which will protect the Commonwealth's property and/or employee's personal work related or professional equipment against loss of property in any of the buildings or trailers from fire, theft, storm or flood.

The insurance shall be kept in effect during the entire period of occupancy, with evidence of all necessary renewals being promptly forwarded to the Engineer.

In case of fire, theft or breakdown, all equipment involved shall be repaired or replaced by the Contractor within 48 hours.

In the event buildings or trailers, being used as field offices or materials laboratory, are destroyed or rendered untenable for any reason, they shall be replaced within two weeks, or as directed.

Title to the buildings and equipment shall remain in the name of the Contractor.

MATERIALS (EQUIPMENT)

740.40 General.

Buildings or trailers shall have equipment as hereinafter specified, which shall be new or in condition satisfactory to the Engineer. The repair or replacement of faulty equipment shall be prompt and at the expense of the Contractor. A suitable non-freezing type fire extinguisher shall be furnished for each field office and materials laboratory.

740.41 Engineers Field Office (Type A).

In addition to the general requirements, the Type A office shall provide a minimum of 450 square feet of floor space with two outside doors, six windows and be furnished as follows:

1. A slant top drafting table, 36″ x 72″ minimum size, two plan racks and a closet equipped with a lock.
2. Two office type desks, minimum top dimensions 30″ x 60″, with two or more drawers on each side.
3. Four desk chairs on casters with adjustable height tilt seat.
4. Four stools (Drafting table type).
5. One fire resistant drawer-type safe, legal size, with combination lock. Combination to be reset at the direction of the Engineer and revealed only to him.
6. A utility table 30″ high, minimum top size 30″ x 60″.
7. Two legal size fire resistant metal filing cabinets, 4 drawer, with locks.
8. An electric sanitary hot and cold water cooler, supplied with cups and drinking water.
9. An electric adding machine, tape type, with tape.
10 A fully automatic electric calculator, with printout and sufficient supply of tapes.
11. An electric typewriter, Elite type, 16½″ carriage with ribbon as required, mounted on a typewriter table on casters.
12. Safety helmets and safety vests for all Department Construction personnel assigned to the project. The safety equipment will not carry any marking such as the name of the Contractor and shall remain the property of the Contractor after completion of the project.
13. A trailerized office shall be provided with a one half bath that shall consist of a full size water closet and a porcelain steel lavatory recessed in a plastic top. The drain and vent lines shall be A.B.S. plastic and supply lines shall be type L copper. A six gallon electric water heater shall be provided.
14. First Aid Kits shall be provided in the amount and with contents as specified in the current requirements of the Massachusetts Department of Labor and Industries regulations.
15. One new or like new Survey Transit, complete with tripod and storage container, for the exclusive use of the Resident Engineer for the duration of the contract. The transit shall be suitable for Construction Surveys, to establish line and grade, equipped with horizontal circle direct-reading to one (1) minute and vernier calibrations graduated to at least twenty (20) seconds, a vertical angle gradation with vernier to thirty (30) seconds, crosshairs for stadia measurements, optical plumbing capability. A compatible level rod with a minimum length of 12′ shall also be supplied for setting elevations for structures, grades, and stakes.
16. One 100 foot steel tape, one 100 foot cloth tape and one plumb bob.
17. One (1) electrostatic or plain paper copier capable of producing 8½″ x 11″, or 8½″ x 14″ copies. Included shall be the cost of paper and chemicals. The total cost for the paper and chemicals shall not exceed $500, for the life of the project. Only one copier will be required if there is more than one Field Office in the Contract.
18. The Contractor shall assume the cost of all telephone installations, maintenance and removal, including the cost of the telephones. Two telephone instruments shall be provided at the Resident Engineer's office. If there are additional Field Offices and/or a Materials Laboratory Building an additional telephone instrument shall be intercommed to each. Payment under this item shall be full compensation for telephone installation, instruments, maintenance and removal. The Contractor will pay all monthly telephone charges and be reimbursed by the Department for monthly use charges only.
19. The following materials testing and sampling equipment shall be supplied if the Contract specifies 150 cubic yards of cement concrete or more and does not require a Materials Laboratory.

(a) One Air Meter 1/4 Cubic Foot Press-Ur-Meter Type (Ref. AASHTO T152 and ASTM C231).

(b) Two (2) Concrete Curing Boxes meeting the requirements of AASHTO T23, Section 9 (Curamold or equal).

(c) A Quick Check Air Indicator Kit meeting the requirements of AASHTO T199.

(d) Concrete Cylinder Molds, 6″ in diameter by 12″ high, single use mold meeting the requirements of AASHTO M205 shall be supplied (4 cylinders per 50 c.y. or fraction thereof). The cylinders shall be approved for use by the Research and Materials Section.

(e) One complete Slump Test Outfit (Ref. AASHTO T23 and T119), as follows:
A slump cone of seamless spun metal, with handles and foot clamps.
A tamping rod, 24 inches long, 5/8 inch diameter, with hemispherical end.
A sturdy pan, 14 gauge metal, with reinforced rims (24 inches x 24 inches x 3 inches).
A brass-wire briquette brush.
A wooden handled steel trowel, 3½ inches x 7 inches.

(f) One wheelbarrow, minimum 2 cubic foot volume.

(g) One longhandled shovel.

(h) If 150 cubic yards of lightweight concrete are specified in the Contract, the following shall be supplied:

(1) 1-Roller Meter type air meter (Ref. AASHTO T196).

(2) 1-Unit weight bucket (Ref. AASHTO T121).

(3) One platform beam scale, capacity 200 pounds, sensitivity 0.01 pound, with two beams at front of platform, reading to 20 pounds by single pounds and to 1 pound by .01 pounds, with additional hanger weights to fulfill capacity of 200 pounds; all parts to be of steel with enclosed weighing mechanism, platform to be 12½" x 14". A digital platform scale, with a minimum capacity of 200 pounds, with similar sensitivity can be substituted. Scale must be calibrated immediately prior to start of Contract.

(i) Plastic lined sampling bags, capable of holding 60 pounds of soil or aggregates. Sample bags are to be approved by the Research and Materials Section.

20. The following shall be supplied if the Contract specifies painting of bridges:

(a) Cans and jars for sampling paint. Cans shall be one quart metal friction top paint sample cans with covers. Jars shall be one quart plastic or glass, designed to hold acid with acid resistant covers.

(b) 2-Each Wet Film Thickness gauges (1-13 mils range).

(c) One Dry Film Thickness Gauge (Tooke Mark III or equal) equipped with spare set of cutting tips.

(d) One Dry Film Thickness (Gauge Nordsen or Inspector Model III) range 0-25 mils.

(e) One Sling Psychrometer.

740.42 Engineers Field Office (Type B).

Engineers Field Office (Type B) shall be equipped as described in Subsection 740.41 except that the minimum floor space shall be 350 square feet.

740.43 Engineers Field Office (Type C).

Engineers Field Office (Type C) shall have a minimum floor space of 250 square feet and be equipped as described in Subsection 740.41 except that only one plan rack, two desk chairs and no paper copier are required.

740.44 Engineer Field Office (Type D).

Engineers Field Office (Type D) shall have a minimum floor space of 150 square feet and be equipped as described in Section 740.41 except that only one door, four windows, one plan rack, no closet, one telephone, one chair, two stools, no utility table, one file cabinet, and no paper copier are required.

740.45 Materials Laboratory Building.

In addition to the general requirements, Materials Laboratory Building shall provide a minimum of 220 square feet of floor space and be equipped as follows:

1. An office-type desk, minimum top dimensions of 32" x 50" with two or more drawers on each side.
2. One desk chair on casters with adjustable height tilt seats.
3. One metal filing cabinet, legal size, four drawer, with locks.
4. A stainless steel sink, at least 22" x 24" outside dimensions, installed in a suitable counter top and supplied with hot and cold running water. Waste shall be disposed through a "Zurn" trap 7" x 11" high (or equal) to a septic tank or sewer.
5. One 48" square galvanized plate of 14 gauge metal.
6. One cylindrical compaction mold 1/30 c.f., 4" I.D. x 4.584" ± high, complete with 2" collar extension and base plate; all parts to be plated for corrosion resistance. (Ref. AASHTO T99; ASTM D698).
7. One cylindrical compaction mold 1/13.33 c.f. 6" I.D. x 4.584" ± high, complete with 2" collar extension and base plate; all parts to be plated for corrosion resistance. (Ref. AASHTO T180; ASTM D1557).
8. One 5.5 lb. rammer, 2" diameter, with circular face and guide sleeve for 12" drop. (Ref. AASHTO T99; ASTM D698).

9. One 10 lb. rammer, 2″ diameter, with circular face and guide sleeve for 18″ drop. (Ref. AASHTO T180; ASTM D1557).

10. Two hardened steel straight edges 12″ x 1¼″ x 1/8″.

11. The Contractor shall provide and maintain for the exclusive use of the Department a Nuclear Density Meter conforming to the following specifications:

Shall meet the requirements of ASTM D2922, D2950, D3017

Shall have test range of

Density — 80 to 170 pcf

Moisture — 0 to 30%

The meter shall have the capability of both direct transmission and or back scatter capable of measuring the density of soil to a minimum depth of 8 inches. When the Contractor delivers to the job site the Nuclear Density Meter, as specified, he shall notify immediately in writing the District Materials Engineer and a copy of such notification be sent to Research and Materials Engineer, Mass. Dept. of Public Works, 99 Worcester Street, Wellesley Hills, MA 02181, so that this gauge can be programmed for periodic wipe tests. Such notification shall include Model Number, Serial Number and Date of Manufacture. Payment for furnishing and maintaining the nuclear density meter and for the stipulated training and licensing of Department Personnel, furnishing the monthly film badge detection service, and all costs related thereto, will be included in the unit price bid.

12. Plastic lined sampling bags capable of holding 60 pounds of soil or aggregates. Sample bags are to be approved by the Research and Materials Section.

13. One sand cone apparatus, including three one gallon clear plastic jugs with screw caps and 12″ x 12″ base plate with hole opening 6″ in diameter. (Ref. AASHTO T191).

14. One galvanized trash can (with cover) 24 gauge, 18″ diameter, 26″ high, for storage of calibrated sand, filled with ten 50 lb. bags Ottawa Standard sand.

15. Four sampling spoons of heavy gauge plated steel, approximately 12″ long.

16. Four one gallon moisture cans, lacquered inside, with friction type lid and bail.

17. Twelve 16 ounce aluminum moisture cans 3¾″ diameter, 2½″ high with covers.

18. *One solution balance, 20 kilogram, capacity to weigh directly to 1 gram, with two weighing beams and taring beam; tare capacity to be 2 Kg; weighing beams to read 1000 grams by 100 gram divisions and 100 grams by 1 gram divisions; additional matching weights (one Kg., two 2 Kg., one 5 Kg. and one 10 Kg.) to be provided to fulfill capacity of 20 Kg. platform to be 11″ diameter. An electronic, direct reading, top loading, 20 kilogram minimum capacity, balance with a precision of 0.1 gram may be substituted for the solution balance.

19. *One single-span, triple-beam scale, minimum capacity 1610 grams, weighing directly to 0.1 gram; weighing beams to read 500 grams by 100 grams, 100 grams by 10 grams and 10 grams by 0.1 gram; pan to be 5½″ diameter; together with a scoop, hanging tare counter weight and plastic balance cover. An electronic top loading balance with a capacity of 2000 grams minimum, and reading to 0.1 gram.

20. *One platform beam scale, capacity 200 pounds, sensitivity 0.01 pound, with two beams at front of platform, reading to 20 pounds by single pounds and to 1 pound by .01 pounds, with additional hanger weights to fulfill capacity of 200 pounds; all parts to be of steel with enclosed weighing mechanism, platform to be 12½″ x 14″. A digital platform scale, with a minimum capacity of 200 pounds, with similar sensitivity can be substituted.

*All scales must be calibrated immediately prior to start of Contract.

21. Two 2-burner commercial or laboratory grade electric hot plates with enclosed elements; one burner single heat, 650 watts; one burner, three-heat, 1000 watts; at least 18″ x 9″ high for use on 115 volts; UL approved, or two 2 burner gas hot plates of equal or greater heat capacity.

22. One gravity convection thermostatically controlled drying oven of rugged construction, with 3/8″ thick Transite (or equal) walls, minimum inside dimensions to be 16″ wide, 11″ deep and 16″ high, equipped with two expanded metal shelves, automatic thermostat and other standard controls capable of maintaining temperatures of 110 ± 5 °C (230 ± 9 °F), a glass thermometer reading from 0 deg. C. divisions; maximum 1600 watts, connected for use on 115V 60 hertz current, unless the Contractor elects to provide 230 volt service.

23. One Gilson Screen shaker set, including standard Gilson shaker plus a set of screens 14¾″ x 22¾″ x 2½″ as follows: 3″, 2″ 1½″, 1″, 3/4″, 1/2″ 3/8″, and No. 4 and shall include a dust pan. All sieves shall meet AASHTO M92.

24. One motor-driven portable sieve shaker for operation on 110 volt 60 hertz, single phase current, complete with belt driven mechanism to produce combination rocking and tapping action, capacity for six full height sieves plus pan and cover; all parts mounted on a sturdy base.

25. A set of brass frame United States Standard testing sieves, all to be full height, 8″ in diameter and matched for nesting; one each of the following, 2″, 3/4″, 1/2″, 3/8″, Nos. 4, 8, 10, 16, 20, 30, 40, 50, 80 and 100, two #200 mesh, two pans and one cover. The sieves shall meet AASHTO M92.

26. Three fine 1″ sieve or sash brushes.

27. Two wooden-handled knives, 10″ overall in length with 6″ thin steel blades.

28. A set of sturdy pans for drying soils as follows: Two 24″ x 24″ x 3″ (minimum size), of 14″ gauge metal with reinforced rims. Eight (for use in oven) approximately 10″ x 14″ x 2¼″ of 12 gauge metal.

29. Two air meters, 1/4 cubic foot, Press-Ur-Meter type (Ref. AASHTO T152 and ASTM C231).

30. Two complete slump test outfits (Ref. AASHTO T23 and T119), 2 each as follows:
A slump cone of seamless spun metal, with handles and foot clamps.
A tamping rod, 24″ long, 5/8″ diameter with hemispherical end.
A sturdy pan (14 gauge metal with reinforced rims, 24″ x 24″ x 3″).
A brass-wire briquette brush.
A wooden handled steel trowel 3½″ x 7″.

31. If the job has more than 150 cubic yards of lightweight concrete a Roller-Meter type air meter meeting AASHTO T196 and a unit weight bucket meeting AASHTO T121 shall be furnished.

32. An electric sanitary water cooler, supplied with cups and drinking water.

33. 2-concrete curing boxes, meeting the requirements of AASHTO T23 Section 9; Shall be Curamold or equal.

34. 6 heavy duty 10 quart plastic pails.

35. 1-quick-check air indicator kit meeting the requirements of AASHTO T199.

36. Concrete cylinder molds, 6″ diameter by 12″ high, single use, meeting the requirements of AASHTO M205 shall be supplied (4 cylinders per 50 c.y. or fraction thereof). Cylinders shall be approved for use by the Research and Materials Section. Three molds shall be submitted for approval prior to start of the project.

37. One copy of the Standard Specifications for Transportation Materials and Methods of Sampling and Testing — Part I and Part II Methods of Sampling and Testing — latest edition, and one copy of the latest interim AASHTO Specifications. Both are published by the American Association of State Highway and Transportation Officials, 444 North Capital Street, N.W., Suite 225, Washington, D.C. 20001.

38. One shovel and two cubic yard wheelbarrow for transporting samples.

Catalogs for the above equipment may be seen at the Department's Research and Materials Laboratory in Wellesley.

COMPENSATION

740.81 Basis of Payment.

Payment for work under these items will be at the respective contract unit bid price for Engineer's Field Office and Equipment (Type A), Engineering Field Office and Equipment (Type B), Engineer's Field Office and Equipment (Type C) and Engineer's Field Office an Equipment (Type D) and Materials Laboratory Building and Equipment.

Payment as described above shall be compensation for all services (heat, gas, light, water, sanitary, etc.), except monthly telephone charges; for all labor, material, fencing, surfacing, equipment service (including general inside cleaning at least once each week) and incidentals necessary to provide, equip, maintain, insure, remove and dispose of the buildings and clean the site as specified and directed. The contract unit bid price will prevail for buildings built or furnished as described, for equivalent trailer space, or office space rented in existing buildings, when such substitution has been approved.

740.82 Payment Items.

740	Engineer's Field Office and Equipment (Type A)	Month
741.	Engineer's Field Office and Equipment (Type B)	Month
742.	Engineer's Field Office and Equipment (Type C)	Month
743.	Engineer's Field Office and Equipment (Type D)	Month
744.	Materials Laboratory and Equipment	Month
999.740	Telephone	Dollars

SECTION 746
TRANSPORTATION VEHICLE

DESCRIPTION

746.20 General.

This item consists of furnishing and maintaining a current model vehicles equipped with strobe lights for the use of Department personnel assigned to the project.

MATERIALS

746.40 General.

The vehicle may be any medium size air conditioned six cylinder four door sedan, van, or other type vehicle capable of transporting four persons in comfort and protected against the elements.

The vehicle will be registered in Massachusetts and it shall be the Contractor's responsibility to pay all fees, insurance charges, fuel, lubricants and maintenance costs necessary to provide a legally operable vehicle acceptable to the Engineer. The vehicle will be made available from 15 days after receipt of the executed contract to 45 days after completion of the project unless released earlier by the Engineer.

746.41 Office Van.

The van shall have a minimum wheel base of 125 inches and be modeled as follows:

1. A 3/4" plywood overflooring to which the furniture is securely bolted.
2. A 4 foot sliding door with window on the side as well as rear doors with windows.
3. Secure locking on all doors.
4. An independent switch for an overhead dome light.
5. The van shall be furnished with a knee hole desk and a two drawer file cabinet which are fastened down, a 3/4" plywood table with formica top and a swivel chair without casters that is movable.
6. Safety equipment shall be furnished with the Van and shall remain the property of the Contractor after completion of the project, safety helmets and safety vests for all Department Construction personnel assigned to the project. The safety equipment will not carry any marking such as the name of the Contractor.

CONSTRUCTION METHODS

746.60 General.

The vehicle will be for the exclusive use of the Resident Engineer and his assistants to accommodate their *official* transportation requirements on and off the project site including portal to portal travel between the project site and the assigned personnel's residence. The vehicle shall not be utilized for non-official or personal use by an individual while it is assigned to this project.

The vehicle shall be used for the transportation of materials and/or samples for testing and also for transportation to properly supervise the coordination of Traffic Police and Safety Functions.

The vehicle shall be maintained in a good state of repair at all times and serviced at the regular intervals recommended by the vehicle manufacturer. Work schedules of the Engineer and/or his assistants will be arranged so that the vehicle will be available for regular maintenance at the scheduled times.

Public Liability and Property Damage Liability Insurance shall be provided throughout the term of this project to the minimum limits established below.

Type	Minimum	Maximum
Public Liability	$250,000/person	$500,000/accident
Property Damage Liability	50,000/accident	200,000/accident

Said insurance shall be maintained in full force and effect during the life of the contract and shall protect the Resident Engineer, his assistants or any other authorized State Driver for personal injury and wrongful

death and for damages to property arising in any manner from their negligence or wrongful acts or failures to act. Such insurance against legal liability shall indemnify and save harmless the Commonwealth and any or all of the officers, agents and employees thereof resulting out of or in consequence of the acts, or failures to act, on the part of the Commonwealth.

COMPENSATION

746.80 Method of Measurement.

Transportation shall be measured by the month per vehicle and shall be the actual number of months each vehicle is required and available to the Resident Engineer and/or his assistants or representatives.

746.81 Basis of Payment.

Transportation Vehicles will be paid for at the contract unit price bid per month for each vehicle, which price and payment shall be full compensation for the vehicle including all fees, insurance costs, maintenance costs, fuel and lubrication costs, repair costs and all other incidental expenses necessary to provide a legally operable vehicle to the satisfaction of the Engineer.

746.82 Payment Items.

*746.—	Transportation Vehicle No. —	Month
746.6	Transportation Office Van	Month

*Item number will differentiate to indicate number of transportation vehicle.

SECTION 748
MOBILIZATION

DESCRIPTION

748.20 General.

This item shall consist of preparatory work and operations including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site, for the establishment of all contractor's field offices, buildings, and other facilities necessary for work on the project and all other work and operations which must be performed or for costs which must be incurred prior to beginning work.

CONSTRUCTION METHODS

748.60 General.

The work required to provide the above facilities and services for mobilization shall be done in a safe and workmanlike manner and shall conform with any pertinent local or state law, regulation or code. Good housekeeping consistent with safety shall be maintained.

COMPENSATION

748.80 Method of Measurement.

Payment for mobilization will be made on a lump sum basis.

748.81 Basis of Payment.

1. The first payment of one third of the lump sum price for Mobilization or 1 percent of the total bid price, whichever is less, will be made on the first estimate.

2. The second payment of one third of the lump sum price for Mobilization or 1 percent of the total bid price, whichever is less, will be made following the completion of 5 percent of the total Contract price.

3. The third payment of one third of the lump sum price for Mobilization or 1 percent of the total bid price, whichever is less, will be made following the completion of 10 percent of the total Contract price.

4. Upon completion of all the work on the project, payment of any amount bid for Mobilization in excess of the total amount previously paid, will be paid by the Department.

748.82 Payment Items.

748. Mobilization	Lump Sum

SECTION 751

LOAM BORROW, PLANTABLE SOIL BORROW, PROCESSED PLANTING MATERIAL OR TOPSOIL REHANDLED AND SPREAD

DESCRIPTION

751.20 General.

This work shall consist of furnishing and placing loam borrow, processed planting material or topsoil rehandled and spread on an approved area in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

751.40 General.

Material shall meet the requirements specified in the following Subsection of Division III, Materials:

Loam Borrow	M1.05.0
Topsoil and Plantable Soil Borrow	M1.07.0
Processed Planting Material	M1.06.1

CONSTRUCTION METHODS

751.60 Preparation of Areas on Which Loam, Plantable Soil Borrow, Topsoil or Processed Planting Material Are to be Placed.

The area upon which the above materials are to be placed shall be raked, harrowed or dragged to form a reasonably smooth surface. All stones larger than 2 inches, undesirable growth over 2 inches and debris shall be removed from the area and disposed of by the Contractor outside the location.

When directed by the engineer, additional suitable material available from excavation or furnished under the Item of 150. Ordinary Borrow, shall be spread as required to repair gullies or depressions. The labor, equipment and materials necessary to place, compact and grade the additional material shall be paid for under the respective item from which the material is obtained.

751.61 Placing Loam, Topsoil or Processed Planting Material.

The loam, processed planting materials or the topsoil obtained from stacked piles shall be hauled, deposited and spread to the directed depths on the areas shown on the plans or designated by the Engineer once these areas have been properly prepared. All grass and weed growth on the areas designated to be loamed, shall be cut to a maximum height of 2 inches, raked, harrowed or dragged before the loam is placed thereon. After

the loam, topsoil or processed planting material has been spread, it shall be carefully prepared by spading or harrowing, and raking with iron rakes. All large, stiff clods, lumps, stones over 3 inches, brush, roots, stumps, litter and other foreign material shall be removed from the loam, topsoil or processed planting materials area and disposed satisfactorily.

The compaction shall be equivalent to that produced by a hand roller weighing from 75 to 100 pounds per foot of width. The compaction may be obtained by rolling, dragging or any method that produces satisfactory results. All depressions caused by settlement or rolling shall be filled with additional materials and the surfaces shall be re-graded and rolled until it presents a reasonably smooth and even finish and is up to the required grade.

During hauling operations, the roadway surfaces shall be kept clean and any loam or other dirt which may be brought upon the surface shall be removed promptly and thoroughly before it becomes compacted by traffic. If necessary, the wheels of all vehicles used for hauling, shall be cleaned frequently and kept clean to avoid bringing any dirt upon the surface. The Contractor shall take all reasonable precautions to avoid injury to existing or planted growth.

751.62 Topsoil Rehandled and Spread

Topsoil which is obtained on the site, from piles of topsoil previously excavated and stacked in accordance with the relevant provisions of Section 120 and designated as topsoil to be rehandled and spread shall be used as required, and as directed by the Engineer, on areas to be seeded or planted.

The topsoil must be approved before it is spread and the Contractor will be required, without additional compensation, to take corrective action as directed, in order to make the topsoil suitable for its intended use.

The Contractor is required under the item of seeding to adjust the acidity by the addition of limestone as determined by testing as required under Subsection 765.61 and to apply the fertilizer as required under Subsection 765.62.

751.63 Plantable Soil Borrow.

Plantable soil borrow shall be used as specified in Subsection 751.61 except that it may be obtained outside the project limits.

COMPENSATION

751.80 Method of Measurement.

The quantity of Loam Borrow, Plantable Soil Borrow, Processed Planting Material or Topsoil Rehandled and Spread shall be determined by measurement in place after compaction to the depth specified on the plans or as directed,and to the volume so ascertained there shall be added 20% to compensate for such loss as may be due to settlement, shrinkage and penetration into the underlying material.

The volume of Topsoil Rehandled and Spread including added percentage for settlement, shall not exceed the total volume of Item 125, Topsoil Excavated and Stacked, less any waste.

751.81 Basis of Payment.

Loam Borrow, Processed Planting Material and Topsoil Rehandled and Spread will be paid for at the contract unit price per cubic yard, complete in place, which prices shall also include the grading of areas where stockpiles of topsoil are removed.

751.82 Payment Items.

751.	Loam Borrow	Cubic Yard
751.2	Plantable Soil Borrow	Cubic Yard
752.	Topsoil Rehandled and Spread	Cubic Yard
759.	Processed Planting Material	Cubic Yard

SECTION 760
IMPERVIOUS SOIL BORROW

DESCRIPTION

760.20 General

This work shall consist of furnishing and placing impervious soil borrow in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

760.40 General.

Impervious soil borrow shall meet the requirements specified in Subsection M1.08.0 of Division III, Materials.

CONSTRUCTION METHODS

760.60 General.

Impervious soil borrow shall be placed and compacted as specified in Subsection 751.60.

COMPENSATION

760.80 Method of measurement.

Impervious soil borrow shall be measured as specified in Subsection 751.80.

760.81 Basis of Payment.

Impervious soil borrow shall be paid for at the contract unit price per cubic yard under the item for Impervious Soil Borrow, complete in place, even if the impervious soil borrow is obtained from Muck Excavation.

760.82 Payment Items.

760. Impervious Soil Borrow	Cubic Yard

SECTION 765
SEEDING

DESCRIPTION

765.20 General.

This work shall consist of seeding certain areas at the locations indicated on the plans or designated by the Engineer, in accordance with these specifications.

MATERIALS

765.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Limestone	M6.01.0
Fertilizer	M6.02.0
Grass Seed	M6.03.0
Crownvetch Seed	M6.03.2

CONSTRUCTION METHODS

765.60 General.

The Contractor shall not proceed with the work of seeding until permission of the Engineer has been obtained.

Before the application of limestone, fertilizer and seed, the Contractor shall harrow or roto-till to a depth of 3 inches, when directed, all areas where loam or topsoil, has been placed under a previous contract when such areas are to be prepared for seeding under this contract. When loam borrow is placed, or topsoil is rehandled and spread; and they are paid for under the respective items of a contract, they will not require harrowing or roto-tilling.

The Contractor shall remove all debris and stones having any dimensions greater than 2 inches before the application of limestone, fertilizer and seed.

765.61 Application of Limestone.

Limestone may be applied in dry form or hydraulically as provided in Subsection 765.65. Limestone where necessary shall be spread and thoroughly incorporated in the layer of loam or topsoil to adjust the acidity of the loam or topsoil. The rate of application of the limestone will vary up to a maximum of 1 pound per square yard depending on the results of laboratory tests conducted by the Department. The limestone shall be thoroughly incorporated into the layer of loam or topsoil and the upper 1 inch of the underlying subsoil by harrowing or other methods satisfactory to the Engineer so as to provide a layer of thoroughly mixed material for the seed bed.

765.62 Application of Fertilizer for Grass.

Fertilizer may be applied in dry form or hydraulically as provided in Subsection 765.65.

After the application of limestone, if found necessary, on the seed bed, fertilizer shall be spread on the top layer of loam or topsoil at the rate of 800 pounds per acre and worked into the seed bed. The full depth of loam or topsoil shall then be spaded or harrowed and graded to the required cross section.

765.63 Seeding Grass.

After the loamed or topsoil areas have been prepared and treated as hereinbefore described, grass seed conforming to the respective formulas hereinbefore specified shall be carefully sown thereon at the rate of approximately 50 pounds per acre. Seeding shall be done in two directions at right angles to each other. Seeding on level areas and on slopes up to and including 4:1 slopes shall be done by means of an approved seeder that will seed and roll in one operation. On shoulders and other narrow areas, the seeding may be done longitudinally in one application.

765.64 Seeding Crownvetch.

When crownvetch (Emerald, Chemung or Pennigift variety) is to be planted by direct seeding, the slopes shall be prepared by spreading Limestone at the rate of two (2) tons per acre or 100 pounds per 1000 square feet.

Fertilizer, granular 5-20-20, shall be applied to the slopes at the rate of 800 pounds per acre, or 800 pounds per acre of granular 0-20-20 plus 40 pounds per acre of N derived from organic material.

The Limestone and Fertilizer shall then be mixed into the soil on the slope by raking or other suitable method.

Crownvetch will not grow satisfactorily in soil with a ph factor of less than 6.0 to 6.5.

Crownvetch seed, minimum 70% germination, including hard seed, shall be treated with an inoculant before sowing. A four (4) ounce package of inoculant is supplied with each 20 pounds of Crownvetch seed. The seed shall be moistened by pouring on a cup of saturate sugar solution and thoroughly mixed. Then the inoculant, a powder is blended with moistened seed by mixing.

The mixture shall then be sown by hand or a drill spreader (The hydraulic method will not be permitted) at a rate of 20 pounds of seed per acre of 7¼ ounces per 1000 square feet.

Perennial Rye grass seed shall then be spread at the rate of 15 pounds per acre or 5½ ounces per 1000 square feet. This rate of seeding must not be exceeded at any time.

The seeds shall then be raked into the previously prepared slope.

Under no condition shall any other grass seed mixture, either plot or slope be sown in the areas of planting because of the competition between the desired crownvetch and the grass.

The slope shall then be covered with two (2) tons of Hay (long strands — minimum 10 inch length) per acre.

765.65 Seeding Grass by Spray Machine.

A hydraulic spray machine, approved by the Engineer, and designed specifically for seed dissemination may be utilized. The application of limestone as necessary, fertilizer and grass seed may be accomplished in one operation by the use of an approved spraying machine. The materials shall be mixed with water in the machine and kept in an agitated state in order that the materials may be uniformly suspended in the water. The spraying equipment shall be so designed that when the solution is sprayed over an area the resulting deposits of limestone, fertilizer and grass seed shall be equal in quantity to those quantities specified above in Subsections 765.61, 765.62 and 765.63.

A certified statement shall be furnished, prior to start of work, to the Engineer by the Contractor as to the number of pounds of limestone, fertilizer, and grass seed, per 100 gals. of water.

This statement should also specify the number of square yards of seeding that can be covered with the solution specified above.

If the results of the spray operation are unsatisfactory, the Contractor will be required to abandon this method and to apply the limestone, fertilizer and seed in accordance with the requirements of Subsections 765.61, 765.62 and 765.63.

765.66 Care During Construction.

The Contractor shall be responsible for the watering of all seeded and grassed areas which shall be kept moist. The Engineer's decision will prevail in the event a dispute develops with the Contractor as to whether or not the seeded and grassed areas are moist. Seeded areas on which growth has started shall be watered to a minimum depth of 2 inches to assure continuing growth. Watering shall be done in a manner which will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the finished surface by the watering equipment. The Contractor shall furnish sufficient watering equipment to apply one complete coverage to the seeded areas in an 8 hour period.

If necessary, suitable signs and barricades of brush or other materials shall be placed to protect the seeded areas.

After the grass has appeared, all areas and parts of areas which fail to show a uniform stand of grass, for any reason whatsoever, shall be reseeded and such areas and parts of areas shall be seeded repeatedly until all areas are covered with a satisfactory growth of grass.

The Contractor shall care for all of the seeded areas until the work has been physically accepted, without compensation in addition to the amount regularly to be paid under this item as hereinafter provided. Care shall include all regrading, refertilizing, reseeding and mowing which may be necessary.

Prior to the acceptance of the project the Contractor will be responsible for mowing the grass when necessary on all flat or rolling slopes from level to and including 4 to 1 slopes to a height of 3 inches when the grass has attained a height of eight inches. The grass on all slopes steeper than 4 to 1 shall be cut when necessary to a height of 3 inches at such a time as a stable turf has been established in the Engineer's judgment.

765.67 Liability.

A satisfactory stand of grass, as determined by the Engineer, shall be required. To be acceptable, a stand of grass shall consist of a uniform stand of at least 60 percent established permanent grass species, with a uniform count of at least 100 plants per square foot.

When all items of the contract, including the work specified under this item, have been acceptably completed except that a satisfactory stand of grass has not been produced, the contract may be accepted.

The rate of establishment of the crownvetch seeding shall consist of a uniform stand of at least 3 vigorous plants per twenty five (25) square feet. Before final acceptance, all areas twenty five (25) square feet or larger, devoid of suitable crownvetch seedings shall be planted with crownvetch plants as specified in Subsection 771.67 of this specification at the rate of one (1) plant per twenty five (25) square feet.

COMPENSATION

765.80 Method of Measurement.

The quantity of seeding shall be the number of square yards based on actual measurements made over the general contour of the areas seeded, complete in place, and accepted.

765.81 Basis of Payment.

This work, including all mowing, will be paid for at the contract unit price per square yard under the item for Seeding, completed in place. When a satisfactory stand of grass has not been established at the time of acceptance, no payment for seeding shall be allowed at the time of acceptance. At the time the final estimate is ready to be forwarded to the Contractor the seeded areas will again be inspected by the Engineer and if a satisfactory stand of grass has been established, the seeded areas with a satisfactory stand of grass will be included for payment.

765.82 Payment Items.

765	Seeding	Square Yard
765.5	Seeding Crownvetch	Square Yard

SECTION 766
REFERTILIZATION

DESCRIPTION

766.20 General.

This work shall consist of an application of fertilizer to seeded areas as indicated on the plans, or as designated by the Engineer, and in accordance with these specifications.

MATERIALS

766.40 General.

Materials shall meet the requirements specified in the Subsection of Division III, Materials.

Fertilizer	M6.02.0
Seed	M6.03.0

CONSTRUCTION METHODS

766.60 General.

Work under this item shall be done in April, May, August or September. No permission will be granted to refertilize in months other than herein prescribed. Areas recently seeded shall be refertilized only after one season of growth of two months duration.

766.61 Application of Fertilizer.

The fertilizer shall have a composition of 10-10-10 and be applied at a rate of 500 pounds per acre. In addition, organic fertilizer derived from any commercial source shall be applied at the rate of 135 pounds of N per acre.

766.62 Seed.

Seed shall be included with the fertilizer at a rate of 10 pounds per acre.

COMPENSATION

766.80 Method of Measurement.

The quantity of refertilization shall be the number of square yards based on actual measurements made over the general contour of the seeded areas, complete in place.

766.81 Basis of Payment.

The work under this item will be paid for at the contract unit price per square yard, complete in place, which price shall include all labor, materials and equipment necessary to do the required work.

766.82 Payment Items.

766. Refertilization	Square Yard

SECTION 767
MULCHING; SEED FOR EROSION CONTROL

DESCRIPTION

767.20 General.

This work shall consist of furnishing and placing hay, straw, wood chip, wood fibre or aged pine bark mulch, as particularly specified, in the required amounts on the areas indicated on the plans or as directed.

MATERIALS

767.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials.

Hay Mulch	M6.04.1
Straw Mulch	M6.04.2
Wood Chip Mulch	M6.04.3
Wood Fibre Mulch	M6.04.4
Aged Pine Bark Mulch	M6.04.6
Seed for Erosion Control	M6.03.1

Bales of Hay for Erosion Control shall be fastened with wire and have a minimum size of 1.0 ft. by 1.5 ft. by 3.0 ft.

CONSTRUCTION METHODS

767.60 Preparation for Mulching.

The areas upon which mulch is to be spread shall be prepared by raking, harrowing or dragging to form a reasonably smooth surface. All stones larger than 2", undesirable growth over 2" in height and all debris shall be removed from the area and disposed by the Contractor in a satisfactory manner. The disposal area shall be outside the location limits of the project, when required by the Engineer and shall be the responsibility of the Contractor without additional compensation.

When required by the Engineer, the Contractor shall spread, compact and grade additional acceptable material to repair gullies or depressions. Such additional material shall be obtained from suitable excavation or furnished by the Contractor under Item 150., Ordinary Borrow. The labor and equipment required to furnish and place the additional material shall be paid for under the respective item from which the material is obtained without additional compensation.

Grading preparatory to mulching will be included for pavement under respective items of mulching.

767.61 Placing Mulch.

Hay or Straw Mulch shall be loosely spread to a uniform depth over all areas designated on the plans, at the rate of 4½ tons per acre, except over certain selected seeded areas where 2 tons of hay per acre shall be used, or as otherwise directed.

Hay or Straw Mulch may be applied by mechanical apparatus, if in the judgment of the Engineer the apparatus spreads the mulch uniformly and forms a suitable mat to control slope erosion. The apparatus shall be capable of spreading at least 80% of the hay or straw in lengths of 6″ or more, otherwise it shall be spread by hand without additional compensation.

Wood Chip Mulch and Aged Pine Bark Mulch shall be loosely spread to a uniform depth over all areas designated on the plans, at the rate of 390 cubic yards per acre (approximately 3″ in depth), or as otherwise directed.

Wood Chip Mulch and Aged Pine Bark Mulch may be applied by mechanical means, except that if the equipment breaks the mulch into small pieces or changes its desired texture, as determined by the Engineer, it shall be spread by hand without additional compensation.

Wood Fibre Mulch shall be uniformly spread over certain seeded areas at the minimum rate of 1,400 pounds per acre unless otherwise directed. It shall be placed by spraying from an approved spraying machine having pressure sufficient to cover the slopes from bottom to top in one operation. Immediately before spraying, the mulching material shall be mixed with water in the sprayer and kept uniformly suspended in the water by agitation during the spraying operation.

767.62 Hay Mulch with Seed for Erosion Control.

The intent of these items is the prevention of slope erosion. If the sequence of operations is such that only portions of slopes have been completed, such portions shall be preserved by seeding and mulching when directed prior to completion of the remaining portions of the slope.

The work to be done under the above items consist of applying seed and hay mulch onto slopes that have been graded and completed to the required line and grade at locations designated on the plans and as directed by the Engineer.

The operations shall be separate with the seed applied first. This work may be applied by hand or by mechanical apparatus, if in the Engineer's judgment, the apparatus spreads the materials uniformly and does not break the hay mulch into fine or small particles or otherwise change the desired texture of the hay mulch.

The seed shall be uniformly applied at the rate of 75 pounds per acre.

767.63 Bales of Hay for Erosion Control.

Bales of hay shall be supplied and placed along the bottom of slopes, ditches and where directed. The bales shall be securely fastened in place by staking or pinning as shown on the plans or in a manner approved by the Engineer.

During the course of construction, it may be necessary to remove and relocate or replace bales of hay as directed.

The removal of collected sedimentation and debris from behind these bales and disposal of same is included in this item.

The bales shall remain in place until the removal is directed by the Engineer. The bales shall then become the Contractor's property and shall be disposed of off the site.

COMPENSATION

767.80 Method of Measurement.

Hay Mulch and Straw Mulch, applied as required, will be measured by the ton delivered on the project as determined from certified weight slips.

Wood Chip Mulch and Aged Pine Bark Mulch will be measured by the cubic yard based on either truckload measurement as delivered on the project or in place measurement, the method of measurement to be determined by the Engineer.

If truckload measurement is used, wood chip mulch taken from this measured volume for mulching trees and shrubs other than placed in mass planting areas will be deducted on the basis of the volume of chips placed over the rated size of each planting pit at a depth of four (4) inches.

No deduction shall be made in mass planting areas for wood chip mulch ordinarily included in the unit price of the trees or shrubs planted therein.

Wood Fibre Mulch will be measured by the ton delivered on the project, as determined from the net weight certified by the manufacturer on the containers, or as determined from weight slips accompanying delivery.

Bales of Hay for Erosion Control will be measured by the unit in place, each.

Ordinary Borrow will be measured as specified in Subsection 150.80 or by truck load measurement, as determined by the Engineer.

Seed for Erosion Control will be measured by the pound.

767.81 Basis of Payment.

Hay Mulch, Straw Mulch and Wood Fibre Mulch will be paid for complete in place at the contract unit price per ton under the item for the particular type of mulch.

Wood Chip Mulch will be paid for complete in place at the contract unit price per cubic yard.

Aged Pine Bark Mulch will be paid for complete in place at the contract unit price per cubic yard.

Bales of Hay for Erosion Control will be paid for each, which shall include all labor, material and equipment necessary to place the bales, relocate as directed and finally remove and dispose of the bales including the removal of sedimentation from behind the bales of hay.

Replacement of Bales of Hay, when directed, will be paid for each.

Ordinary Borrow will be paid for complete in place at the contract unit price per cubic yard.

Seed for Erosion Control will be paid for at the contract unit price per pound.

767.82 Payment Items.

767.	Hay Mulch	Ton
767.3	Straw Mulch	Ton
767.4	Wood Chip Mulch	Cubic Yard
767.5	Wood Fibre Mulch	Ton
767.6	Aged Pine Bark Mulch	Cubic Yard
767.8	Bales of Hay for Erosion Control	Each
765.2	Seed for Erosion Control	Pound
150.	Ordinary Borrow	Cubic Yard

SECTION 768
HYDRAULIC SOIL STERILANT SPRAYING

DESCRIPTION

768.20 General.

The purpose of this work is to eliminate all vegetative growth from under and along highway guard rail by chemical spraying, therefore, reference in said Subsection 8.08 to this type of roadside growth is deleted as pertaining to treated areas. However, as sterilant chemicals are extremely toxic to all vegetation, care must be exercised in the application so that areas other than those indicated are not affected by run-off or spillage.

Only those sterilants which are currently approved by the State Pesticide Board and the Department will be permitted. The purpose of this work is to kill all vegetative growth and sterilize the soil in designated areas only; therefore, a controlled application of material must be maintained.

As this work is of a special nature, the Contractor may be required to furnish the Department with a written statement indicating that he has the necessary skill, experienced personnel and a qualified supervisor with at least two years experience in this kind of work together with a listing of all equipment of his own and available to him which he intends to use in performing the work required in a satisfactory manner.

The Contractor shall, at his own expense, preserve and protect from injury all property either public or private along and adjacent to the roadway and be responsible for and repair all damage and injury thereto arising out of or in consequence of any act or omission of the Contractor or his employees in the performance of this work.

The Contractor will be responsible for all damage caused by the use of these chemical sprays which are harmful to trees, shrubs, crops etc.

Spraying shall be done only during the full daylight hours, weather permitting.

Extreme care must be taken in the application of the chemical solutions so that areas other than those specified are not affected.

If, in the judgement of the Engineer, it is necessary at any time, the Contractor shall when directed, employ such forces and equipment for one or more additional shifts as will be required to take full advantage of all daylight hours to insure the proper completion of the work. The Contractor shall not receive any additional compensation therefor.

MATERIALS

768.40 General.

The chemical sterilant shall be 80% Diuron or one approved by the Massachusetts Department of Food and Agriculture — Pesticide Board.

Diuron is a wettable powder not soluble in water, therefore constant agitation is necessary.

The chemical spray mixture to be applied shall be proportioned as follows:

15 pounds of sterilant added to 100 gallons of water.

The active ingredients of the alternative sterilant material shall conform to the following Subsections of Division III, Materials:

Herbicides M9.02.2

Material shall be added slowly to the water with agitation. The agitation must be maintained constantly from the time of mixing until the spray tank is empty so that there will be no settling of the chemical. If the sprayer is not empty at times of interruption, such as lunch periods, etc., the agitator must be kept running to prevent any undesired settlement. If unforeseen circumstances make it necessary to leave material in the spray tank overnight, it must be brought back into complete suspension to the satisfaction of the Engineer before spraying starts

CONSTRUCTION METHODS

768.60 General.

The spraying apparatus shall be mounted on a single self-propelled vehicle and so constructed that no drool or spray shall be apparent at the nozzle beyond the point of shut-off, nor shall there be any leakage in any portion of the distributing apparatus at any time.

Two experienced licensed operators are necessary, one to act as the truck driver and the other as the nozzleman. Contractor's personnel shall be properly licensed in accordance with Chapter 94B of the General Laws, as amended by Chapter 521 of the Acts of 1962, and the Rules and Regulations adopted under Chapter 133B (Chapter 3 of the Acts of 1978) by the Pesticide Board of the Commonwealth of Massachusetts, Dept. of Food and Agriculture.

It is required that the truck be equipped with a well constructed working platform suspended from the front bumper, with safety railing.

The spraying equipment shall be so assembled, with fixed distributing apparatus, that a controlled minimum swath of 3 feet may be treated under the total length of guard rail sections while the vehicle is in motion. This swath will extend from a point 6" in back to a point 6" in front of the guard rail, but in some locations a greater width may be required in front of guard rail necessitating two spray runs for complete coverage.

The distribution apparatus must be so designed that a straight line application will result and consist

of an extended arm from 3/8" to 1" in diameter, depending upon the screen and size of the nozzles, containing sliding feed pipe with shut-off and two fixed nozzles so calibrated and set that 3/4 pound of actual sterilant chemical (5 gallons of mixed spray solution) will be distributed per 1000 square feet (500 lineal feet by 2 feet in width) at an application speed of not greater than 8 MPH. The speed shall not exceed that speed under which the nozzleman can control the equipment to get satisfactory coverage. On curves, speed must be reduced to control application to desired areas.

Filter screen for the suction and line strainer and individual nozzle screen shall be 40 mesh.

COMPENSATION

768.80 Measurement and Payment.

Hydraulic Soil Sterilant will be measured and paid at the respective contract unit price per square yard actually treated or by the hour as stipulated in the Proposal.

768.82 Payment Items.

768.1	Hydraulic Soil Sterilant Spraying	Hour
768.2	Hydraulic Soil Sterilant Spraying	Square Yard

SECTION 770
SODDING

DESCRIPTION

770.20 General.

This work shall consist of the construction of lawn, field or collected natural growth sod as required, on the areas indicated on the plans, or as designated by the Engineer, and in accordance with these specifications.

MATERIALS

770.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Loam Borrow	M1.05.0
Topsoil and Plantable Soil Borrow	M1.07.0
Sod	M6.05.0
Seed	M6.03.0

CONSTRUCTION METHODS

770.61 Laying Sod.

A foundation for the lawn and field sod shall be constructed and it shall consist of loam borrow, plantable soil borrow or topsoil rehandled and spread in quantities sufficient to produce, after natural settlement has taken place and after tamping, a depth of at least 4 inches. Fresh sods shall then be placed in final position on the areas designed for sodding. Sods shall be placed in a solid, strip or spot pattern as designated on the plans or as directed. When the solid pattern is used the sods shall be laid edge to edge with staggered joints. All sods shall be very carefully handled, to prevent loosening and separation of the loam from the roots. The combined thickness of the sod and loam shall be at least 6 inches. The sod shall be settled by watering it and by tamping on a board laid over it.

When the sods are to be placed in temporary storage piles, and they are in the form of separate flat slabs instead of folds or rolls, they shall be placed in layers so that the grassy side of the first or bottom layer shall be uppermost, whereas in the next succeeding layer the roots shall be uppermost, and so on in such a manner as to place the grass or roots of each succeeding layer in immediate contact with the corresponding surface of the preceding layer, in order to avoid rapid growth of the grass while in storage. The piles shall be sprinkled with water and covered with burlap, straw or other acceptable material which shall be kept moist when required and as directed. As a rule, temporary storage will not be permitted for a period longer than 5 days. The sod shall not be stored in such a manner to compress the thickness of sod below the minimum required.

Collected natural growth sod as specified in Subsection M6.05.0 shall be placed in an excavation in the existing ground to the depth of the sod and shall be placed in either a staggered pattern or in strips as directed. If the staggered pattern is used, sods shall be placed not over 3 feet apart. If strips are used, they shall run approximately parallel with the roadway and not over 10 feet apart. Loam shall not be used in laying natural growth sod. Mulch shall be carefully replaced around sods placed in premulched areas.

Care shall be taken that the collected sods shall be firmly embedded in the natural soil. A hole shall be excavated in the slope beneath the mulch to the depth and width of the sod and the sod placed therein. Soil and mulch shall then be placed and compacted around the sod. In all cases, the mulch must be parted at each planting location prior to planting and then satisfactorily replaced immediately following the planting. Collected natural growth sod shall be placed within one day after arrival on the project. Sods which have been stored beyond this time limit and sods which have become dried out or broken prior to placement in final position on the designated areas shall be rejected by the Engineer.

770.62 Fastening Sod to Slopes.

On slopes steeper than 3:1, lawn and field sod shall be held securely in place by fastening alternate lines of sod with wooden pegs. The pegs shall be not less than 12 inches in length, and they shall be spaced 3 feet apart and driven flush with the surface of the sod. Other approved methods of fastening sod to slopes may be used where pegging is not practicable.

770.63 Surface Dressing of Lawn and Field Sodding.

When the sod has been set in final position, loam shall be used to fill the joints and as a surface dressing to cover the sodded areas to a depth of about 1/4 of an inch. A grass seed mixture conforming to the specifications stated in Subsection M6.03.0 for Slopes and Shoulders, shall be mixed with clean, dry sand or dry sandy loam and sown upon the loam surface dressing at the rate of 0.45 of a pound to each 100 square yards. The sodded areas shall then be compacted, and the compaction shall be equivalent to that produced by a hand roller weighing between 75 and 100 pounds per foot of width and to produce a smooth, uniform surface.

Natural growth sod should be pruned after planting. All woody plants such as sweet fern, sheep laurel and blueberry shall be pruned 50% of their top growth.

770.64 Maintenance and Care.

The Contractor shall be responsible for any necessary watering of sodded areas.

If necessary, suitable signs and barricades of brush or other materials shall be placed to protect the sodded areas.

Before acceptance of the work, a satisfactory uniform stand of grass will be required. (See Subsection 765.66).

The contractor shall maintain all of the sodded areas until the work has been officially accepted, without compensation in addition to the amount regularly to be paid under this item, as hereinafter provided. Maintenance shall include all reseeding or resodding which may be necessary, as determined by the Engineer.

COMPENSATION

770.80 Method of Measurement.

The quantity of lawn and field sodding shall be the number of square yards based on actual measurements made over the general contour of the areas sodded, complete in place and accepted. The quantity of collected natural growth sods each conforming to M6.05.0 in a healthy condition, shall be the actual number of such sods at the time of acceptance of the project.

770.81 Basis of Payment.

The work involved in lawn or field sodding will be paid for at the contract unit prices per square yard, complete in place, under the respective items for Lawn Sodding or for Field Sodding, which prices shall include loam for filler and top dressing and seed, except loam used for foundation of sod which will be paid for as loam borrow, plantable soil borrow or topsoil rehandled and spread.

Collected natural growth sods will be paid for at the contract unit price, each, complete in place, under the item for Collected Natural Growth Sods.

770.82 Payment Items.

770.	Lawn Sodding	Square Yard
770.1	Field Sodding	Square Yard
770.2	Natural Growth Sod — Lowbush Blueberry	Each
770.3	Natural Growth Sod — Bearberry	Each
770.4	Natural Growth Sod — Mountain Laurel	Each
770.5	Natural Growth Sod — Sweet Fern	Each
751.	Loam Borrow	Cubic Yard
751.2	Plantable Soil Borrow	Cubic Yard
752.	Topsoil Rehandled and Spread	Cubic Yard

SECTION 771
PLANTING TREES, SHRUBS AND GROUNDCOVER

DESCRIPTION

771.20 General.

This work shall consist of furnishing, transplanting, planting and/or transplanting trees, shrubs, vines, ground cover and seedlings of varieties and sizes specified in locations as shown on the plans and/or as directed by the Engineer.

The work shall include excavation of pits, placing of backfill mixture, mulching, watering, staking or guying, wrapping, liming, fertilizing, seeding, care of the plants and replacement of unsatisfactory plants and materials during the life of the contract.

MATERIALS

771.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials with the amendments and supplements contained herein:

Loam Borrow	M1.05.0
Peat Borrow	M1.06.0
Topsoil and Plantable Soil Borrow	M1.07.0
Lime Stone	M6.01.0
Fertilizer	M6.02.0
Bone Meal	M6.02.1
Crownvetch Seed	M6.03.2
Woodchip Mulch	M6.04.3
General Planting	M6.06.0
Nursery Stock	M6.06.1

Crownvetch Potted Seedlings	M6.06.2
Tree Paint	M6.07.0
Materials for Guying & Staking	M6.08.0
Wrapping Material	M6.09.0
Water for Irrigation	M6.10.0

The Contractor shall furnish written certificates of compliance in triplicate for each load of plant material showing where the plants were grown and listing all transplantings, age or size as specified, grade and quantity. All plants shall be tagged so that proper identification can be made.

All trees and shrubs shall be balled and burlapped, ;unless otherwise provided by the plans and specifications.

The caliper, height, age and other dimensions as specified for all planting material shall apply at the time planting is done and the plants will be inspected by the Engineer at this time as to these requirements as well as the quality or grade and varieties required. All plants not approved by the Engineer shall be removed from the project by the Contractor.

The trees, shrubs, vines and evergreen seedlings shall be Northern Grown Nursery Stock. Botanical and common names shall conform with the current edition of Hortus Third, compiled by the staff of L.H. Bailey Hortorium, Cornell University.

The current edition of U.S.A. Standard for Nursery Stock sponsored by the American Association of Nurserymen, Inc., shall be the Department's standard for all plants and for balling and burlapping sizes and requirements.

The term "plant" shall refer to any tree, shrub, seedling, vine or groundcover.

771.41 Storing of Materials.

Materials may be temporarily stored within the highway layout as directed by the Engineer. When materials are stored within the layout, the site shall be abandoned immediately upon completion of the project and the storage area returned to its original natural condition at the sole expense of the contractor.

771.42 Delivery and Protection.

Arrangements shall be so made so far as practicable to have plants delivered as the pits or beds are ready for them. Whenever plants cannot be planted on the day of arrival, all those with bare roots shall be "heeled-in" in moist soil in a satisfactory manner. All "heeled-in" plants shall be properly maintained by the Contractor until they are planted. In the event that "heeled-in" plant material must be held over until the next planting season, such material shall be lifted and replanted in a satisfactory manner in nursery rows as directed by the Engineer. The ball of roots of balled and burlapped plants, if not planted immediately after delivery and inspection, shall be adequately protected by loam covering until removed for planting and in a satisfactory manner appropriate to the condition. Throughout the work, care shall be exercised to keep the roots of all plants from drying out, to preserve the solidity of the balls of "B&B" plants, and to prevent plants from being broken, scarred or damaged in any way. All emergency storage of materials shall be at the entire risk of the Contractor.

771.43 Backfill Mixture for Bare-Rooted & Burlapped Plants.

A. Evergreen Trees and Evergreen Shrubs
   1 part peat borrow
   2 parts loam borrow
   10 pounds bone meal per cubic yard of mixture
B. Deciduous Trees and Deciduous Shrubs
   1 part peat borrow
   3 parts loam borrow
   10 pounds bone meal per cubic yard of mixture
C. Roses, Vines and Ground Cover
   1 part peat borrow
   2 parts loam borrow
   20 pounds bone meal per cubic yard of mixture

The Contractor shall notify the Engineer in writing at least 15 days in advance when he intends to use the backfill mixture, the source and amount of material available and reserved for backfilling. Samples for testing will be taken in the field at the source. The Contractor shall furnish facilities and assistance to the Engineer for collecting and forwarding these samples.

771.44 Container Grown Plants.

All container grown plants shall be healthy, vigorous, well-rooted and established in the container in which they are sold. They shall have tops which are of good quality and are in healthy growing condition. An established container grown plant shall have roots penetrating the plantable container, or, on removal of the container, shall reveal roots that thoroughly penetrate the soil mass to the extent that the soil mass does not crumble apart on handlings.

The container shall be sufficiently rigid to protect the root mass during shipment.

The container sizes shall be provided in accordance to the "USA STANDARD FOR NURSERY STOCK" specifications by the American Association of Nurserymen, Inc.

Container grown crownvetch shall conform to the provisions of Subsection M6.06.2.

The potting mixture in containers shall be 1 part peat, 1 part loam and 1 part coarse sand. If necessary, ground limestone shall be added to raise the pH value to 6.0. Superphosphate shall be added at the rate of 6 pounds per cubic yard.

The potting mixture for sweet fern shall be equal parts of peat and sand, with no additives required.

Plants of Liner size and Sweet Fern root cuttings shall have been grown in the container for a minimum of twelve (12) weeks.

The certificate of compliance for container grown plants shall contain, in addition to the requirements listed in Subsection 771.40, the guaranteed composition of the potting mixture and the date of planting in the container. A random sample may be required from each delivery for soil and root inspection upon request of the Engineer.

CONSTRUCTION METHODS

771.60 General.

Balled and burlapped plants may be planted in the spring until June 15 and in the fall from August 15 to November 1.

Container grown plants may be planted at any time the ground is not frozen (provided specified minimum time of growth and root development have been met).

Bare rooted plants shall be planted only from the time ground thaws in spring until May 15.

The seeding season for crownvetch shall be from April 15 to August 15.

771.61 Turf Removal.

In areas of mass shrub planting where there is an established turf the Contractor will be required to excavate the sod, as indicated on the plans or as directed by the Engineer, to a depth sufficient to remove the root system (approximately 4").

The shape and dimensions of the areas to be so treated shall be determined in the field by the Engineer.

It shall be the Contractor's responsibility to dispose of all material removed in a manner satisfactory to the Engineer.

771.62 Excavation of Planting Pits.

The dimensions of the planting pits for bare rooted or balled and burlapped plants shall be as follows:

A. Trees more than 4 feet high

Diameter at least 2 feet larger than the diameter of the ball or root spread; depth at least 12" greater than the depth of the ball or root system.

B. Trees 4 feet high or less

Least dimension 2 feet.

C. Shrubs

Least dimension 2 feet.

D. Roses, Vines and Ground Cover

Least dimension 1 foot.

The shape of the pits may vary from square to round with the approval of the Engineer. In all cases the least dimension of the pit shall be sufficient to easily accommodate the root system without crowding. The excavated material shall be disposed of as directed.

771.63 Planting Bare Rooted Plants (Except Seedlings).

The backfill mixture of soil placed beneath the plant shall be firmed prior to setting the plant.

The plant shall be set in the planting pit at a depth within one inch below the depth at which it was previously growing. The root system shall be carefully spread and the pit partially backfilled, making sure that the soil filters in among the roots. The backfill shall be formed with care taken not to injure or bruise the roots.

When the pit is between 2/3 and 3/4 full it shall be puddled to eliminate air pockets and settle the soil. After the water has percolated into the soil, the rest of the pit shall be filled in. A mound shall be formed around the edge of the pit to form a shallow saucer to aid watering. The pit area shall then be puddled again and any depressions occurring as a result filled in with the backfill mixture. The plant shall be woodchip mulched, after watering, to a depth of 4 inches as provided in Subsection 771.71.

771.64 Planting Balled and Burlapped Plants.

The plant shall be set in the planting pit at a depth within one inch below the depth at which it was previously growing. The burlap shall then be untied, loosened and spread away from the ball. Any excess burlap shall be cut away and disposed of as directed. Roots that have been wrapped around the ball shall be made to lay in as natural a manner as possible. Backfill shall then be placed around the ball and firmed.

The planting procedure shall also include that as specified in the first and third paragraphs of Subsection 771.63, entitled "Planting Bare Rooted Plants (except Seedlings)".

771.65 Planting Container Grown Plants.

The plant shall be placed in a hole that is six (6) inches larger than the diameter of the container and the surface of the soil of the container shall be level with the surrounding ground. Any part of a plantable container projecting above the level of the soil shall be removed. All metal, plastic or other non root-thru type container shall be completely removed during the process of planting. The part of the hole outside the container shall be backfilled with the excavated soil and thoroughly firmed and puddled with water to eliminate air pockets. A mound of soil shall be formed on the ground around the container to form a shallow saucer to aid watering. On steep slopes, the mound around the saucer may be omitted on the uphill side. The plant shall be woodchip mulched, after watering, to a depth of 4 inches as provided in Subsection 771.71.

771.66 Planting Bare Root Seedlings.

Bare root seedlings of the variety indicated on the plan shall be planted by opening a wedge-shaped hole in the slope of a sufficient size to take the seedling's roots that are to be directed downward and without kinks. The seedling shall be placed at a depth in the hole approximately one (1) inch below its previously planted depth. The planting hole shall be closed by making a second wedge-shaped hole about 2 inches from the first in order to force the first closed, which then shall be closed and compressed with the heel.

Bare root seedlings shall be given a liquid mud bath prior to planting.

For seedlings to be planted on grass covered slopes, it will require removal of the sod on a one (1) foot square area for a maximum depth of two (2) inches at each seedling location prior to planting.

Seedlings must be delivered to the project in a dormant condition. If there is any evidence that growth has started, the entire load or lot will be rejected.

Evergreens will be rejected if the fine roots were lost in digging.

771.67 Planting Crownvetch.

Crownvetch shall be planted on areas that are bare, eroded or where grass growth is sparse and in areas of separated turf as indicated on the plan or directed by the Engineer. When crownvetch in peat pots is to be planted the slopes shall be prepared by spreading limestone at the rate of 1.5 tons per acre or 75 pounds per 1000 square feet and fertilizer, granular 0-20-20 at the rate of 600 pounds per acre or 15 pounds per 1000 square feet. Crownvetch will not grow satisfactorily in soil with a pH factor of less than 6.0 to 6.5.

Perennial Rye Grass seed shall be sown only on large bare areas are the rate of 15 pounds per acre or 5½ ounces per 1000 square feet and then raked into the previously prepared slope. This rate of seeding must not be exceeded at any time, because of the competition between the crownvetch and rye grass. Deteriorating slopes, where grass is sparse, require no rye grass.

Under no condition shall any grass seed mixture, either plot or slope, be sown in the areas of crownvetch planting.

The slope shall then be covered with hay at the rate of two (2) tons per acre.

The mulch material shall be parted for each planting. Holes, six (6) inches square or round and six (6)

inches deep shall be spaced five (5) feet on centers in staggered rows. The hole shall then be backfilled with Loam Borrow. (M1.05.0).

The outer shell or peat pot must be removed before planting.

Plants shall be placed at a depth in their hole approximately one (1) inch below their previously planted depth. After planting, the loam around the plant shall be satisfactorily compressed and a slight depression left to catch rain water, and the previously parted mulch shall be drawn back around the plant.

Limestone at the rate of one-half ton per acre or 25 pounds per 1000 square feet, and Fertilizer, granular 0-20-20 at the rate of 200 pounds per acre or five (5) pounds per 1000 Square Feet shall be spread over the mulch, between the rows, near the plants.

The total amount of Limestone to be used in this planting shall be two (2) tons per acre and the Fertilizer shall be 800 pounds per acre.

771.68 Staking and Guying.

Type I(a) Evergreen Trees 3 to 4 feet high
Deciduous trees 5 to 6 feet high

These trees shall be supported by one stake driven firmly two (2) to three (3) feet into the ground. The stake shall be located far enough from the tree to avoid damaging the roots and so that the top of the stake shall be about 2/3 the height of the tree. The point of attachment to the stake shall not be more than six (6) inches from the trunk. If the stake must angle toward the tree, it shall be driven at such an angle to cross the trunk and shall extend about four (4) inches past the trunk.

Secure the tree to the stake with 12 gauge hose-covered wire twisted to provide tension The length of the hose shall be 8 inches.

Type I(b) Trees higher than type 1(a)
and less than 3 inches caliper

These trees shall be supported with two (2) stakes on opposite sides and driven into the ground at least two (2) feet. The stakes shall be cut off at a height in aesthetic proportion to the height of the tree. The stake shall not be higher than three fourths (3/4) the height of the tree. Secure the tree to stakes with 12 gauge wire with hose and twist the wire to provide tension. The length of the hose shall be 8 inches.

Type II Trees 3 to 4 inch caliper

These trees shall be securely guyed by wire, protective material and anchors. Three guys shall be equally spaced around the tree. Each guy shall be fastened around the tree trunk immediately above a substantial limb located 1/2 to 2/3 of the tree height above the ground and anchored at a distance from the trunk equal to 2/3 of the height of attachment to the tree. The anchor shall be a hardwood stake. The anchor stake shall be firmly driven at an angle and to a depth of at least 15 inches and the excess length of stake shall be cut off 3 inches above the ground.

The guy wire with protective hose shall be placed around the tree trunk, secured at the hose by a single twist, extended with both wires to the anchor stake and securely fastened with enough slack in the guy to permit ten to twenty twists for tensioning. After installation of all guys, the wires shall be twisted by a lever in the same direction as previous twists to provide tension, as directed by the Engineer.

771.69 Wrapping.

Only deciduous trees will require wrapping. Trunks of trees one (1) inch caliper and over shall be completely wrapped with burlap or other approved material beginning at the base of the tree and extending to the first branch. Wrapping shall be tied at the top and bottom and at 2-foot intervals. Wrapping of tree trunks shall not be completed until after inspection and approval by the Engineer. Wrapping of tree trunks shall be completed within five (5) calendar days after planting.

771.70 Protective Screen.

All Euonymous, Flowering Cherries and Flowering Crabs shall be protected to a height of 12″ to 18″ above the ground from animals and rodents by a protective cage. The cage shall be of wire or plastic mesh or other approved material and shall not make any direct contact with the tree. Standard practice shall apply.

771.71 Mulching.

No mulch shall be applied prior to the first watering of the plant. Trees and shrubs shall be mulched not later than one week after planting.

Mulch material shall be furnished and placed over all pit or saucer areas of individual trees and shrubs and over the entire area of shrub beds to the depth indicated on the plans.

In areas to be planted with roses, vines, or ground cover, the entire area shall be mulched before planting. The mulch shall be parted at the location of each hole and carefully replaced around the plant immediately after planting.

Preparation for mulch areas of mass planting shall conform to the provisions of Subsection 767.60.

Mulch material may be wood chips, aged pine bark or other material as indicated on the plans or approved by the Engineer.

771.72 Pruning.

Pruning of all plants shall be done only by persons skilled in this work, as follows: Initially, all broken or dead or injured branches shall be cut flush with the trunk or limb, and broken roots shall be pruned on the plant side of the break. Additional pruning shall be done in accordance with accepted nursery practice for the variety of plant involved. The foregoing shall be done at the time of planting.

Dieback shall be pruned before final acceptance.

Pruning shall not deform or otherwise destroy the typical shape or symmetry of tree and shall not reduce the height by more than 1/3. The leader of the tree shall not be cut back unless otherwise directed.

Cuts larger than one inch in diameter shall be painted with approved tree paint.

771.73 Care and Maintenance.

The Contractor will be held responsible for all planted material until the project is completed and accepted, at which time all plants shall be in a healthy, growing condition and free from weeds or other obnoxious materials or conditions. All plants shall be care for during the course of the project by weeding, cultivating, pruning, trimming, tightening of guys, resetting or replacement of plants where necessary, and by performing other operations to keep the plants healthy and growing.

771.74 Weeding.

The Contractor will be responsible for weeding around planted materials mulched with wood chips. All weeding shall be completed before the acceptance of the project. At no time shall weeds attain the height of 6 inches during the period of contract prior to acceptance.

771.75 Watering.

All plants shall be watered during planting and all plants, except seedlings, shall be watered at least twice each week for a minimum of twelve (12) waterings. At each watering the soil around each tree or shrub shall be thoroughly saturated. If sufficient moisture is retained in the soil, as determined by the Engineer, the required watering may be reduced.

Trees will require a minimum of 10 gallons of water, each; shrubs — a minimum of 5 gallons, each; and a minimum of 1500 gallons per acre on areas planted or seeded with crownvetch.

Trees or shrubs planted after October 15 shall be thoroughly watered at the time of planting, after which subsequent watering will not be required.

771.76 Period of Establishment.

The Contractor shall employ all possible means to preserve the plants in a healthy growing condition. The plant establishment period shall be for at least one year following the satisfactory completion of all planting on the contract or for the duration of contract, whichever is later. Care during the establishment period includes watering, cultivating, pruning, repair and adjustment of guys and stakes, and such other work as specified or ordered by the Engineer.

771.77 Replacement of Defective Plant Material.

The Contractor shall replace all plant material that has not shown satisfactory evidence of growth. A semi-final inspection by the Engineer and the Contractor will be made to determine the acceptability of the plant material at a date no later than September 20 prior to a November project completion date. Each tree shall show at least 75% healthy growth and any other plants, except seedlings and crownvetch, shall show at least 50% healthy growth. All dead and unsatisfactory plants shall be replaced in kind and size with plants as originally specified, or on approval by the Engineer in writing, by alternate or substitute varieties of plant material of equal value. Replacement plantings of evergreens shall be in place by October 15 and of deciduous by November 1st. Replacement plantings shall conform to the provisions of this section, excepts the requirements for establishment.

Seedling and crownvetch plantings shall be allowed a tolerance of 25% for dead or defective plants, provided there are no prominent bare spots. If the number of seedlings or crownvetch plants in any planting area are less than the allowable tolerance, sufficient replacement plantings shall be made to eliminate the bare spots and also meet the specified tolerance.

All dead and unsatisfactory plants, except seedlings and crownvetch shall be promptly removed from the project.

A final inspection of all plant material for acceptance will be held after the replacement planting has been completed.

COMPENSATION

771.80 Method of Measurement.

The quantity of plants to be paid for will be the number of living trees, shrubs, vines and ground cover plants of specified kinds and sizes furnished, planted and accepted in accordance with these specifications.

The quantity of seedlings to be paid for will be the number of seedlings originally planted, provided the establishment rate of the replacement plantings are acceptable in accordance with the specifications.

The quantity of crownvetch planting will be the number of acres measured on the surface and accepted in accordance with the specifications.

Turf Removal will be measured in its original position on the designated surface area and by a depth of four (4) inches.

Woodchip mulch used on areas other than over tree or shrub planting pits will be measured by truck-load volume on delivery at the project. The mulch taken from this measured volume and used for mulching trees and shrubs will be deducted on the basis of the volume of chips placed over the rated size of each planting pit at a depth of four (4) inches.

771.81 Basis for Payment.

The quantity of trees, shrubs, vines, seedlings and ground cover plants measured as provided above will be paid for at the contract unit prices each for planting of the types, species and sizes called for in the bid schedule. The unit price per planting item shall include furnishing and delivering all plants, furnishing and delivering prepared backfill soil, mulch, fertilizer, digging plant pits, planting, pruning, guying and staking, wrapping, mulching, weeding, watering, cleanup, plant establishment work and care including replacements, and for all labor, equipment, tools and incidentals necessary to complete the work prescribed in this section, except that mulch for vines and ground cover plants will be paid for at the contract unit price for the mulch specified.

Crownvetch plantings will be paid for under the contract unit price per each potted plant. The unit price per each shall include furnishing and delivering all plants and materials, preparing the slope, fertilizing, liming, planting, seeding, raking in the seed, mulching, watering, plant establishment work and care including replacements and for all labor, equipment, tools and incidentals necessary to complete the work prescribed in this section.

Turf removal will be paid for at the contract unit price per cubic yard under the item for Earth Excavation.

Wood chips for mulching areas other than specified for trees and shrubs will be paid for at the contract unit price per cubic yard, in place, under the item for Wood Chip Mulch.

No payment will be made for mulching specified as required and included in payment for other contract items.

771.82 Payment Items — General Categories.

772. to 774.	Evergreen Trees B & B	Each
775. to 784	Deciduous Trees B&B	Each
785. to 787.	Evergreen Shrubs B&B	Each
788. to 795.	Deciduous Shrubs B&B	Each
796.	Vines, Groundcover and Crownvetch, Pot-Grown	Each
798.	Seedlings	Each
120.	Earth Excavation	Cubic Yard
767.4	Woodchip Mulch	Cubic Yard

SECTION 800
TRAFFIC CONTROL DEVICES

SECTION 801
CONDUIT, MANHOLES, HANDHOLES PULL BOXES AND FOUNDATIONS

DESCRIPTION

801.20 General.

The work under this section shall consist of furnishing and installing and/or constructing the following in accordance with the requirements of the specifications, as directed on the plans and as directed by the Engineer.

A. Unless otherwise specified or indicated on the plans conduits or ducts, intended for use as raceways for the installation of wires and cables, shall be 3-inch nominal size.

1. Type NM — Rigid Non-Metallic (Bituminous Fiber, Fire Clay Cement, or Plastic) — shall be used for all underground runs unless otherwise specified. When Type NM Electrical Conduit is specified either of the Types NM Electrical Conduit listed under Subsection M5.07.0 may be used in the work, at the option of the Contractor, but only one type shall be used throughout any one contract.

2. Type RM — Rigid Metallic (Steel, Steel Plastic Coated, Special Alloys or Aluminum) — shall be used for all above ground runs, unless otherwise specified, and where augured or jacked conduit is required. When specified for underground use or to be encased in concrete, conduit shall be plastic coated or manufactured from metal inherently resistant to corrosion.

3. Type FM — Flexible Metallic (Steel or Steel Plastic Coated) — shall be used where flexibility and special applications are required.

B. Junction Boxes or Pull Boxes shall be of such dimension as shown on the Standard Drawings. Unless otherwise specified, other designs shall not be used. Pull Boxes shall be installed in all conduit or duct runs over 150 feet in length, where there is an abrupt change in direction, grade or elevation, to provide a direct one conduit entrance for wire and cable into signal, mast arm or strain pole foundations, and as directed by the Engineer.

C. Electric Manholes as shown on the Standard Drawings, plans, and/or as directed by the Engineer.

D. Foundations for light standards, lighting load centers, standard signal posts, pedestal signal posts, mast arms, strain poles and control cabinets.

MATERIALS

801.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Cement and Cement Concrete Materials	M4
Pipe, Culvert Sections, Conduit and Fittings, Pull and Junction Boxes	M5
Paint and Protective Coatings	M7
Metal, Related Materials, Cast Iron Frames and Covers	M8
Gravel	M1.03.0 Type c

Metallic pull and junction boxes may be cast iron, welded sheet steel or cast aluminum, with gasketed covers securely fastened with monel or stainless steel screws that will, with cover in place, be watertight. Cast iron or sheet steel boxes shall be hot dipped galvanized conforming to the applicable portions of ASTM A 153.

CONSTRUCTION METHODS

801.60 Conduit.

A. Excavating Trench.

The conduit shall not be placed until after the gravel subbase for the roadway has been constructed and the rolling thereof has been completed.

The trench for a single conduit line shall be excavated to a width of 18 inches to a depth not less than 36 inches below the proposed grade of the finished pavement as shown on the plans. Whenever 2 or more conduit lines are to be laid in the same trench, the trench shall be excavated to the width shown on the plans or as specified in the Special Provisions. If the condition of the bottom of the excavated trench is wet, clayey or spongy, or otherwise unsatisfactory, the Engineer may require that the bottom of the trench be excavated deeper and the space filled with clean gravel to form a firm bearing for the conduit. The gravel shall be firmly compacted in layers not over 6 inches in depth. The grade of the finished trench shall be parallel to the proposed pitch of the traffic conduit or duct.

B. Preparation of Bed.

After the trench has been excavated to the proper width and depth as specified above, a gravel foundation 6 inches in depth shall be constructed on the bottom of the trench to provide a proper cushion for the conduit. This cushion of gravel shall be thoroughly tamped.

C. Laying Conduits.

Unless otherwise directed, all conduit lines shall be direct from one end to the other, no bends being allowed except when entering a pull box or signal base. Whenever 2 or more conduit lines are to be laid in the same trench, the conduits shall be separated from each other by a minimum distance of 3 inches.

D. Joints.

All joints shall be made in accordance with conduit or duct manufacturer's recommendations, NEMA, UL and the Massachusetts Electrical Code (MEC).

E. End Markers.

Dead ends of conduit lines shall be plugged with wooden, plastic or fibre stoppers. To mark the ends, sections of 2 inch by 4 inch studs, long enough so as to project above the surface of the ground after the trench has been backfilled, shall be set vertically before the backfill is placed. For single conduit lines, the stud shall be butted directly against the stopper in the end of the conduit. Where 2 or more conduit lines converge to a common point, each line shall be ended 2 feet from the common point of intersection and a stud set up at this point. Backfill shall not be placed until the Engineer has established the necessary ties to the studs.

F. Concrete Envelope.

All Type NM Conduits or ducts marked "X" on the plans shall be encased in a concrete envelope as shown on the Standard Drawings.

G. Filling Trench.

Gravel fill shall be made around the sides of the conduit and over it for a depth of 3 inches and thoroughly tamped. A plank of spruce, fir, hemlock or other satisfactory wood, about 6 inches wide and 2 inches thick, (nominal dimensions) shall be placed over this gravel and the filling of the trench with suitable materials in layers of not over 6 inches, compacted thoroughly, shall be completed. If Extra Heavy Wall (Schedulle 80) Conduit is selected as an option for Rigid Non-Metallic Conduit, an approved underground warning tape may be substituted for the 2 inch by 6 inch plank.

H. Testing Installation.

After the trench is backfilled, the Contractor shall, in the presence of the Engineer, test the installation by pushing or pulling through the entire length of the conduit line a rod, rope or fish tape on the end of which is attached a brush and ball with a diameter not smaller than 1/4 of an inch less than the inside diameter of the conduit. All obstructions, including stones, dirt, concrete, etc., shall be removed, and damaged conduits shall be replaced at the expense of the Contractor.

I. Conduit and Duct Crossing Paved Roadways.

Unless otherwise specified, when a trench has been cut across a paved surface, the trench shall be bridged with a 6 inch concrete slab as shown on the Standard Drawings.

When jacking or drilling methods are specified for placing conduits under existing pavements, pavement shall not be disturbed without the approval of the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to located the obstructions. Jacking or drilling pits shall be kept 3 feet clear of the edge of any type pavement wherever possible.

J. Conduit on Structures.

Conduit system on structures shall consist of furnishing and installing all material and equipment and performing all work necessary for a complete conduit system. The type of conduit shall be as designated on the plans conforming to the requirements of Subsection M5.07.1. All conduit bends shall be made in a neat and workmanlike manner, crushed or deformed conduit shall not be used. Conduit ends shall be reamed to remove all burrs, and all chips resulting from reaming removed from the conduit before installation. The ends of all conduit runs shall be protected by grounding bushings and be capped if wire and cable is not to be installed immediately. Conduit shall be held rigidly in place to prevent misalignment during placing of concrete. Reinforcing bars shall not be cut, bent, displaced or otherwise altered from that shown on the design plans, unless directed otherwise by the Engineer. One manufactured expansion fitting (made of material compatible with the conduit) shall be used for each conduit run on structures at every expansion joint of the structure, unless flexible metallic conduit loops or bends are stipulated. Clamps or hangers shall be provided at intervals not exceeding 5 feet.

Conduit runs shall be made with the minimum practicable number of bends. The total of the angles of bends between junction or pull boxes shall not exceed 270°. So far as practicable, all bends shall be formed by the use of factory standard radius elbows. For metal conduit, where special angles of bends or offset bends are required, they may be formed to a radius of not less than 6 times the nominal inside diameter, provided the bend is made on a pipe bending machine. Field bends may be made by the use of a conduit bender forming curves the minimum radius of any portion of which shall not be less than 12 times the nominal inside diameter. Short radius bends shall be accomplished by the use of junction boxes or special condulets. Hot bends or other methods of bending which will destroy the protective coating on the metal conduit will not be permitted.

Conduit in which the cross sectional area has been reduced or which contains sharp kinks will be rejected. Unless the plans indicate otherwise, conduit shall be continuous from outlet to outlet: however, the runs may be interrupted by condulets placed for the purpose of pulling conductors or making short radius bends. All metal conduit shall be cut square, the ends internally reamed and threaded the proper length and assembled at all fittings in proper manner so that all joints will be mechanically secure, water tight, and provide electrical continuity. All threaded connections shall be given a coat of pipe joint compound before fitting up.

The ends of field cut joints on non-metallic conduit, except plastic, shall be tapered to conform to factory ends. The sections shall be joined at couplings and fittings by tapping the ends of sections sufficiently to provide water tight joints without over stressing or cracking the fittings. Where non-metallic conduit is joined to metallic conduit, special tapered and threaded non-metallic adaptors shall be used. When fitting-up compound is specified for non-metallic conduit the compound shall be of a type which will remain plastic during assembly and set within a reasonable period thereafter. The compound shall be carefully painted on joints so that excess compound will not intrude on the inner surface of the conduit after assembly.

All junction boxes shall be of sufficient size to provide for proper splicing and packing of all conductors, plus additional space for a future increase of 50% in the number of conductors or conductor size.

All unused openings in boxes and fitting shall be closed by tight metal plates or plugs and all dead ends of conduit, except where provided for drainage, shall be fitted with pipe caps.

All terminal ends of conduit not ending in boxes or condulets shall be fitted with rubber bused caps containing the required number and size of holes to tightly fit the conductors running through, or fitted with standard water tight terminal fittings or pot-heads.

Where an obstruction may have developed in any conduit run, it shall be removed, if practicable. If the obstruction is not removed, the affected portion of the conduit system shall be removed and replaced with new, clean conduit, or, if this cannot be accomplished, an entire new conduit shall be placed around the affected section at a location selected by the Engineer.

All conduit encased in concrete shall be rigidly held in proper position during concrete placement. Nonmetallic conduit shall be secured against separation at the joints during concrete placement by being tied to a separate steel rod at least 1/2 inch diameter running the full length of the conduit. Such rod and ties shall be considered as parts of the electrical installation.

Provisions for adequate drainage shall be made in all conduit systems. Horizontal runs shall be slightly pitched and unless completely sealed against moisture, all low points shall be drained.

Conduit shall be adequately suported by sleeves, fixed boxes, hangers, clamps or anchorages placed at intervals not exceeding 5 feet. Anchor bolts which are indicated on the plans as set in concrete shall be placed in the proper location before placing concrete.

Condulets, pull boxes, junction boxes and caps shall be of galvanized cast or malleable iron, of the threaded connection type with cast waterproof covers fitted with moisture proof gaskets. The covers of junction boxes which house transformers or cutouts shall be attached to the box by hinges or chains.

Conduit or raceway sleeves shall be placed during construction of the portions of the structures in which they are located. They shall be maintained in a clean condition and protected from damage or obstruction by placing removable plugs or caps until ready for use.

In general, exposed conduit shall not be placed until all adjacent construction work has been completed. Portions of conduit to be encased in masonry, or boxed in between structural members, shall be placed in advance of placing concrete or during assembly of structural members and protected from damage and plugging by use of covers or tight fitting metal caps.

801.61 Electric Manholes, Handholes, Pull Boxes and Junction Boxes.

A. General.

Electric manholes, handholes, pull and junction boxes shall be built to the lines, grades, dimensions and designs shown on the the plans or Standard Drawings with the necessary frames, covers, etc., in accordance with the applicable provisions of Section 201, Basins, Manholes and Inlets.

B. Cast in Place Concrete Units.

After excavation, all loose material shall be removed before the forms are installed. All conduits, ground rods, pulling irons and reinforcing steel shall be installed rigidly in place before the concrete is placed. After the concrete for the manhole, handhole or pull box is placed, and forms removed, all exposed portions of the concrete shall be neatly finished. Frame castings shall be set according to the requirements of Subsection 201.63 Placing Castings.

C. Pre-Cast Concrete Units.

The construction methods for pre-cast concrete units shall conform to the relevant provisions of Section 901, Subsection M4.02.14 and the above Subsection 801.61-B.

D. Metallic Units.

Metallic pull and junction boxes shall be installed at the approximate locations shown on the plans, or in long conduit runs, they shall not be spaced over 150 feet from each other. It shall be in the option of the Contractor, at his expense, to install additional pull or junction boxes that he may desire to facilitate his work.

Pull or junction boxes installed shall not be of dissimilar metal to the metal conduit used in any one electrical system.

801.62 Foundations.

Light standard, lighting load center, signal post, strain pole, signal mast arm and signal control cabinet foundations, shall be constructed with the necessary anchor bolts (supplied under the items listed in Section 815 TRAFFIC CONTROL SIGNALS, 820 HIGHWAY LIGHTING and 824 FLASHING BEACONS, ILLUMINATED WARNING SIGNS AND LIGHTED BARRIER ARROWS), reinforcing rods, conduit elbows or sweeps, etc., as shown on the Standard Drawings, and in accordance with the applicable requirements of Section 901 CEMENT CONCRETE MASONRY.

For core type foundation estimating and bidding purposes, in the absence of boring samples, or the actual determination of the soil properties at the proposed footing location, the Department will accept an assumed soil bearing pressure of two (2) Kips per square foot for the design of the footing using the Span Wire Assembly Design Chart III of the Departments Standard Drawings. The moments shall be calculated from the data obtained from the relevant traffic control signal plan.

However, the augered foundations shall not be constructed prior to soil classification of the subsurface soil by a qualified firm or person to perform the soil classification, analysis, and footing design.

The actual existing soil conditions shall be determined from hollow stem auger boring samples (see Section 190.62 for Hollow Stem Auger Borings). If the results of the auger boring show that the soil classification requires the use of a Foundation Design Chart that requires a greater depth the foundation shall be constructed according to the requirements of the appropriate chart and payment will be made for the difference in depth under Item 815.98.

Inversely, if it is determined the soil classification permits the use of a Foundation Design Chart that requires a lesser depth, the Department shall be credited for the difference in depth under Item 815.98.

All unsuitable material within the limits of the footing must be removed at the direction of the Engineer (Peat organic material, material that has been dumped, etc.).

The concrete for the footing shall be placed immediately after excavation to prevent water from collecting in the excavated area.

COMPENSATION

801.80 Method of Measurement.

When separate items are listed in the Proposal for various types of Electrical Conduits each type will be measured according to the following:

Electrical Conduits of each kind and diameter will be measured by the linear foot between end terminals along the center line of the conduit as actually installed, complete in place and accepted. When conduit ends terminate in pull or junction boxes, measurement shall be to the center line of such pull or junction boxes.

Electric manholes, handholes, pull and junction boxes, and signal and lighting foundations shall be measured for payment as a unit.

Allowance for rock, if not already paid for under previous rock excavation, shall be based on the width of rock encountered in the trench but not to exceed the width specified in Subsection 801.60. Structure excavation shall be measured in accordance with Section 201.

The measured quantity (including a 6 inch depth allowance) will be paid for under the item for Class B Rock Excavation.

Gravel will be measured by the cubic yard as specified in Subsection 150.80.

Cement Concrete Masonry will be measured by the cubic yard as specified in Subsection 901.80.

801.81 Basis of Payment.

The unit contract price per linear foot, shall be full compensation for furnishing all conduits, couplings, expansion fittings, elbows, bends, caps, sleeves, clamps, hangers, reducers, condulets, tees, jointing compound, sealing compound, cement concrete required in Subsection 801.60-F and 801.60-I, planking required in Subsection 801.60-G and gravel required in Subsection 801.60-B; for placing the electrical conduit in accordance with these specifications, including all excavation or jacking required, backfilling of the trenches, chipping or sawing of pavement, bedding or hanging of conduit and all other work incidental to the construction of the conduit system, except that when electrical conduit is included on any project as an integral part of a traffic control signal or Highway Lighting System and the conduit is now shown as a pay item, it shall be considered as incidental to the construction and be included in the lump sum price for such systems.

The accepted quantities of signal and lighting foundations (including anchor bolts) will be paid for at the contract unit price each.

Anchor bolts will be paid for under the items listed in Sections 815.82 and 824.82.

The accepted quantities (including cost of castings) of electric manholes, handholes and pull and junction boxes will be paid for at the contract unit price each, complete in place.

Any incidental work or materials for which no basis of payment is provided will be considered as completely covered by the unit price bid.

Class B Rock Excavation will be paid for under Item 144. The contract unit price shall be considered full compensation for the satisfactory disposal of the Class B Rock excavated material.

Hollow Stem Auger Borings will be paid for in accordance with Section 190.81.

801.82 Payment Items.

801.2 to 801.66	—in. Electric Conduit Type NM (—) *—option, *—single, double, 4 bank or 6 bank (—)	Linear Foot
802.2 to 802.4	—in. Electric Conduit Type NM — Bituminous Fibre	Linear Foot
803.2 to 803.6	—in. Electric Conduit Type NM — CEM, ASB, or Fire Clay Cement	Linear Foot
804.05 to 804.6	—in. Electric Conduit Type NM — Plastic (UL)	Linear Foot
805.2 to 805.6	—in. Electric Conduit Type NM — Plastic (NEMA)	Linear Foot
806.05 to 806.6	—in. Electric Conduit Type RM — Steel (Galvanized)	Linear Foot
807.05 to 807.6	—in. Electric Conduit Type RM — Aluminum	Linear Foot
808.2 to 808.6	—in. Electric Conduit Type RM — Steel (plastic coated)	Linear Foot
809.05 to 809.4	—in. Electric Conduit — Flexible Metalic	Linear Foot

810	Conduit Encased in Concrete — SD4.041	Linear Foot
811.10 to 811.14	Electric Manhole — SD2.0—* (*SD2.010 to SD2.014)	Each
811.20 to 811.24	Electric Handhole SD2.0—* (*SD2.020 to SD2.024)	Each
811.3	Pull Box—in. x —in. SD2.03—*	Each
811.35	Pull Box adjusted	Each
811.36	Electric Manhole adjusted	Each
811.37	Electric Handhole adjusted	Each
811.40 to 811.52	Junction Box —X—X—in.	Each
812.10 to 812.15	Light Standard Foundation SD3.01—* (*SD3.010 to SD3.015)	Each
812.20	Lighting Load Center Foundation SD3.020	Each
812.30	Standard Signal Post Foundation SD3.030	Each
812.31	Pedestal Signal Post Foundation SD3.040	Each
812.40	Signal Mast Arm Foundation SD3.040	Each
812.50	Signal Control Cabinet Foundation SD3.050	Each
815.98	Footing Cost Adjustment	Linear Foot
144.	Class B Rock Excavation	Cubic Yard
191.10	Hollow Stem Auger Borings	Linear Foot

SECTION 813
WIRING, GROUNDING AND SERVICE CONNECTIONS

DESCRIPTION

813.20 General.

This work shall consist of furnishing and installing wire and cable of the type and size indicated for traffic signals, highway lighting and related electrical systems, equipment grounding systems, new ground electrodes or connections to existing ground electrodes and all materials and equipment necessary to deliver power to traffic signal, highway lighting and related electrical systems.

Service points shown on the plans are approximate only. The Contractor shall determne exact locations and riser elevations from the serving utility, arrange to complete the service connections and be responsible for all charges incidental thereto.

All electrical connections, splicing, grounding, resistance tests, service connections and circuit identification shall be done by a licensed electrician holding "Certificate B" issued by the State Board of Examiners of Electricians.

813.21 Cable Types and Uses.

A. General.

The types of wire and cable shall be used in the following manner:

Type 1 — All traffic control signal circuits above ground supported by a messenger wire, in duct or other electrical wire and cable raceway and shall be installed only when the air temperature is above 35 degrees F.

Type 2 — Same as Type 1 except may be installed at any air temperature above 20 degrees F.

Type 3 — All traffic control circuits installed above ground supported by integral messenger.

Type 4 — Same as Type 3 and when an electrical continuous metallic shield is required.

Type 5 — All traffic signal circuits for direct earth burial or severe service conditions.

Type 6 — Traffic control signal heads.

Type 7 — All power and lighting distribution systems in duct or other electrical wire and cable raceways.

Type 8 — Same as Type 7 and includes direct earth burial, services and roadway wire loops (USE XLP only).

Type 9 — Special purpose when specified.

Type 10 — Grounding and bonding traffic control and highway lighting systems.

Type 11 — Shielded detector lead-in cable for wire loop detectors.

Type 12 — Multi-conductor heavy duty portable power cord for traffic control signal mast arm and high mast tower lighting.

Type 13 — Loop detector wire with tube.

MATERIALS

813.40 General.

A. Wire and Cable.

Unless otherwise specified, all traffic signal cable conductors shall be not less than #14 AWG, solid or stranded, and all conductors for mast arm wiring shall not be less than #16 AWG stranded. Materials shall meet the requirements specified in Section M8.

B. Equipment Grounding.

Unless otherwise specified, equipment grounding conductors shall be not less than #8 AWG insulated or bare, solid or stranded copper wire meeting the requirements specified in Section M8.16.10.

C. Ground Electrodes.

Ground electrodes shall consist of a water pipe, driven rods or other devices approved for the purpose. Water pipes and driven rods used as grounding electrodes shall conform to the following requirements:

1. A metallic underground water piping system shall be used as grounding electrodes where such a system is available.

2. Where a water system is not available, the grounding connection shall be made to an electrode meeting the requirements specified in Section M8.

D. Service Connections.

All equipment furnished shall be new unless specifically mentioned otherwise and shall meet the current requirements of NEMA, UL and the code wherever such standards apply.

CONSTRUCTION METHODS

813.60 Wire and Cable.

A. Steel Messenger Cable Fittings.

Messenger cable (integral with Types 3 & 4 Traffic Signal Cable) shall be secured to strain poles by means of pole bands. Pole bands shall be installed as detailed on the Standard Drawings. Strain insulators shall be installed as shown on the plans. Attachments to utility owned poles shall be according to the local utility company requirements and under the supervision of the local utility company Engineer. The Contractor shall furnish and install back guys, head guys, anchors, etc. that may be requested by the local utility Engineer, where guys are necessary due to the placement of traffic signal equipment on utility poles.

Traffic signal cable shall be attached to messenger cables by spinning the cable to the messenger with an approved lashing material (.045 stainless steel or Kevlar-Aramid fiber core with nylon jacket) or when approved in writing by steel cable rings approved for the purpose

B. Installation of Copper Wire and Cable.

Installation of wire and cable shall not begin until the conduit system has been tested in accordance with the requirements of Section 801.60 Conduit, Paragraph H. Testing Installations.

All conductors and grounding wire shall be drawn, by hand, into ducts or conduits without damage to covering, sheath, insulation or wires. This wiring shall not be done until all work which may damage the wires has been completed. In pulling, all wires shall be drawn freely into conduits without kinks or bends, twisting or lapping. In general, all conductors in each conduit run shall be pulled at the same time, fed from free running reels. Powdered soapstone, talcum or other approved lubricant may be used to assist in placing wire and cable in conduits.

A sufficient length of slack shall be allowed for each cable in all manholes, handholes, pull and junction boxes and equipment enclosures, to provide for neat racking and movement due to thermal expansion and contraction.

C. Splicing.

Splices shall be made in accordance with the Electrical Code by Journeymen Electricians holding "Certificate B" issued by the Board of State Examiners of Electricians.

Splices shall be made only in manholes, handholes, control cabinets, junction boxes or signal and lighting bases.

Pull boxes shall not be used for splicing, except in pull boxes where vehicle detectors are used, soldered splices will be permitted in the pull box nearest the detector (see Subsection 813.60, B). Detector leads shall not run in the same cable sheath or jacket in cable carrying signal currents.

The conductors shall be joined by the use of connectors and terminal lugs, listed by Underwriters Laboratory, and meet all requirements of the Massachusetts Electrical Code.

Splices shall be insulated. Unless otherwise specified, the Contractor may use any of the following:

1. A filler compound or moisture-resistant self-fusing tape, applied to a thickness equal to, and well lapped over, the original conductor insulation, followed by two layers of electrical insulating tape.

The dielectric strength of splices shall be at least equal to that of the cable insulation.

2. An UL approved electrical spring connector ("wire-nut") with an approved sealing compound for protection from dampness and water.

3. An approved re-enterable rigid body splice kit with a non-hardening sealing compound compatible with the wire insulation.

4. An approved heat-shrinking cable sleeve or tape, designed to provide electrical insulation and protect overhead and underground splices from moisture penetration, corrosion and electrical breakdown.

After wiring and splicing is completed, all conduit runs shall be plugged at all manholes, handholes, pull boxes, junction boxes, cabinets and foundations to form a complete closed conduit or duct system to prevent air circulation.

Approved sealing compound (including foam) shall be used in liberal amounts, carefully forced into the ends of the conduits and tightly packed around all wire and cables completely sealing the opening.

D. Highway Lighting Circuit Identification.

The Contractor shall furnish and install colored tapes and identification tags on all lighting conductors at the points where they connect to equipment and on cables in all pull and junction boxes and pole shafts. The colored tapes shall cover 6" portion of the conductor at these points, line 1 — black, neutral — white, line 2 — red, line 3 — blue. In pole shafts, line — black, neutral — white, photocell bypass — red. The tags shall be nylon or other suitable non-metallic material, not less than ¾" in diameter, and not less than 1/32" thick. Identification markings shall be stamped on the tags by means of small tool dies. Each tag shall be securely tied to the proper conductor by nylon or other suitable non-metallic cord (plastic or nylon).

E. Traffic Control Signal Circuit Identification.

The Contractor shall wire and splice traffic control signal circuits to conform to the following color identification code:

5/C Cable	Vehicle Phases	Overlaps	Pedestrian Phases
1. Black	Spare	Spare	Push Button Switch
2. White	Phase 1 through 8 — C	Overlap — C	Walk/Don't Walk — C
3. Red	Phase 1 through 8 — R	Overlap — R	Don't Walk — R
4. Green	Phase 1 through 8 — G	Overlap — G	Walk — G
5. Orange	Phase 1 through 8 — Y	Overlap — Y	Push Button Switch
6. Blue	Spare		
7. White/Black	Phase 2-C		
8. Red/Black	Phase 2-R		
9. Green/Black	Phase 2-G		
10. Orange/Black	Phase 2-Y		
11. Blue/Black	Spare		
12. Black/White	Phase 3-C		
13. Red/White	Phase 3-R		
14. Green/White	Phase 3-G		
15. Blue/White	Phase 3-Y		
16. Black/Red	Phase 4-R		
17. White/Red	Phase 4-C		
18. Orange/Red	Phase 4-Y		
19. Blue/Red	Phase 4-G		
20. Red/Green	Spare		

The number of conductors required for each traffic control signal system shall be as follows:

All systems shall have a minimum of one (1) five (5) conductor cable for each of the following controller outputs to field wiring required by the timing and sequence plan for the system:

Vehicle Phases Overlap Phases Pedestrian Phases

Approval may be given, when requested in writing, for alternate use of one (1) 20/C cable in lieu of four (4) of the above 5/C cable.

The Contractor shall furnish and install colored tapes and identification tags on all cables at the points they connect to equipment, in all signal bases, in all pole shafts, and in all pull and junction boxes.

The tapes shall cover a 6 inch portion of the cables at the above locations with the following colors:

Black for Ring 1

Red for Ring 2

Brown for Detectors

Orange for Overlaps

Yellow for Pedestrian Phases

The tags shall be nylon or other suitable non-metallic material, not less than ¾ inches in diameter and not less than 1/32 inches thick. Identification markings shall be as follows:

Vehicle Phase Numbers Ring 1

Vehicle Phase Numbers Ring 2

Detector Phase Numbers

Overlap Phase Numbers and Letters

Pedestrian Phase Numbers

The identification markings shall be stamped on the tags by means of small tool dies. Each tag shall be securely tied to the proper cable by nylon or other suitable non-metallic ties.

813.61 Equipment Grounding.

With each cable run an equipment grounding conductor shall be installed to which all equipment shall be bonded in accordance with standard practice and the Code.

Metallic cable sheaths, metal conduit, non-metallic conduit grounding conductors, ballast and transformer cases, metal poles and pedestals, metal junction and pull boxes, and metal cabinets shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded to the ground electrode installed at the service point.

Bonding of traffic signal standards, pedestals, strain poles and mast arms shall be accomplished by installing a 3/16 inch or larger brass bolt in the lower portion of the shaft.

For bonding purposes in all non-metallic type conduit, the grounding conductor shall be run continuously. Where non-metallic conduit is to be installed for future use, the above mentioned conductor may be omitted.

In lieu of the continuous equipment grounding conductor, when approved by the Engineer, a ground electrode may be installed at each pole or standard.

Bonding of metallic conduit systems in concrete foundations and pull boxes shall be by means of approved grounding bushings (compatible with the conduit) and bonding jumpers.

All expansion sleeves in metallic conduit runs shall be provided with a bonding jumper, as specified.

813.62 Ground Electrodes.

A. General.

When an underground water system is used as the grounding electrode, the grounding conductor shall be securely attached to the piping system by welding or brazing or other approved means.

If a water-piping system is not available, a driven rod, as specified in Subsection 813.40 C, shall be used as the grounding electrode. Driven rods should, as far as practical, be embedded below permanent moisture level. Except where rock is encountered, rods shall be driven to a depth of at least 8 feet. Where rock is encountered, other devices approved for the purpose shall be used (see Article 250 — Grounding MEC).

B. Resistance Tests.

Grounding electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, additional rods shall be driven, placed at least 8 feet apart and connected in parellel with a #6 AWG bare copper solid or stranded conductor, as directed by the Engineer.

The measurement shall be made with either a Ground Ohmer or Megger Ground Tester with all wire disconnected (except parallel connections and test wires) from the rod and in the presence of the Engineer. The Contractor shall furnish the Engineer with a report of all resistivity tests, indicating the values obtained for each and combinations (parallel connected) of rods tested. This report shall become a part of the "as built" records.

813.63 Service Connections.

Each service shall include a meter socket; a three wire single phase or four wire three phase solid neutral disconnect of size noted; the necessary conduit; conduit risers; cable and ground assembly; all installed in accordance with the Code, serving utility and Department requirements.

Service equipment shall include all equipment from the distribution lines of the serving utility to and including the metering equipment. Meter will be furnished and installed by serving utility.

Service disconnect, unless otherwise specified, shall be a standard type circuit breaker, encased in a NEMA Type 3R raintight enclosure that can be padlocked.

In general, all traffic signal services will be 120 volts or 120/240 volts, single phase, 60 hertz, alternating current, and all highway lighting will be 120/240 volts, 240/480 volts, single phase, or 277/480 volts, three phase, 60 hertz, alternating current.

Conduit for services shall not be less than 1 ¼ inch and be rigid metal above ground, securely fastened every 3 feet.

All wire and cable shall conform to Subsection M8, Type 8. The wires between the serving utility distribution lines and service disconnect shall not be smaller than #6 AWG.

The ground electrode shall conform to the requirements of Subsection 813.62.

Ground clamps shall be approved by UL and acceptable to the local power company.

In the case of underground services the Contractor shall furnish and install all equipment as required by the serving utility.

The Contractor shall make adjustments in the installation to comply with the varied requirements of the Code and serving utility and perform all work to the satisfaction of the Code, serving utility and the Department.

COMPENSATION

813.80 Method of Measurement.

A. Wire and Cable.

All cable will be measured by the linear foot, the measurement being made along the center line of the conduit in which the conductor is placed. No allowance will be made for the necessary lengths of slacked cable laid around the sides of manholes, handholes, junction boxes, pull boxes, or extending from foundations for making splices, taps in cable, and connecting the internal components of control cabinets.

B. Equipment Grounding.

Equipment grounding will be measured as a unit including all nuts, bolts, washers including lockwashers, connectors, clamps and incidental materials to form a continuous system. Equipment grounding conductor will be measured by the linear foot conforming to Subsection 813.80 A.

C. Ground Electrodes.

When a metallic underground water system is used as the grounding electrode, measurement will be made on the basis of the grounding conductor installed and connected to the metallic water-pipe system.

Measurement for ground rods will be based on units 8 feet, 10 feet or longer, as specified. If in the driving of standard units, obstructions are encountered, measurement will be made for the actual length driven. The ground rod shall then be withdrawn and redriven at a new location to meet requirements specified above.

D. Service Connections.

Service Connections of each type will be measured on the basis of the number of services installed and connected to the serving utility distribution lines with all appurtenances in acceptable operating condition.

813.81 Basis of Payment.

A. Wire and Cable.

All cable will be paid for at the respective contract unit price per linear foot for the type and size specified, which price shall include installation and connection of wire and cable and all splices and circuit identification. All additional materials required to complete the installation shall be considered as incidental thereto and included in the contract price for wire and cable and no additional compensation will be allowed.

B. Equipment Grounding.

The lump sum price for "Equipment Grounding" shall be full compensation for work necessary or incidental to the installation of the equipment ground, modifying existing grounds, or both, as shown on the plans. All additional materials and labor not shown on the plans or standard drawings called for herein and which are required to complete the installation shall be considered as incidental thereto and be included in the contract unit price for equipment grounding.

Equipment grounding conductor will be paid for at the conract unit price per linear foot as specified in Subsection 813.81 A.

C. Ground Electrodes.

This work will be paid for at the relevant unit price which price shall include all ground clamps, #6 AWG copper conductors, excavation, backfilling, compaction, welding or brazing, all tests, reports and work incidental thereto.

Allowance will be made for ground rods not driven to minimum depths because of obstructions and will be paid for at the contract unit price per linear foot for ground rod.

D. Service Connections.

Service connections will be paid for at the contract unit price for each service connection complete in place.

All additional work called for herein which is required to complete the service connection shall be considered as incidental to the construction.

813.82 Payment Items.

813.10	Traffic Signal Steel Messenger Cable — Type 0	Linear Foot
813.21 to 813.25	Traffic Signal Cable — Type #— (#1 to #5)	Linear Foot
813.26	Traffic Signal Head Wire Type 6	Linear Foot
813.30 to 813.39	Wire Type 7 No—* General Purpose (*10-4/0)	Linear Foot
813.40 to 813.49	Wire Type 8 No—* Direct Burial (*10-4/0)	Linear Foot
813.50	Wire Type 9 Special Purpose (TW-THW)	Linear Foot
813.51	Wire Type 9 Special Purpose (UF)	Linear Foot
813.52	Wire Type 10 — #8 Grounding and Bonding	Linear Foot
813.53	Wire Type 11 — Loop Detector Lead-in	Linear Foot
813.54	Wire Type 12 — Heavy Duty Portable Cord	Linear Foot
813.55	Wire Type 13 — Loop Detector Wire and Tube	Linear Foot
813.60	Equipment Grounding	Lump Sum
813.70	Ground Rod	Linear Foot
813.71	Ground Rod 8 feet Long	Each
813.72	Ground Rod 10 feet Long	Each
813.80	Service Connection (Overhead)	Lump Sum
813.81	Service Connection (Underground)	Lump Sum

SECTION 815
TRAFFIC CONTROL SIGNALS

DESCRIPTION

815.20 General.

This work shall consist of furnishing and installing or modifying at each location, traffic control signals ready for operation.

Included in the work is the furnishing and installing or modifying existing traffic signal control equipment, signal heads, electric lamps, pedestrian push buttons, control equipment, vehicle detectors, posts and bases, poles, pedestals, mast arms, strain pole and span wire assemblies and all incidental materials (included in Section 801 and 813) necessary for operating the traffic control signals.

This work shall also include furnishing and erecting any pertinent signs and all painting required to complete the installation. The removal, salvage, stockpiling, reinstallation or transporting of existing traffic installations will be covered under this section and appropriate pay items where applicable.

The locations of signal heads, controllers, standards and appurtenances shown on the plans are approximate and exact locations will be established by the Engineer in the field.

The responsibility for the exact and satisfactory installation of traffic signals shall rest with the Contractor and work performed, if not acceptable by the Engineer, shall be executed to the satisfaction of the Engineer by the Contractor at the Contractor's expense.

All electrical equipment shall be designed, manufactured and tested in accordance with the applicable standards of the ANSI, EIA, FSS, IMSA, ITE, NEMA, UL and these Specifications.

Unless otherwise designated on the plans, on the Standard Drawings for Traffic Signals as set forth in the Special Provisions, and as specified herein, all work and materials shall conform to the requirements of the Massachusetts Electrical Code herein referred to as the electrical code.

Wherever reference is made to codes or standards mentioned above, the reference shall be construed to mean the code or standard that is in effect on the date of advertising of the project.

All electrical connections, splicing, grounding, resistance tests, service connections and circuit identification shall be done by a licensed electrician holding "Certificate B" issued by the State Examiners of Electricians.

Standard symbols and construction details for traffic signal installations are shown on the current Traffic Signal and Highway Lighting Standard Drawings.

Within 30 days following execution of the Contract, the Contractor shall submit to the Engineer for approval, a list of equipment he proposes to install. The submision shall include all equipment identified on the plans or in the specifications by the name of the manufacturer, model or identifying number of each item. The list shall be supplemented by catalog cuts and such other data as may be required, including wiring diagrams of any special equipment and any proposed minor deviation from the plans. All the above data shall be submitted in triplicate for checking. Following checking, correction and review, not less than five (5) complete approved sets shall be resubmitted to the Engineer for distribution. The Department shall not be liable for any material purchased, labor performed, or delay to the work prior to such review and approval.

The Contractor shall provide the Department, within 10 days of receipt of approval, written proof that he has ordered the Traffic Control Signal Devices required by this Section.

Shop drawings are required for all structural support materials and fabricated items that are not specifically detailed on the plans. Shop Drawings are not required for items that are on the Departments "Approved Equipment List."

The warranties that the Contractor receives from each manufacturer of equipment and materials pertinent to the complete and satisfactory operation of traffic signal installation shall be turned over to the Department at the time of acceptance of the project, at no cost to the Department. Each warranty so furnished shall indicate its expiration date, and be in effect for a minimum period of one year from the date traffic signals were placed in continuous operation.

If within one year from the date the traffic signal system is placed on continuous operation the equipment and materials do not meet the warrants specified above and the Engineer notifies the manufacturer or his authorized representative promptly, the manufacturer or his authorized representative thereupon shall correct any defect either by repairing or replacing any defective part or parts, at no cost to the Department.

The Contractor shall, at his own expense, replace any part of the traffic signal control equipment found to be defective in workmanship, material or manner of functioning within six months from the date of final acceptance of all the installations.

It is the intent of the Plans, Specificatins and Special Provisions to provide a complete traffic control signal system throughout the project.

It is not intended that every fitting, minor detail or feature be shown and described, as the assumption is made that either the Contractor or his Subcontractor is an expert in the particular area of responsibility and is capable of interpreting the plans, specifications and special provisions so that the bid shall include all items required and that they shall be provided and installed in a neat and workmanlike manner.

Any installation of wiring by the Contractor will be performed by licensed electricians.

815.21 Equipment.

All new equipment including controllers with cabinets, vehicle detectors and detector amplifiers shall be furnished, except as noted, and installed by the Contractor. When equipment and materials are to be furnished the Contractor by the Department, the equipment and materials will be made available to him at the project site.

No equipment or accessories specified in Sections 815 will be accepted unless type tested and approved by the Department prior to the date of the proposal.

The Department will list annually all equipment and accessories that have been type tested approved and/or approval withdrawn.

Such approval by the Department of equipment or accessories, however, shall not relieve the Contractor of any responsibility required under Section 5.00. All approvals will be conditional and the Department reserves the right to withdraw its approval of equipment or accessories at any time for any of the following reasons:

a. Delivery of equipment or accessories which do not meet requirements of Section 815.

b. Equipment or accessories with abnormal maintenance and performance records.

MATERIALS

815.40 General.

The materials required are those specifically covered in the plans and in accordance with Division III of the Standard Specifications.

Any and all signs required shall conform to Section 828 of the Standard Specifications and the Manual on Uniform Traffic Control Devices.

Unless otherwise indicated on the plans or specified in the Special Provisions, all materials shall be new and of the latest design.

Any equipment that has been type tested and approved by the Department (Subsection 815.21) will be considered as meeting these specifications.

Where existing systems are to be modified, the existing equipment and material shall be incorporated in the revised system, salvaged or abandoned as directed by the Engineer in writing.

815.41 Controllers.

A. General.

1. Operate on a power input of 120 volts, single phase, 60 hertz, alternating current.

2. Capable of operating in a coordinated system with preemption equipment, supervised in a master system, without major internal wiring modifications.

3. Be housed in a weatherproof cabinet of adequate size as specified hereinafter. The cabinet shall be furnished as a housing for the controller, auxiliary equipment and terminal facilities and conform to the following electrical and mechanical requirements.

a. Doors — The cabinet shall have a main door equipped with a keyed tumbler lock of the type in current use by the Department and an auxiliary door equipped with a conventional police lock and key. Two keys shall be furnished with each lock. Door hinge pins shall be made from stainless steel.

b. Switches — Panel behind the auxiliary door shall be provided with the following switches:

1. Main power switch.

2. A switch to change from automatic to flashing operation or vice versa, with the controller power "off" in flashing operation.

3. A switch to energize the controller while the signal lights are "off" or on "flashing operation" (accessible only when main door is open). This switch shall be interlocked with the above switch so that the controller must go through the start-up sequence when going from flashing operation to automatic operation (unless prohibited by the conflict monitor). All switches shall be labeled as to function.

c. Vents — Cabinets shall be equipped with screened rain-tight "T" vents 1 ½" or larger for pre-timed controllers. Cabinets containing vehicle actuated controllers shall be equipped with a thermostatically controlled fan and filtered vents.

d. Shelves — Cabinets shall be fitted with two (2) substantial shelves or brackets to support the controller and auxiliary equipment.

e. Radio Interference — Controllers, flashers or current interrupting devices shall be equipped with suitable radio interference suppressors. The Contractor shall, if notified by the Department of such interference, provide and install the additional equipment necessary to eliminate the interference.

f. Flasher — Each cabinet shall be provided with a solid state electronic device capable of providing flashing operations at the rate of 50/60 flashes per minute. Flasher device shall be furnished mounted on a plug-in base with plug-in mounting. The device shall be capable of normally producing "flashing yellow" indications for all signals facing the main street and "flashing red" indications for signals facing the cross streets, or in a combination specified. The output load rating with incandescent lamp load shall not be less than 15 amperes. The "automatic" to "flash" switch specified in b.-2 above shall be wired in such a manner that no pedestrian indications will show during flashing operation.

g. Circuit Breaker — A two-pole, solid neutral circuit breaker panel for power service shall be mounted in the cabinet.

h. Wiring — All cabinet wiring shall be neat and firm and the following installed in the cabinet:

1. Unfused terminals for neutral side of power supply.

2. Terminals for signal light cables, one for each signal circuit and one for more terminals for the common conductor.

3. Terminals for detectors, pedestrian push-buttons, controllers, auxiliary equipment, field conductors, overlap outputs, plus an additional ten (10) terminals for spares.

4. Terminals for interconnecting cables (when required).

5. All terminals shall be suitably identified.

6. A flexible cable shall be furnished for connecting the controller to the cabinet terminals.

7. Signal light load switches (number as required by type of controller).

8. Convenience outlet, Standard 3-wire grounding duplex receptacle, 20 amp. capacity, with integral ground fault interrupter.

9. Overload protection for all wiring and auxiliary equipment.

10. Surge protector for protecting equipment against over-voltage transients, caused by manmade or natural sources.

B. Actuated Controllers

Traffic actuated controllers shall consist of a complete assembly of the following elements:

1. Controller Unit (Dispatcher or Timer)
2. Interface Requirements
3. Terminals and Facilities
4. Solid-State Load Switches
5. Solid-State Flashers
6. Voltage/Conflict Monitors
7. Auxiliary Equipment
8. Cabinets
9. Cabinet Foundations and/or Anchor Bolts
10. Technical Manuals and "Box Prints"

The first eight (8) elements of the controller assembly shall be wired to perform all the controller signal operations for the specific type of controller specified.

1. Controller Unit (Dispatcher or Timer).

a. The controller unit shall meet all applicable requirements of the National Electrical Manufacturers Association (NEMA) Standards contained in NEMA Publication No. TS-1 current edition and the following:

b. Be in compliance with Section 815.21 Equipment

c. All controllers units shall provide solid-state timing circuits utilizing power line frequency as a base.

d. All timing and control parameters shall be retained in memory when power is "off," battery-backup to retain memory will not be accepted.

e. The units shall be modular and operator programmable data entry adjustments shall be accomplished through thumb-wheel, pin, or keyboard devices located on the front panel of the unit.

f. All plug-in modules of like function shall be interchangeable between 2-to-4-phase frames and 2-to-8-phase frames. All modules of unlike function shall be keyed and electrically interlocked to prevent insertion or operation in a slot not designed for its use or cause a malfunction.

g. All controller units shall be provided with internally generated overlaps in a manner described in NEMA Standard TS-1, Section 14, and programmed by the use of an interchangeable plug-in circuit board assembly (See Fig. 14-9 of Section 14). Keyboard-entry controller overlaps may be provided by means optional to the manufacturer.

2. Interface Requirements.

a. The controller frame types listed in Table 2 shall meet all the applicable interface requirements of NEMA Standard TS-1, Section 13.

3. Terminals and Facilities.

a. Each electrical terminal within the facility shall be identified with nomenclature that corresponds to the nomenclature on the controller assembly wiring diagram. Terminal nomenclature shall be adjacent to terminals. All load switches, relays, flashers, circuit breakers, fuses and switches within the facilities shall be identified with nomenclature on the controller assembly wiring diagram.

b. All functional points on the connectors of the controller units shall be terminated in the facilities.

c. All conflict monitor input channel leads that can be used to monitor the maximum number of signals available in a given configuration shall be terminated on terminal strips in the cabinet.

d. The facilities shall be so wired that the intersection will revert to flashing operation if the conflict monitor is disconnected.

e. Unless otherwise specified, loop detector leads and harnesses will be required and shall be terminated (4-harnesses for 2-to-4-phase frames and 8-harnesses for 2-to-8-phase frames).

f. Fully-programmable wired load switch sockets with load switches, flash transfer relay sockets with relays, and dual circuit flasher socket with flasher shall be provided in quantities shown in Table 2.

g. When specified, programming automatic transfer from normal operation to flashing operation (Uniform Code Flash), shall comply with the requirements of the MUTCD Section 4B-18 — Flashing Operation of Traffic Control Signals.

h. It shall be possible to easily change the flash indications (Flashing Yellow to Flashing Red or vice-versa) and load switch positions (Overlap to Pedestrian or vice-versa) from the front side of the terminal facilities using only simple tools without the need to unsolder or resolder connections.

i. A support shall be provided so that, as a minimum, it is supporting the flasher and load switches at some point between 3 inches and 8 inches from the panel surface. At least 90% of the area beneath the load switch and flasher shall be open to allow for the free flow of air across the load switches and flasher (see NEMA TS-1, Section 10 for other requirements).

4. Solid-State Load Switches.

a. The solid-state load switches shall be a modular assembly containing three (3) solid-state switch packs.

b. The front panel shall be provided with three indicators to indicate the state of the input circuit of the load switch.

c. Each switch pack shall be readily serviceable by the use of a screwdriver or small hand tools without soldering or unsoldering connections.

d. Load switches shall meet requirements of NEMA Standard TS-1, Section 5.

5. Solid-State Flasher

a. Solid-state flashers shall meet the requirements of NEMA Standard TS-1, Section 8 for Type 3, 15 ampere, dual-circuit. Load switch packs shall be serviceable as in 4. above.

6. Voltage/Conflict Monitors.

a. Voltage/Conflict monitors shall meet the requirements of NEMA Standard TS-1, Section 6, as follows:

1. Type 6 — for 2-to-4-phase frames.
2. Type 12 — for 2-to-8-phase frames.

7. Auxiliary Equipment

a. Space shall be provided for all shelf mounted auxiliary equipment including harnesses, cables and space for equipment with maximum dimensions of 7″ High × 11″ Deep × 12.5″ Wide.

8. Cabinet (Aluminum)

a. Cabinets shall be fabricated from 5052-H32 sheet aluminum alloy at least 0.125 of an inch thick and adequately reinforced. It shall be of all-weather construction.

b. Meet the applicable requirements listed under A. General.

c. The convenience outlet required by this section shall have integral ground fault interrupter.

d. An incandescent light, with switch shall be installed in the cabinet (switch to be installed next to test switch).

e. Detector test switches shall be provided on the back of the door inside the cabinet (4 in Type CB cabinets and 8 in Type CC and CD cabinets).

f. The cabinet shall be equipped with a door stop assembly to hold the door open at approximately 90 degrees and 180 degrees.

g. The cabinet shall be equipped with a thermostatically controlled fan assembly (adjustable between 90 and 150 Degrees F) with a minimum capacity of 100 cubic feet a minute. The fan shall be mounted in the top of the cabinet in a manner to prevent rain, snow or insects from entering the cabinet.

h. Each cabinet shall be provided with a filtered louver vent in the front door. A UL listed vent filter shall be supplied which is odorless and fireproof. The filter shall contain a metal grill for protection. Filter resistance shall be rated at 300 feet per minute of air at .06 inches water column.

i. All surfaces of the cabinet and doors shall be painted a minimum of two (2) coats of aluminum paint, excluding primer, as follows:

1. Cabinets that come from the manufacturer with one or more coats or paint (excluding primer) will be accepted, if there are no scars and abraded areas.

2. If cabinets show any scars or abraded areas the contractor shall repair these areas and apply one (1) coat of aluminum paint.

9. Cement Concrete Cabinet Foundations and/or Anchor Bolts.

a. All cabinets shall be complete with 3/4″ × 16″ anchor bolts (2) for Type CA or CB cabinets and 4 for Type CC or CD cabinets.

b. When new cement concrete foundations are required they shall be constructed in accordance with section 801.

10. Technical Manuals and "Box Prints."

The following documentation shall be provided prior to final acceptance as furnished by the manufacturer.

a. Controller Unit, Flasher, Load Switches, Conflict Monitor and all external logic units.
   1. Electronic schematic of circuit boards.
   2. Pictorial layout of components on circuit boards.
   3. Service manual for troubleshooting.
   4. Manual describing the theory of operations.
   5. Parts list showing manufcturers part number and location.

b. Controller cabinet.
   1. Cabinet wiring diagram.
   2. Field wiring diagram.

The following types of controllers shall be furnished, as specified:

Type 2DW to 4DW — A 2-to-4-phase full-vehicular-actuated or semi-vehicular-actuated control device, that in response to vehicular actuation from all streets, transfers the right-of-way from one phase to another as the movement of traffic on all streets demands and with a separately adjustable timing for the pedestrian portion of combined pedestrian-vehicular phase for all phases and with the addition of adjustable timing capable of increasing and decreasing the various time intervals due to variation in volume of moving and waiting traffic (Use Type 4DW Controller).

The minimum timing requirements for adjusting of time intervals are shown in Table 1.

Type 5DW to 8DW — A 2-to-8-phase control device as specified for Type 2DW to 4DW with four additional phases added (Use Type 8DW Controller).

The minimum timing requirements for adjusting of time intervals are shown in Table 1.

All vehicular actuated controllers shall be installed in a weatherproof outdoor cabinet of adequate size to house the controller, load switching assemblies and any other auxiliary equipment required by the plans and specifications.

The nominal minimum size cabinets for controllers shall be as follows:

Type CA — Cast Alum. Base Mounted (14″ × 28″ × 47″) Approximate
Type CB — Sheet Alum. Based Mounted (16″ × 27″ × 46″) Approximate
Type CC — Sheet Alum. Base Mounted (24″ × 38″ × 54″) Approximate
Type CD — Sheet Alum. Base Mounted (24″ × 38″ × 72″) Approximate

TABLE 1
NOMINAL MINIMUM TIMING REQUIREMENTS FOR CONTROLLERS

The following functions, with the associated minimum timing ranges and maximum increments, shall be provided as a minimum when required by the application listed under Controller Type number in Table 2.

Function	Range Seconds	Increment Seconds
Minimum Green (Initial)	1–30	1
Passage Time (Vehicle)	0–9*	0.25
Maximum 1	1–99	1
Maximum 2	1–99	1
Yellow Clearance	0–7*	0.25
Red Clearance	0–7	0.25
Walk (W)	1–30	1
Ped. Clearance (DW)	0–30*	1
Added Initial	0–3 per act.	0.125
Time to Reduce	1–60	1
Time Before Reduction	1–60	1
Minimum Gap	0–7.75*	0.125

Note: *Zero shall be satisfied by any time between zero and 100 milliseconds.

TABLE 2

Controller Type	4DW	8DW
Frame Type	2-4	2-8
Conflict Monitor Type	6	12
Vehicle Load Switches	4	8
Ped. Load Switches	1	3
Overlap Load Switches	3	1
Flash Transfer Relays	4	6
2-Cir. Flasher (15A)	1	1
Power Cir. Breaker	30A	50A
Cabinet MDPW Type	CB	CC

Note 1: Type 5DW to 8DW Controllers may require external logic to produce an exclusive pedestrian phase.

Note 2: CB cabinets are to be wired for 2-4 phase frames.
CD cabinets are to be wired for 2-8 phase frames.

C. Pre-Timed Controllers.

1. A pre-timed electro-mechanical controller assembly shall consist of a controller, flasher and other equipment as specified in contract documents, that are wired in a controller cabinet to make a complete and operational traffic controller assembly.

2. A pre-timed solid-state controller assembly shall consist of a controller, load switches, a flasher, a conflict/voltage monitor and other equipment as specified in contract documents, that are wired into a controller cabinet to make a complete and operational traffic controller assembly. Pre-timed solid-state controller assemblies shall meet all applicable requirements of the elements listed under B. Actuated Controllers.

The following types of controllers shall be furnished as specified:

Type 11A or 11B — a multi-dial device which shall be of the type capable of being operated as an isolated unit, as a unit in a non-progressive system, or when specified, a unit in an interconnected progressive system equipped to provide an omittable push-button actuated exclusive pedestrian phase without any physical changes to the controller required. Unless otherwise specified, each controller shall be furnished with 3-dial units with 3-offsets per dial for Type 11A and equipped with master supervisory contacts to provide supervision for an interconnected system for Type 11B.

Type 12A, 12B or 12C — Multi-cycle length, multi-cycle split, and multi-cycle offset control device arranged to operate with a master controller and capable of operating in any split, cycle and offset selected from a central source or at the controller itself for Type 12A, equipped with master supervisory contacts capable of operating as a master-local for Type 12B and equipped with master supervisory contacts capable of operating as a master only for Type 12C.

Type 13 — A single dial control device which shall be of the type capable of being used as an isolated unit, when specified, or as a unit in an interconnected progressive system where exclusive pedestrian control is required. This controller shall be of the alternate sequence type providing for a constant total cycle length. Time required for the exclusive push-button actuated pedestrian phase shall be deducted from the latter part of the Main St. green interval.

Type 14 — A single dial control device which shall be of the type capable of being used as an isolated unit where exclusive pedestrian control is required. This controller shall be of the alternate sequence type with the time required for the exclusive push-button actuated pedestrian phase added to the total time cycle. This controller shall not be used in an interconnected system.

Type 15A or 15B — A single dial control device which shall be of the type capable of being used as an isolated unit, or when specified, as a unit in an interconnected progressive system at mid-block locations for Type 15A or at an intersection for Type 15B, where exclusive pedestrian control is required.

Type 16 — A master controller supervising a series of controllers of various types into a traffic adjusted interconnected coordinated system. When this type of controller is required special provisions will be prepared for the particular project.

Unless otherwise specified, all the above controller types shall be installed in weatherproof metal cabinets of the type regularly supplied by the manufacturer, pre-timed electro-mechanical controllers shall be supplied with a complete set of timing gears (60-70-80-90-100-110-120 seconds) for all timing dials contained therein.

Cabinets shall be fitted with the necessary adaptors to permit post top mounting on a standard signal post or in a ground mounted cabinet.

D. Fire Station and Railroad Pre-emptors.

Unless otherwise permitted in writing, pre-emption equipment shall be constructed and wired so as to transfer control of the signals from the controller to the pre-emptor timing unit.

In response to remote instructions, the pre-emptor shall stop controller timing and start pre-emption timing, the pre-emptor shall simultaneously perform the following:

1. Transfer field circuits to the pre-emptor timing unit.
2. Select and time the proper signal indications for the protection interval, as shown on the plans.
3. Unless permitted in writing, wiring of pre-emption equipment will not be permitted in the traffic signal controller cabinet.

The pre-emption equipment shall be housed in a separate cabinet and shall not be in any way attached to the traffic signal controller cabinet, but shall be supported on its own post or pedestal mounted cabinet.

E. Time Switch (Type TS-4).

A Type TS-4 time switch is a four (4) circuit solid-state device that controls multiple daily operations on a weekly schedule and may be instructed to suspend operations when programmed.

The elements of the Type-4 Time Switch are as follows:

1. Precision Time Reference.

The time reference shall be accomplished by digital methods using 60 Hertz power line frequency as a time base when power is present and a crystal controlled oscillator back-up source when power has failed or the time reference may be the digital encoded time signal that is broadcast by the National Bureau of Standards.

In the event of power failure, all programs and relationships shall be held in memory, without modification, or the use of batteries, for at least forty-eight (48) hours. The back-up source shall have an accuracy of .005% or greater.

2. Time Clock.

The time clock shall be provided with four (4) independent circuits which are controlled by pre-programmed time of day events. The time of day shall be accurately set to the nearest second. Time of day, day of week, date, year and the operation of the four (4) relay outputs shall be easily set from the integral keyboard. All data required to properly set and program the clock and review the stored program shall be clearly displayed. The time clock shall be capable of remembering a minimum of twenty (20) program steps. A program step is defined as the time of day and the day or days of the week for which the relay outputs shall be turned on or off. The time clock shall be capable of initiating a minimum of ten (10) basic program plans. The time clock shall automatically compensate for daylight saving time (DST) and eastern standard time (EST) changes.

3. Outputs.

The time switch shall have four (4) single pole, double throw relay outputs with a contact rating of at least 10A at 120VAC resistive load. Skip plan relay control shall be limited to one (1) output relay. Interface to the power line and the controlled device shall be by suitable connectors and cabled wire harness at least forty-eight inches (48") long. Each conductor shall be a minimum of #18 AWG with 600 volt insulation suitable for at least 90 degrees Centigrade.

4. Physical.

The time switch shall be provided with a case. The case shall be provided to protect the circuits from dust, and shall be fastened securely to the unit and be easily removable for servicing. At least two (2) mounting holes shall be provided for mounting to a suitable backplate. Holes shall provide clearance for at least a No. 10 screw. In addition to the above mounting required, a mounting adaptor plate shall be provided to simplify mounting in crowded cabinets.

5. Power Requirements.

The time switch shall perform under the following conditions:

a. Voltage — 95 to 135 VAC, nominal voltage 120 VAC.
b. Frequency Range — 60 Hertz plus or minus 3.0 Hertz.

6. Documentation.

A complete set of operating and maintenance instructions shall be provided with each unit.

F. Special Function Units.

1. Master Control Units.

These units (solid-state or electro-mechanical) shall be designed to perform such functions as coordination, detector switching preemptor, double clearance timing and other functions as may be required by complex traffic control signal systems. When these types of units are required plans and special provisions will be prepared for the particular projects.

2. Time Base Coordination Units (TBCU).

The TBCU shall coordinate control equipment to achieve the coordinated operation of an intersection with other intersections without the use of wire or cable between intersections. The elements of the TBCU are as follows:

a. Precision Time Reference.

The time reference shall be accomplished by digital methods using 60 Hertz power line frequency as a time-base when power is present, and a crystal controlled oscillator back-up source when power has failed or the digital encoded time signal that is broadcast by the National Bureau of Standards. In the event of power failure, time of year, all programs, and synchronization relationships, shall be held in memory, without modification, for at least 100 hours. The back-up source shall have an accuracy of .005% or greater.

b. Time Clock.

The time clock shall operate on a fifty-two (52) week cycle that is easily programmed to the nearest second of the week, day, hour, and minute of the year. The fifty-two (52) week cycle shall begin with week zero (0) and return to week zero (0) after week fifty-one (51). Days of the week shall cycle Sunday day zero (0) through Saturday day six (6). Hours of the day shall be on a twenty-four hour basis with double zero (00) being midnight. The clock shall make automatic correction for Daylight Savings Time and return to Standard Time at user programmed times, programmed at the start of week zero (0) of the one (1) year cycle.

c. Programmable Microprocessor.

The TBCU shall provide for programming of all timing and operation parameters as follows:

1. Cycle and Offset.

The TBCU shall be capable of providing four (4) cycle lengths adjustable from 030 to 255 seconds in one (1) second increments. At least three (3) smoothing routines shall be provided and be user programmable to smooth coordination plan cycle and offset change.

2. Free/Flash.

Time selection of the "free" function shall cause the intersection controller to operate in the free mode. Time selection of "flash" function shall cause the intersection controller to operate in the "flash" mode, subject to the requirements of Section 4B-18 of MUCTD.

3. Coordination Control.

The TBCU shall be capable of providing coordination control methods of cycle select, offset select, yield/hold with force-off, phase omit, phase skip, permissive period, and similar control functions.

4. Program.

At least eight (8) programmable outputs shall be provided capable of being programmed to change its state (on or off) at any second of the year in one (1) second increments or change its state (on or off) on a per cycle basis with the TBCU capable of setting the duration of the cycle and the starting and ending times of the outputs. In addition, two of the eight outputs shall be capable of being programmed for up to eight (8) starting and ending times on a per cycle basis for NEMA Force-off Ring 1: Phases 1, 2, 3, 4 and Force-off Ring 2: Phases 5, 6, 7, 8 and/or Phase Omits. Sufficient user programmable memory shall be provided to allow implementation of the following program structure:

a. 50 event times (a listing of times at which controlled events start or stop during a 24-hour period).

b. 15 day programs (a listing of which outputs switch at which event time during a 24-hour period).

c. 200 day program events (a listing of coordinating plan conditions or the time switching of an output).

d. 5 week programs (a week program specifies which day program shall be used on each day of the week).

e. 1 year program (specifies which week program shall be used on each week of the year).

f. 30 exception days (an exception day causes a day program different from that in the year program to be used on a specific day).

g. 4 cycle lengths (cycle lengths are the times in seconds of the coordinated background cycles).

h. 12 offset values (a system reference for the start of an individual intersections coordinated phase green).

i. 3 smoothing methods (select interrupter, short way, or maximum dwell smoothing of offset and cycle changes).

j. Free/Flash (the controller may be time-switched to free of coordination control or to flash mode by time-switching).

k. 2 Daylight Savings/Standard Time changes (a change ahead 1 hour and a change back 1 hour that can be programmed).

l. 4 synchronization reference times (1 per cycle to start time of an external timing reference pulse).

m. 4 programmable entries to define on and off times in % of each cycle for outputs that pulse 1 or more times each cycle).

5. Programming Methods.

To prevent accidental and unauthorized changing of stored coordination plans it shall be required to enter a predetermined number code before memory can be entered, erased, or altered. However, it shall be possible to read all data stored in memory without entering the memory number access code. This memory shall be easily programmed by using any of the following methods:

a. Keyboard Entry

The keyboard entry shall give positive feedback to the programmer that a key was pressed and recognized.

b. Program Transfer

Any TBCU shall be capable of programming any other unit of the same make and model by plugging a simple transfer cable between the programmed unit and the unit to be programmed. If an error occurs during program transfer, this error shall be indicated and the unit shall erase itself.

6. Display.

The TBCU shall be capable of displaying any of its stored information, operation status, battery fail and power on/off.

7. Inputs/Outputs.

Eight NEMA "Phase-On" signal information shall be input to the TBCU to be used as enables for the two (2) eight pulses/cycle outputs to control force-off and/or phase omit outputs. The TBCU shall operate with any type of traffic signal controller using NEMA TS-1 compatible input and output levels and conventions. Each output shall be totally isolated from each other and from the internal logic circuitry. The TBCU shall contain monitoring circuitry to turn all output off whenever failures such as a processor malfunction, power supply out of regulation, invalid data in user memory, battery overly discharged, and program conflicts have occurred. Electrical connections to and from the TBCU shall be made by inserting a keyed mating connector. The TBCU shall be completely replaceable in the controller cabinet without the use of tools or the necessity of disconnecting and re-connecting individual wires leading therefrom.

8. Operating Standards.

The TBCU shall perform under the following conditions:

a. Voltage

95 to 135 Volts AC. The nominal voltage shall be 120 Volts AC.

b. Frequency Range

60 Hertz plus or minus 3.0 Hertz.

c. Power Interruptions

See NEMA TS-1 — 2.1.04.

d. Temperature and Humidity

See NEMA TS-1 — 2.1.05.

e. Power Service Transients

See NEMA TS-1 — 2.1.06 and 2.1.08.

f. Vibration

See NEMA TS-1 — 2.1.14.

g. Shock

See NEMA TS-1 — 2.1.15.

9. Housing.

Housing and hardware shall be manufactured from corrosion resistant materials. Circuit boards and assemblies shall be readily accessible for servicing and materials shall conform to the requirements of NEMA TS-1 — 4.2.02. All controls shall be on the front panel and including a fuse for line voltage input power, replaceable without disassembling the TBCU.

10. Harness.

All connections to external points shall be made through front panel connections and each TBCU shall have included a harness with mating connectors at least six (6) feet in length.

815.42 Detectors.

A. Magnetic Detector Amplifiers and Sensors.

Magnetic detector amplifiers shall be entirely solid-state with the exception of the output relay, designed to operate in extremes of temperature and humidity. Front panel adjustments shall be provided to control sensitivity. The amplifier in combination with the sensors listed shall be capable of providing the following:

1. Multi-Lane Sensor.

Non-directional, non-compensated, with a zone of influence 12 feet each side of sensor.

2. Single-Lane Sensor.

Non-directional, non-compensated, with a zone of influence 18 inches each side of sensor.

The magnetic detector amplifier and sensors shall conform to all applicable requirements of Section III of "A Standard for Vehicle Detectors," a revised standard of The Institute of Transportation Engineers.

B. Magnetometer Detector Amplifier and Sensors.

Magnetometer detector amplifiers shall be entirely solid-state with the exception of the output relay, designed to operate in extremes of temperature and humidity. Front panel adjustments shall be provided to control select mode of operation, calibrating the units and adjustment for hold time. The amplifier in combination with the sensors listed shall be capable of operating satisfactorily with the following sensors.

1. One (1) to six (6) sensors, cylindrical in shape no larger than one (1) inch in diameter and four (4) inches in length.

The magnetometer detector amplifier and sensors shall conform to all applicable requirements of Section IV of "A Standard for Vehicle Detectors," a revised standard of The Institute of Transportation Engineers.

C. Inductive Loop Detector Amplifier and Sensors.

Inductive loop detector amplifiers shall be entirely solid-state with the exception of the output relay, designed to operate satisfactorily with sensors embedded in a roadway. Inductive loop amplifiers shall conform to all applicable requirements of the National Electrical Manufacturers Association (NEMA) Standards Publication TS-1 (latest revision) for the following types:

1. Type 1 — Shelf-mounted, 1-channel detector unit, as specified, responding to a percentage change in inductance, with delay and extension timing, relay output and powered from a 120 Volt AC source. Units shall conform with the applicable requirements of NEMA TS-1, Sections 7, 11 and 15.

2. Type 2 — Shelf-mounted, 2-channel detector unit, as specified, responding to an absolute change in inductance, with delay and extension timing, relay output and powered from a 120 Volt AC source. Units shall conform with the applicable requirements of NEMA TS-1 Sections 7, 11 and 15 and the following:

Inductance Range — Any configuration of wire-loop sensor(s) and shielded lead-in, including series/parallel combinations having a total inductance up to 2000 microhenries with a maximum shielded lead-in length of 1000 feet.

Tuning Adjustments — No tuning adjustments, units shall automatically self-tune within ten (10) seconds upon the application of power or following power interruption.

Sensitivity — Each channel of the unit shall be capable of detecting any valid vehicle over any test loop configuration described in NEMA TS-1, Sections 7, 11 and 15. A minimum of eight (8) sensitivity adjustments shall be provided for each channel.

Each channel MS connector output of the Type 1 and Type 2 detector units shall mate with cable connector MS 3106A-18-1S to be supplied with each unit (1-cable for 1-channel units, 2-cables for 2-channel units). Each connector cable supplied for each channel of each unit shall be ten (10) wire color coded and labeled A through J pin terminations as follows:

A. AC− Common	F. Output N.O.
B. Relay Common	G. Output N.C.
C. AC+ Line	H. Chassis Ground
D. Loop Input	I. Delay/Extension Logic Ground
E. Loop Input	J. Delay/Extension Logic Input

Each cable shall be a minimum of five (5) feet in length.

D. Ultra-Sonic Vehicle Detectors.

Ultra-sonic transceivers shall be entirely solid-state with the exception of the output relay, designed to operate in extremes of temperature and humidity. Front panel adjustments shall be provided to control range and gain. The transceiver in combination with a transducer shall be capable of providing the following:

1. Multi-Lane detection (Overhead mount)
2. Single-Lane detection (Overhead mount)
3. Multi-Lane detection (Side-fire mount)
4. Single-Lane detection (Side-fire mount)

Ultra-Sonic vehicle detectors shall conform to all applicable requirements of Section VI of "A Standard for Vehicle Detectors," a revised standard of The Institute of Transportation Engineers.

E. Pressure Sensitive Detectors.

Pressure sensitive detectors shall be of the directional or non-directional type and of the lengths shown on the plans.

A directional detector relay unit shall be furnished and installed in the controller cabinet for each phase having a directional detector.

F. Pedestrian Push Buttons.

Pedestrian push buttons shall be of the tamper-proof type. They shall consist of direct push type buttons and momentary contact switch in a cast metal housing.

The assembly shall be waterproof and so constructed that it will be impossible to receive any electrical shock under any condition. The housing shall be shaped to fit the curvature of the pole to which it is attached, to provide a rigid installation. Saddles shall be provided to make a neat fit when required.

Immediately above each pedestrian push button a 5″×8″ metal sign shall be installed on the crosswalk side of the post or pole.

815.43 Mast Arms — Strain Poles and Span Wire Assemblies.

A. General.

1. Mast Arms shall consist of a shaft complete with bracket arm, shaft cap, cable support (''J'' hook), with or without transformer base as specified, signal head hanging device, and safety chain anchor lug. Unless otherwise specified mast arms shall be made of aluminum or steel.

The design includes two types of mast arms:

Type I — Arms with one signal at the end.

Type II — Arms with signals mounted at intermediate points and at the end.

The arms shall upsweep in design without tie-rods or overbracing. Arms shall be self-supporting (single member arm) or supported by an underbrace (truss). Arm upsweeps shall be limited to between 0 and 6 feet of rise from the lowest point of attachment to the pole to the tangent terminal point of attachment of the signal head hanging device. Unless otherwise specified, single member arms shall not be made of aluminum.

All mast arms shall provide for wiring entrances directly into the pole of shaft from inside the mast arm, there shall be no exposed wiring.

Nominal wall thickness of aluminum structural members shall be not less than 0.188 inches and for aluminum structural pole or shaft members not less than 0.250 inches. Steel structural members shall not be less than 7 gauge.

All arms shall be provided with a lug for anchoring signal head safety chain.

2. Strain Pole and Span Wire Assemblies shall consist of galvanized steel strain poles, span wires, compression fittings, tether wires when specified, clamps, pole caps, wire entrances, disconnect hangers, signal head hanging devices, signal cable hanging devices, sign hanging devices when specified and all necessary miscellaneous materials to form a complete span wire assembly.

The design includes two types of span wire assemblies.

Type I — Span Wire Assembly with free swinging signals.

Type II — Span Wire Assemblies with Tether Wire.

Span Wire Assemblies shall conform to the requirements as shown on the Standard Drawings.

B. Support for Mast Arm Mounted and Span Wire Mounted Signal Heads.

Mast Arm Type I — The structure shall be designed to support free-swinging signal heads, of 6 square feet projected area weighing 160 pounds at the extreme end of the 20, 25, 30, 35 or 40 foot arms as shown on the plans. For signal heads over 6 square feet projected area, see Type II below.

Mast Arm Type II — When free-swinging signal heads over 6 square feet projected area, or fixed signal heads at the extreme end of the arm, or at intermediate points on the arm are specified, requirements will be as shown on the plans and/or Special Provisions. Acceptance of the Type II Mast Arm will be contingent upon the review and approval of shop drawings submitted by the Contractor.

Span Wire Assemblies Type I and Type II — Requirements will be shown on the plan and/or Special Provisions. Acceptance of Type I or Type II Span Wire Assemblies will be contingent upon the review and approval of shop drawings submitted by the Contractor.

All structures shall be designed and constructed in accordance with the requirements of AASHTO ''Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals'' (Current Edition) for a wind speed of 90 MPH.

All structures shall be constructed in accordance with the applicable requirements of the Department's Standard Drawings.

C. Anchor Bolts.

Anchorage shall consist of four or more high strength steel bolts positioned and designed to withstand the forces corresponding to the moment which will cause failure to the shaft.

Bolts shall be of the proper size, length and design to develop proper bond in transferring loads to the cement concrete foundation.

Anchor bolts shall be furnished with a template.

Each anchor bolt shall have two (2) hex nuts, two (2) flat washers and one (1) lockwasher to facilitate leveling of the shaft. Anchor bolts shall be galvanized.

D. Finish.

The bracket arms shall be furnished with a finish compatible to that of the shaft to insure uniformity of appearance. The exterior of the shaft and bracket arm shall be free of protuberances, dents, cracks, discoloration and other imperfections marring their appearance.

For shipping purposes, the shaft and bracket arm shall be protected to preserve the finish.

815.44 Post and Bases.

Standard Signal Post shall consist of a 4″ shaft complete with an octagonal base (8 feet or 10 feet long including base).

Pedestal Signal Post shall consist of a 4″ shaft complete with a pedestal base (8 feet or 10 feet long including base).

Aluminum Signal Posts shall consist of tapered aluminum shaft with a cast aluminum transformer base (8 feet or 10 feet long including base).

815.45 Vehicle Signal Heads.

Signal heads shall be weathertight asemblies, conforming to the requirements of "Adjustable Face Vehicle Traffic Control Signal Head Standard," ITE Technical Report #1, ANSI (D10.1).

Optically Programmed Adjustable Face Traffic Control Signal Heads that have been type tested and approved by the Department (Subsection 815.21) will be considered as meeting the requirements of this specification.

815.46 Pedestrian Signal Heads.

Pedestrian Signal Heads shall be of the two section incandescent type conforming to the ITE Standard for Adjustable Face Pedestrian Signal Heads, (ITE Technical Report Number 5).

The housings shall be of sufficient size to accommodate square or rectangular lenses with a legend consisting of the words "DON'T WALK" in portland orange and "WALK" in lunar white when illuminated, with minimum size of 3″ letters for Type A and 4½″ letters for Type B.

815.47 Louvred Hood and Optically Programmed Adaptors.

1. Where specified, louvred hoods shall be either of the following stipulated type:

Type A — 8″ or 12″ 3-vane with 7 degree cut-off.

Type B — 8″ or 12″ 6-vane with 3 degree cut-off.

Type C — 8″ or 12″ Multi-vane with adjustable 2½ to 30 degree cut-off.

2. Optically programmed signal adaptors shall comprise of an optical extension adaptable to standard 8″ signal sections for controlling the visibility of the indication. The projected indication may be selectively visible or veiled anywhere within 20 degrees of the optical axis.

815.48 Traffic Signal Lamps.

Lamps shall be of the type designed to withstand excessive vibration and intended for use in traffic signal heads. All traffic signal lamps for use in 8″ signal heads shall have a light center length of $2\frac{7}{16}$″. All traffic signal lamps for 12″ signal heads shall have a light center length of 3″. All lamps shall have a voltage rating of 125 volts and a rated life of 8000 hours minimum.

Other requirements shall be as follows:

1. For 8″ Signal Heads

a. 60 watt series, 675 Approximate Initial Lumens.

2. For 12″ Signal Heads

a. 150 watt series, 1950 Approximate Initial Lumens.

3. Optically Programmed Heads

a. 75 watt PAR for pedestrian heads

b. 150 watt PAR for signal heads

4. Flashing Warning Beacons

a. 25 watt series (8″ heads)

b. 40 watt series (12″ heads)

CONSTRUCTION METHODS

815.60 General.

Details of construction shall conform to all applicable requirements of the Standard Specifications and drawings, plans, details, Special Provisions, manufacturer's instructions and directions of the Engineer.

815.61 Painting.

All painting required shall be done in conformance with applicable portions of Subsection 960.63.

Aluminum posts, pedestals, poles, standards or mast arms shall not be painted. All galvanized surfaces shall not be painted unless abraded or damaged at any time after the applications of the zinc coating. The surfaces shall then be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coatings after which the cleaned areas shall be painted with two coats of paint, conforming to the requirements of Subsection M7.04.11.

All traffic signal, highway lighting and related electrical equipment (except new traffic signal controller cabinets) that comes from the manufacturer with one or more coats of paint (excluding primer) will be accepted, as one coat if scars or abraded places are properly cleaned and spot coated.

Two additional coats of paint shall then be applied. If such equipment is painted at the factory with just a primer coat, the Contractor shall apply three coats of paint.

Paint shall be applied to all interior surfaces before equipment and appurtenances are installed and to all exposed parts of the equipment and appurtenances after they have been completely installed, using the following colors:

Controller Cabinets (Exterior)	Aluminum
Controller Cabinets (Interior)	Aluminum or White
Signal Posts (Exterior Steel)	Yellow
Signal Posts (Interior Steel)	Aluminum or Yellow
Mast Arm and Mast Arm Pole (Exterior)	Aluminum
Mast Arm and Mast Arm Pole (Interior)	Aluminum
Housings (Back)	Yellow
Housings (Front)	Black
Visors (Outside)	Yellow or Black
Visors (Inside)	Dull Black
Backboards	Dull Black
Louvers	Dull Black
Meter Sockets	Aluminum

Painting may be omitted if equipment and materials are received from the manufacturer with equivalent paint specified above. All scars and abrasions shall be spot coated with two coats of the specified paint.

Steel poles (inner and outer surfaces) shall be painted in accordance with the applicable provisions of the Specifications.

All surfaces of aluminum bases in contact with concrete shall be coated, in the field, with a protective coating recommended by the manufacturer of the base.

815.62 Signals.

A. General.

Signal posts, bases, mast arms, mast arm shafts and strain poles shall be handled in loading, unloading and erecting in such a manner that they will not be damaged. Any parts that are damaged due to the Contractor's operations shall be repaired or replaced at the Contractor's expense.

Unless otherwise directed by the Engineer, posts, bases, mast arms and strain poles shall not be erected on concrete foundations until the concrete has set for at least three days.

Mast arms and strain poles shall be raked sufficiently to be plumb after all loads have been placed, poles shall be raked by adjusting double nuts. Shims or similar devices for plumbing or raking will not be permitted.

The bottom of the housing assembly of a signal head not mounted over a roadway shall not be less than 8 feet nor more than 15 feet above the sidewalk or, if none, above the pavement grade at the center of the roadway.

The bottom of the housing assembly of a signal head suspended over a roadway shall not be less than 16 feet nor more than 19 feet above the pavement grade at the center of the roadway.

Each signal face shall consist of one or more sections, rigidly and securely fastened together, capable of being positioned to face one direction of traffic.

Each section shall be a self-contained assembly consisting of a housing with door, visor and optical unit (lens and reflector) with traffic signal lamp.

B. Signal Head Section.

Each section shall be constructed to the requirements of ANSI specified in Subsection 815.46 including the following:

1. Optical units for 8" sections shall be equipped with traffic signal lamps as specified in Subsection 815.48.
2. Optical units for 12" sections shall be equipped with traffic signal lamps as specified in Subsection 815.48.
3. Optical units for 12" optically programmed sections shall be equipped with traffic signal lamps as specified in Subsection 815.48, equipped with dimming device to reduce lumen output of each signal lamp for night time operations.

Signal faces containing sections with both 8" and 12" lenses may be required. All signal heads including multiple assemblies shall be completely shop assembled and delivered ready for erection. Multiple units shall be assembled using 1 ½" pipe for the supporting framework and include 1 ½" center supporting pipe for post top mountings. Span wire and mast arm units shall have approved tie braces for the lower framework without a center support. Welding shall not be used in frame assembly.

Each socket shall be wired with two #18 AWG stranded leads not less than 16 feet long conforming to the requirements of Subsection 813.40 for Type 5 traffic signal head wire, Type TFF or TEW.

The color of the leads from the socket behind the:

Red lens — 1 red and 1 white wire
Yellow lens — 1 yellow and 1 white wire
Green lens — 1 green and 1 white wire
Green arrow — 1 blue and 1 white wire

At the option of the manufacturer, approved connecting blocks may be installed inside the housing for these connecting wires, provided a 16 foot colored lead for each socket and 1 white common lead is furnished as an integral part of each housing.

C. Hangers and Adaptors.

Hangers and adaptors shall be of bronze or malleable iron, or other approved material, strongly constructed, and of hollow design to permit the suspension of signal heads from mast arms or span wires or mounted on brackets, posts or pedestals.

Signal heads intended for post or pedestal mounting shall have suitable slipfitters for post top mounting and be secured to posts by means of set screws.

Mast arm mounted signal heads shall have an approved universal joint and safety chain.

Bracket mounted signal heads shall have suitable brackets to attach them to timber or metal poles to permit either internal or external wiring. Brackets shall be of proper size to be properly attached to pole as shown on the Standard Drawings.

Span-wire mounted signal heads shall have a span-wire hanger similar in design to that shown on the Standard Drawings. Hanger shall be specifically designed for supporting a hanging object from steel stranded messenger cable and have "U" bolts to prevent lateral movement only. Each hanger shall be complete with a wire entrance device.

Where specified, integral terminal compartments shall be provided for any of the above types of mounting. Terminal compartments shall be fabricated of non-frangible metal and be of adequate size to accommodate a terminal block containing not less than twelve poles, each with two pressure type connectors. Each connector shall be capable of holding four #12 AWG conductors.

D. Backplates

Where stipulated, backplates shall be furnished and installed. Backplates shall be constructed of anodized half hard aluminum sheet, .06" nominal thickness and of the dimensions to fit the signal head housing used.

E. Pole Clamps.

When required for mounting signal heads or equipment, pole clamps shall conform to the general design shown on the Standard Drawings.

815.63 Controllers.

All controller cabinets, control equipment and accessories shall be factory wired ready for operation. Field work will be limited to placing cabinets and equipment and the connecting of field wiring to terminal strips. Cabinets shall be mounted on the foundation and a clear silicone sealer shall be used at the base of the cabinet to form a water-tight seal with the foundation.

In addition, the Contractor shall provide to the Engineer two (2) copies of the Operating and Maintenance Instruction Manuals complete with wiring diagrams of the internal, external and field connections for each type of controller furnished on the project and listed in Section 815.41, C. Pre-Timed Controllers and two copies of the Technical Manuals and "Box Prints" for each type of controller furnished on the project and listed in Section 815.41, B. Actuated Controllers, the required Technical Manuals are listed in Paragraph 10 of the above Section 815.41, B. Actuated Controllers.

815.64 Detectors.

The Contractor shall install the detectors at the locations as shown on the signal layout plan in accordance with the applicable requirements of the Department's Standard Drawings.

All detector lead-in cable shall be continuous without splices from the pull box nearest the detector to the controller cabinet terminals provided without passing through any signal bases.

Splices, when necessary in the pull box nearest the detector shall be soldered and made completely water-tight using an approved rigid body re-enterable closure.

Detector leads shall not be run in the same cable sheath (jacket) with wires carrying signal currents.

Magnetic Detector Multi-Lane, shall be installed inside a 3" Type NM conduit, 18" below the surface of the road in a cement concrete envelope not less than 4" thick at any point as shown on the Standard Drawings.

Magnetic Detector Single Lane and Pressure Sensitive Detectors, shall be installed in accordance with manufacturer's recommendations.

Ultra-Sonic Detectors shall be installed overhead on mast arms or on posts (side-fired) in close conformity with the required lines and grades.

Wire-Loop and Micro-Loop Detectors shall be installed in slots saw-cut in the pavement and oriented to the traffic lane.

The size and type of conductor and method of installation shall conform to the Department's Standard Drawings.

The saw-slots shall be filled with an approved roadway loop embedding sealer to protect the wire.

815.65 Disposal of Existing Equipment.

When removal of existing traffic signal equipment and appurtenances is called for, the order of work shall be as directed by the Engineer. Removal of existing traffic signal equipment and their accessories shall be done in a manner that will not damage reusable material.

All signal posts and bases shall be separated from one another without damage to either unit (4" shaft unscrewed from base).

When stipulated, existing material shall be utilized in the construction of the new installation. Material to be installed shall be thoroughly cleaned before reinstallation. All reinstalled material, after cleaning and spot coating, shall receive two brush coats of paint to all parts as specified for new installations. Paint shall be applied after material is in place.

The Contractor shall furnish and install all necessary materials and equipment, including new foundations, etc., required to complete the reinstallation.

All traffic signals, flashing beacons and pedestrian signals to be reinstalled shall be relamped with new lamps of the size and type required for new installations.

Existing material removed and not utilized in the new installation shall be salvaged and transported by the Contractor to the Department Storeroom, unless directed otherwise.

Underground conduit, conductors, foundations and detector frames not reused shall be removed from the project, except if not interfering with other construction, they may with written approval of the Engineer be abandoned in place.

815.66 Tests Required Before Acceptance.

The Contractor shall record and make a written report of the following tests to be made on all traffic control signal installations in the presence of the Engineer:

1. Resistance Test required by Section 813.62.
2. An insulation resistance 500 Volt megger test shall be made for each inductive loop sensor and lead-in at the controller cabinet where the combination is to be terminated.

The following test procedure shall be performed in the presence of the Engineer before and after the loop sensor is sealed in the pavement as detailed below.

The cost of equipment, labor, and materials to perform such testing and similar re-testing following repairs, replacement, or adjustment of any detector assembly within the project area shall be included in the price bid for the Traffic Control Signal installation for that location, or under Item 819.831 if applicable.

After installation of wire loop sensors in the roadway and installation of shielded lead-in connecting the loop sensors to the terminals in the controller cabinet, each loop sensor and lead-in combination shall be tested (at the controller cabinet before termination) for proper installation.

The resistance from lead to lead of the same loop sensor shall not exceed three (3) ohms per one thousand feet as measured by a high quality meter suitable for measurements of low resistance.

A megohm-meter test at 500 Volts DC, shall be made between the two leads of a loop/lead-in combination temporarily spliced together, but otherwise disconnected from all terminals, and the shield drain wire and then the earth ground connection. These resistances shall be recorded and shall be equal to or greater than one hundred (100) megohms. The lowest acceptable value shall be 80 megohms under certain worst case conditions as determined by the Engineer.

A megohm-meter test at 500 Volts DC shall be made between lead-in shield and earth ground connection. This resistance should be at least one hundred (100) megohms. The lowest acceptable value shall be greater than fifty (50) megohms under worst case conditions as determined by the Engineer.

If any loop sensor lead-in combination fails to pass any one of the above four tests, it shall be repaired and then re-tested on two occasions at least two weeks apart, and then shall pass on each re-test occasion.

If the loop sensor lead-in combinatin does not pass all these re-tests, a new loop sensor and/or lead-in shall be installed, and then shall pass all tests, at no additional cost.

After the above tests have been satisfactorily completed, all loop sensor/shielded lead-in inductances shall be measured and a written report of the results shall be filed with the Engineer and a copy stored with the ``Box Prints`` at the intersection along with a copy of the ground electrode resistance tests required by Section 813.62B and the above.

Operation Tests — After satisfactory completion of the required tests, the system(s) shall be placed in operation.

Final acceptance will not be made until the system(s) has operated satisfactorily, as designed and the timing has been fine tuned, for a period of not less than 30 days from a date designated by the Engineer.

This test period shall be included within the specified contract time. Operation of the system(s) shall not in any way be construed as an acceptance of the system(s), or any part of it, or as a waiver of any of the provisions of the contract.

The Contractor shall be responsible for the system(s) during this period of operation and he shall make any adjustments or repairs that may be required and remedy defects or damages which may occur, at his own expense.

815.67 As Built Drawings.

1. Upon completion of the work, the Contractor shall mark and submit five (5) complete copies of ``as built`` or corrected copies of the contract plans (copies for marking furnished by the Department), showing in detail all construction changes, especially locations and depths of conduit and locations of posts, standards, handholes, manholes and pull boxes. All ``as built`` drawings shall be dated

2. Manufacturer's instructions for the maintenance, servicing and operation of all equipment, wiring diagrams of all equipment (except traffic signal controllers specified in Section 815.41B, Paragraph 10), and a parts list sufficient for the ordering of any parts, and any other data thereof as required by the Engineer.

Copies to be distributed as follows:

1. District Traffic Maintenance (1 complete set)
2. Traffic Maintenance Boston (1 set as described in 1. above)
3. Electrical Systems Boston (1 set as described in 1. above)
4. Wellesley Maintenance (1 complete set)
5. Control Cabinet (1 set as described in 2. above) with Technical Manuals and ``Box Prints`` required by Section 815.41B, Paragraph 10.)

COMPENSATION

815.80 Method of Measurement.

Traffic Control Signals, Traffic Control Signals removed and reset or stacked or transported, Traffic Signal Controllers and accessories shall each be measured for payment as a unit.

Signal post, signal post bases, mast arms (with the specified bracket arm lengths with or without transformer bases) and span wire assemblies shall be paid for at the contract unit price each complete in place.

Signal heads, mounting assembly, louvers, backplates and pole clamps will be paid for at the contract unit price each and when specified, as complete assemblies, which price shall be full compensation for work necessary or incidental to the construction of signal heads, modifying existing heads, or both, including conduit, wiring, and salvaging existing materials.

All additional materials and labor required to complete all of the above items as specified shall be considered as incidental to the construction and be included in the contract price each unit.

815.81 Basis of Payment.

The accepted quantities of traffic signal controllers and accessories, signal posts, signal post bases, transformer bases, mast arms with specified bracket arm lengths, span wire assemblies and traffic signal vehicle detectors shall be each measured for payment as a unit which price shall include full compensation for anchor bolts.

When specified in the Contract, Traffic Control Signals and Traffic Signals removed and reset, stacked or transported shall be paid for as a contract lump sum price which price shall be full compensation for all work necessary to perform the stated work, including, but not limited to, modification of existing signals, excavation, backfilling, compaction, concrete foundations, conduit, wiring, restoring facilities destroyed or damaged during construction and salvaging existing materials.

All additional materials and labor necessary to complete the work shall be considered as incidental to the construction and be included in the lump sum price.

815.82 Payment Items.

815.10 to 815.83	Traffic Control Signal Type —*	
	*(from 1. 1P. 1W to 8. 8P. 8W. 8D)	Lump Sum
815.89 to 815.95	Traffic Control Signal Type —*	
	*(9 to 15)	Lump Sum
816	Traffic Signal Removed and Reset	Lump Sum
816.0—*	Traffic Signal Reconstruction *Location No.	Lump Sum
816.40	Traffic Control Signal Removed and Reset	Lump Sum
816.80	Traffic Control Signal Removed and Stacked	Lump Sum
816.90	Traffic Control Signal Removed and Transported	Lump Sum
817.10	Signal Post and Base Standard — 8 ft.	Each
817.11	Signal Post and Base Standard — 10 ft.	Each
817.20	Signal Post and Base Pedestal — 8 ft.	Each
817.21	Signal Post and Base Pedestal — 10 ft.	Each
817.30	Signal Post Standard — 6 ft. — 10 in.	Each
817.31	Signal Post Standard — 8 ft. — 10 in.	Each
817.32	Signal Post Pedestal — 6 ft. — 10 in.	Each
817.33	Signal Post Pedestal — 8 ft. — 10 in.	Each
817.40	Signal Base Standard — 14 in. Octagonal	Each
817.41	Signal Base Pedestal — 15 in. Square	Each
817.50 to 817.53	Signal Mast Arm *— ft. — Aluminum	Each
817.60 to 817.63	Signal Mast Arm *— ft. — Steel	Each
817.70 to 817.73	Signal and Lighting Mast Arm — ft. × — ft.	Each
818.01 to 818.05	Signal Head 1 Way — *— Section 8 in. Lens	Each
818.11 to 818.15	Signal Head 1 Way — *— Section 12 in. Lens	
	*(1-5)	Each
818.23 to 818.25	Signal Head 1 Way — *— Section 2-12 in. Lens	Each
818.33 to 818.35	Signal Head 1 Way — *— Section 12 in. Red Lens	
	*(3-5)	Each
818.40	Signal Head 1 Way — 1 Section 9 in. Square Lens	Each
818.41 to 818.42	Ped. Signal Head — Letter Height *— in. min.	
	*(3 in. - 4½ in.)	Each
818.51 to 818.54	*— Way Post Top Mounting Assembly	Each
818.55 to 818.58	Mast Arm Mounting Assembly — *— Way	Each
818.59 to 818.62	Post Side Mounting Assembly — *— Way	Each

818.63 to 818.66	Span Wire Mounting Assembly — *— Way	
	*(1-4)	Each
818.70 to 818.71	Louvered Hood for *— in. Signal Section	Each
818.80 to 818.81	Back-Plates for *— in. Signal Head	
	*(8 in. - 12 in.)	Each
818.82	Back-Plates for Combined 8 in. + 12 in. Signal Head	Each
818.90 to 818.94	Ornamental Pole Clamp *— in. Dia.	
	*(4½ in. - 8⅝ in.)	Each
818.95	Pole Clamp with Wire Entrance	Each
819.01 to 819.38	Traffic Signal Controller — Type *—	
	*(Types 1. 1P. 1W. thru Type 15)	Each
819.50	Railroad Pre-Emptor	Each
819.51	Fire Station Pre-Emptor	Each
819.52	Special Internal Unit	Each
819.53	Special Function Unit	Each
819.60 to 819.64	Coordinating Unit — Type *—	
	*(Type FF to Type S4)	Each
819.70	Signal Light Switching Assembly — Type DC	Each
819.71	Signal Light Switching Assembly — Type SS	Each
819.72	Detector Unit Conflicting Green	Each
819.800	Magnetic Detector Amplifier	Each
819.801	Vehicle Detector (Directional) Compensated Magnetic	Each
819.802	Vehicle Detector (Multi-Lane) non-Compensated Magnetic	Each
819.803	Vehicle Detector (Single-Lane) non-Compensated Magnetic	Each
819.810	Detector Amplifier — Magnetic (Special)	Each
819.811	Detector Sensing Head — Magnetic (Special)	Each
819.820	Vehicle Presence Detector — Ultrasonic	Each
819.821	Vehicle Motion Detector — Ultrasonic	Each
819.830	Vehicle Detector — Wire Loop OSC and Relay	Each
819.831	Wire Loop Installed in Roadway — SD4.041	Linear Foot
819.840	Directional Detector Relay — Pressure Sensitive	Each
819.841 to 819.843	Nondirectional Detector *(— ft.) — Pressure Sensitive	Each
819.844 to 819.846	Directional Detector *(— ft.) — Pressure Sensitive	
	*(4, 6, 8)	Each
819.850	Pedestrian Push Button	Each
819.851	Push Button for Green Light (Sign)	Each
819.852	Push Button for Walk Signal (Sign)	Each

SECTION 820
HIGHWAY LIGHTING

DESCRIPTION

820.20 General.

This work shall consist of furnishing and installing or modifying highway lighting.

Included in the work is the furnishing and installing or modifying electrical conduit, electric manholes, handholes, pull or junction boxes, concrete foundations, wire and cable, equipment grounding, ground rods, service connection, lighting poles or towers, luminaires, control equipment, load center assemblies, photoelectric control switches, contactors, time clocks, and all incidental materials necessary for operating and controlling highway lighting systems as indicated on the plans. All systems and/or components shall be complete in every respect, fully wired, thoroughly tested, and ready for use.

The locations of highway lighting equipment shown on the plan are approximate and the exact locations will be established by the Engineer in the field with the exception of Lighting Poles or Towers. Their locations may be altered 10 feet (±) only by written permission from the Engineer, if obstructions are encountered during installation.

TRAFFIC CONTROL DEVICES

All electrical equipment shall be designed, manufactured and tested in accordance with the applicable standards of the ANSI, EIA, FSS, IMSA, ITE, NEMA and UL and these specifications.

Unless otherwise designated on the plans, on the Standard Drawings for Highway Lighting, as set forth in the Special Provisions, and as specified herein, all work and materials shall conform to the requirements of the NEC as amended by the MEC, herein referred to as the electrical code.

Wherever reference is made to codes or standards mentioned above, the reference shall be construed to mean the code or standard that is in effect on the date of advertising of the project.

All electrical connections, splicing, grounding, resistance tests, service connnections and circuit identification shall be done by a licensed electrician holding "Certificate B" issued by the State Examiners of Electricians.

Standard symbols and construction details for highway lighting installations are shown on the current Traffic Signal and Highway Lighting Standard Drawings.

Within 30 days following execution of the Contract, the Contractor shall submit to the Engineer for approval, a list of equipment which he proposes to install. The submission shall include all equipment identified on the plans or in the specifications by the name of the manufacturer, model or identifying number of each item. The list shall be supplemented by catalog cuts and such other data as may be required, including wiring diagrams of any special equipment and of any proposed minor deviation from the plans. All of the above data shall be submitted in triplicate for checking. Following checking, correction and review, not less than five (5) complete approved sets shall be resubmitted to the Engineer for distribution. The Department shall not be liable for any material purchased, labor performed, or delay to the work prior to such review and approval.

The warranties that the Contractor receives from each manufacturer of equipment and materials pertinent to the complete and satisfactory operation of highway lighting installation shall be turned over to the Department at the time of acceptance of the project, at no cost to the Department. Each warranty so furnished shall indicate its expiration date, and be in effect for a minimum period of one year from the date the highway lighting was placed in continuous operation.

If within one year from the date the highway lighting system is placed on continuous operation the equipment and materials do not meet the warrants specified above and the Engineer notifies the manufacturer or his authorized representative promptly, the manufacturer or his authorized representative thereupon shall correct any defect either by repairing or replacing any defective part or parts, at no cost to the Department.

It is the intent of the Plans, Specifications and Special Provisions to provide a complete highway lighting system through the project.

It is not intended that every fitting, minor detail or feature be shown and described, as the assumption is made that either the Prime Contractor or his Subcontractor is an expert in the particular area of responsibility and is capable of interpreting the plans, Specifications and Special Provisions so that the bid shall include all items required and that they shall be provided and installed in a neat and workmanlike manner.

820.21 Definitions.

A. Highway Lighting Poles — An aluminum or galvanized steel structure providing a 30 foot to 50 foot mounting height for luminaires mounted on truss type (2-15 feet) bracket arm.

B. Area Lighting Pole or High Mast Tower — A steel structure providing a 40 foot to 200 foot mounting height for luminaires and equipped with lowering device to permit luminaire maintenance at ground level.

C. The term load center assemblies, as used herein, shall constitute assemblage of parts, equipment and miscellaneous items, forming a complete and independent load center and circuit protector system, housed in a weatherproof trunk cabinet or building as specified.

D. Luminaires shall consist of a housing, reflector, refractor or door glass, refractor holder or door glass holder, lamp socket, mounting device, ballast components, photoelectric control when specified and light source.

MATERIALS

820.40 General.

All materials shall be new. Luminaires shall incorporate the latest photometric and design standards of IES, NEMA and UL.

Where existing systems are to be modified, the existing equipment and material shall be incorporated in the revised system, salvaged, or abandoned, as directed.

All equipment and materials shall meet the requirements specified in applicable provisions of Section 800.

820.41 Design Requirements.

The completed structures with all luminaires and appurtenances attached thereto shall be designed and constructed in accordance with the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" (Current Edition) for a wind speed at 90 mph.

820.42 Equipment.

A. Highway Lighting Poles (Transformer Base).

1. Poles from 30 to 50 feet unless otherwise specified may be made of aluminum or galvanized steel. All poles over 50 feet shall be made of galvanized or weathering steel. All aluminum poles over 40 feet may be in two (2) sections telescoped together and lapped not less than two (2) times the pole diameter at the lapped-joint. Each pole shall be fabricated in a manner that will accommodate a truss type bracket arm (2–15 feet) in length.

2. Bracket arms shall be designed for 2 inch slipfitter mounted 75 pound luminaires with a projected area of 3.3 square feet.

3. Poles shall have a handhole with a reinforced frame and cover. The opening shall be approximately 4″×6″ located approximately 12 inches from the bottom of the pole and placed 90 degrees to the bracket arm. Shaft cap shall be aluminum, weatherproof and arranged to be held securely in place on the shaft by a set screw or screws or stamped cap.

4. A bonding means shall be provided in the transformer base and at handhole of each pole.

5. Transformer base for all poles shall be aluminum of the frangible type. The base shall be approximately 20 inches high and be provided with a door having a minimum opening of 8 inches by 12 inches. Four (4) hex head connection bolts with four (4) hex nuts, eight (8) flat washers and four (4) lock washers, galvanized to ASTM A-153 requirements, shall be provided with each transformer base.

6. Anchor bolts for poles with mounting heights of 35 feet or less shall be minimum 1 inch by 40 inches with a 4 inch "L" bend at the unthreaded end, bolts for poles with mounting heights in excess of 35 feet shall be minimum 1¼ inches by 48 inches with a 6 inch "L" bend at the unthreaded end.

Each anchor bolt shall have two (2) hex nuts, one for the top and one for the bottom of the base plate, to facilitate leveling of the pole, two flat washers and one (1) lock washer.

7. The bracket arms shall be furnished with a finish similar to that of the shaft to insure uniformity of appearance. The exterior of the pole and bracket arm shall be free of protuberances, dents, cracks, discolorations and other imperfections marring their appearance.

8. For shipping purposes, the shaft and bracket arm shall be protected to preserve the finish.

9. The dead load deflection at the top of the shaft caused by the weight of the arm, luminaires and all appurtenances attached thereto shall not exceed 2% of the shaft length.

10. All aluminum poles over 20 feet in length shall have internal dampers installed to reduce vibrations.

B. Area Lighting Poles or High Mast Tower.

Where area lighting poles or high mast towers are required, plans and Special Provisions will be prepared for the project. In general, requirements will be similar to those specified in Subsection 820.41.

Anchorage shall consist of four (4) or more high strength steel bolts, having two (2) heavy duty hex nuts, and fabricated from high strength low alloy steel having a minimum yield of 50,000 psi positioned and designed to withstand the forces corresponding to the moment which will cause failure to the shaft.

Anchor bolts shall be furnished with a template and a prefabricated reinforcing cage welded to the bolts.

C. Highway Luminaires.

The luminaire shall be of the horizontal burning gaseous discharge lamp type with IES Type II, III or IV lateral light distribution, as indicated on the plans, with medium vertical light distribution and semi-cutoff vertical light control.

The luminaire shall have a precision-case aluminum housing providing for slipfitter end mounting capable of adapting to 1¼″ or 2″ mounting brackets with provisions for vertical adjustments of not less than 3°. The reflector shall be of detachable snap-in design, manufactured of polished aluminum. The refractor shall be mounted in a door frame assembly and hinged with a safety catch to the luminaire at the house side and fastened at the street side by an automatic type latch. The refractor and door frame assembly shall be forced upward at the street side by spring pressure when latched against the gasket seat. Gaskets between the reflector and the refractor and the socket entry shall be made of a material capable of withstanding the temperatures involved and be held securely in place. Refractor shall be heat resisting glass with inner or outer prisms.

When stipulated, luminaires shall be furnished and installed with glare shields.

Luminaires shall have an internal ballast of the regulator type capable of operating from multiple circuit voltages indicated on the plans, at a power factor of not less than 95%. The ballast shall be pre-wired to the lamp socket and terminal board, requiring only connection of the power supply leads to the ballast primary terminals. The ballast shall provide regulation within 4% (8% for 1000 watt units) variation in center rated lamp watts with a ±13% variation in primary volts from the ballast voltage-design center. Ballast shall provide satisfactory lamp starting to −20°F, minimum over the recommended line voltage variation. Ballast and capacitor components shall be arranged so that their operating temperature is not exceeded.

Unless otherwise specified the luminaire shall include a photoelectric control device, as specified in Section 820.42-1, and locking type mounting receptacle in accordance with NEMA standards. The receptacle shall be pre-wired to the terminal board.

Lamps shall be of the gaseous discharge type and wattages indicated. They shall conform to ANSI (ASA) requirements as listed in reputable lamp manufacturers catalogues. Lamps failing during first 1000 hours shall be considered defective and be replaced at no cost to the Department.

D. Area Lighting Luminaires.

Area lighting luminaires are used mainly for special applications. Where this type of lighting is required. Special Provisions and Plans will be prepared for the particular project. In general luminaires will be similar to luminaires specified in Subsection 820.42-C.

E. Flood Lighting Luminaires.

Flood lighting luminaires are used mainly for special applications. Where this type of lighting is required. Special Provisions and plans will be prepared for the particular project. In general, luminaires will be similar to luminaires specified in Subsection 820.42-C and will have special mounting arrangements.

F. Underpass Lighting Luminaires.

Luminaires shall consist of a one or two lamp VHO/CW/RS fluorescent type with internally mounted ballast and recessed sockets. The housing shall be one piece aluminum with sufficient structural bracing for self support. The ends of the luminaire shall be tapped for 3/4″ conduit. The reflector shall be polished aluminum readily removable for access to the interior of the housing for wiring and servicing. The refractor shall be heavy plastic and hinged to allow the cover to swing open. Gaskets shall be provided to form a seal between the housing and refractor. Luminaire shall be watertight and capable of withstanding water pressures up to 100 PSI with standard cleaning nozzles commonly used in cleaning tunnels. Luminaires shall be provided with adjustable aluminum or stainless steel brackets to allow a 90° minimum rotation of the luminaire through the longitudinal axis.

Luminaires shall have an internal ballast capable of operating from multiple circuit voltages indicated on the plans and capable of furnishing design voltages and current for the specified fluorescent lamp or lamps. It shall operate satisfactorily over a voltage range of ±5% of its nominal primary voltage rating. Line feed back from the lamp through the power line shall be corrected by means of a built-in interference suppressor incorporated in each ballast. Power factor correction shall be not less than 90% and each ballast shall be capable of starting its lamp or lamps at a temperature of −20°F.

G. Sign Lighting Luminaires.

Sign lighting luminaires may be of the incandescent, gaseous discharge or fluorescent type. Where this type of lighting is required, Special Provisions and Plans will be prepared for the particular project. In general luminaires will be similar to luminaires specified in Subsection 820.42-C and 820.42-F.

H. External Ballasts.

The basic ballast housing shall be adaptable by brackets, lugs, or adaptors for either pole-base, pole-side, pole-top, flat wall mounting or direct burial. The housing shall be of heavy gauge aluminum or fibre-glass. All assembled core windings and terminals shall be sealed within the housing by a high-melting point filling

compound. The electrical characteristics shall conform to ballasts mounted integrally as specified in Subsections 820.42-C and 820.42-F. A manufacturer's name plate shall be an integral part of the housing. The name plate shall have the manufacturer's name, model number, serial number, hook-up diagram, power supply data and the load that the ballast is capable of operating.

I. Photo Electric Control.

The controls shall be twist-lock plug-in devices to be used with highway lighting equipment conforming to NEMA standards. They shall be of the tubeless type rated for 50 or 60 hertz, alternating current, at the following voltages and load capacity with inrush current rating not less than 100 amperes:

1. 105–285 volts, 18000 volt-amperes
2. 120 volts, 1800 volt-amperes
3. 208 volts, 1800 volt-amperes
4. 240 volts, 1800 volt-amperes
5. 277 volts, 1800 volt-amperes
6. 480 volts, 1800 volt-amperes

Controls shall have a turn-on range of 0.5 to 2.5 foot-candles and shall be factory adjusted to turn on at 1 foot-candle. The turn off level shall be between 1 and 2 foot-candles higher than turn on levels. It shall be possible, by means of simple hand tools or by a calibrated adjustment knob, to adjust the turn on time of the lights when the north sky illumination falls within the range of values specified herein.

Normal operation of the photo electric control shall not be affected by line voltage variations of $\pm 10\%$. Minimum operating temperature range shall be from $-20\,°F$ to $+150\,°F$. The unit shall have a built-in surge protective device for protection from induced high voltage and follow through currents.

A time delay feature shall be incorporated as a part of the control circuit to prevent false turn-offs by transient light. The controlled lighting load shall remain on or become energized in the event of any functional failure of the photo electric control circuit.

J. Multiple Control Switch.

The switch shall be equipped for either pole or wall mounting with all components (relays, etc.) housed in a weatherproof enclosure and designed for controlling loads up to 6000 watts. The switch shall be pre-wired complete with NEMA twist-lock receptacle for an integrally mounted photo electric control, as specified in Subsection 820.42-I or controlled remotely by a switch. Photo electric control voltage must match multiple control switch voltage.

K. Multiple Circuit Contactor.

The contactor shall be an unenclosed single phase, two-pole open type magnetic contactor of the rating indicated. Contactors shall be constructed for surface mounting on a false back. The contactor coil shall be remotely operated by a multiple control switch as specified in Subsection 820.42-J and a photo electric control as specified in Subsection 820.42-I or controlled remotely by a switch as specified in subsection 820.42-L, or controlled remotely by a time clock as specified in Subsection 820.42-M, as shown on the plans or specified in the Special Provisions.

L. Remote or Test Switch.

A heavy duty, single-pole tumbler switch rated at 20 amperes, encased in a heavy duty metal weatherproof housing, shall be installed in the control cabinet or lighting pole bases as a highway lighting test switch. The switch shall be rated for operation on the voltage specified for the device it controls. The switch shall be wired so as to shunt the photo electric control, multiple control switch, multiple circuit contactor or time clock and energize the lighting circuits.

M. Astronomic Time Clock.

Astronomic time switches shall be 35 amperes, double pole, single throw, heavy duty, 42°–30′ North Latitude, astronomic dial street light type with high torque synchronous motor and 10 hour main spring operation to provide accurate timing during power interruptions. When power is restored after any failure, the motor shall resume timing and automatically wind the main spring.

The motor shall be designed to operate on 120/240 volts, 60 hertz, alternating current at temperature ranging from minus 20 °F to plus 150 °F.

The time clock shall have a wall mounted pressed steel case with rain-tight gasketed door cover and mounted in the load center housing.

N. Service Riser Pipe.

Galvanized steel conduit shall meet the requirements of Subsection M5.07.1A.

O. Secondary Conductors.

Secondary conductors shall conform to the requirements of Section 813.63.

P. Service Cabinet or Housing.

The housing for load center assemblies shall be a trunk type cabinet as specified in Section 815 for vehicle-actuated traffic signal controllers, and of a size to house all equipment. The cabinet shall be the product of a Manufacturer with an established reputation who has designed and produced similar cabinets.

Q. Circuit Protection.

The Contractor shall furnish and install on the rear wall of the trunk type cabinet a power distribution panel. A main bus shall be provided, protected by a main and branch circuit breakers. All equipment shall be designed for the amperage, voltage and phase designated. The general arrangement of circuit breakers shall be in accordance with the circuit diagram shown on the plans. Circuit breakers shall be unenclosed molded case bolt-on type with end conductor terminals, suitable for surface mounting on a metal false back. The Contractor shall provide a chart mounted on the cabinet door identifying circuit breakers and the circuits they control.

Circuit breakers shall be of the rating shown on the plans.

R. Load Center Concrete Foundation.

The Contractor shall construct the service cabinet foundation of reinforced cement concrete as shown on the standard drawings on a 12″ gravel sub-base.

S. Meter Socket.

A 200 ampere meter socket approved by the serving utility shall be furnished and installed on the service cabinet or where directed by the serving utility.

CONSTRUCTION METHODS

820.60 General.

Details of construction shall conform to all applicable provisions of Sections listed under Subsection 820.40 and the specifications set forth hereinafter.

Highway lighting poles, area lighting poles and high mast towers shall be handled in loading, unloading and erecting in such a manner that they will not be damaged. Any parts that are damaged due to the Contractor's opeations shall be repaired or replaced at the Contractor's expense.

Unless otherwise directed by the Engineer, poles or towers shall not be erected on concrete foundations until the concrete has set for at least 28 days.

All surfaces of aluminum bases in contact with cement concrete shall be field coated with an aluminum impregnated caulking compound recommended by the manufacturer of the base.

Poles and towers shall be raked sufficiently to be plumb after all loads have been placed, poles shall be raked by adjusting the two (2) nuts supplied with each anchor bolt. The mounting height shall be measured from the light source to the roadway surface directly below. The bracket arm shall be securely attached to the shaft and the pole erected with the bracket arm perpendicular to the center line of the roadway.

The Contractor shall mark on each light pole or tower, six (6) feet above the roadway suitable numbers and letters two (2) inches minimum height displaying the pole number and circuit to which it is connected.

The luminaires shall be installed on the brackets specified, parallel to the road surface or aimed as indicated on the plans, securely fastened, lamped, connected, cleaned and ready for operation.

The service riser, the service cabinet, and the concrete mat shall be installed as shown on the plans and as required by the Code. The work under this item shall include all conduit to 4 feet beyond the load center. The service cabinet shall be installed on the concrete mat, complete with distribution panel mounted inside. The electrical components shall be mounted with machine screws and wired as shown on the plans or as directed. All conduits in the service cabinet shall be bonded together and grounded to the cabinet with not less than #8 AWG bare copper conductors. A 3/4″ × 12′ long ground rod shall be driven in accordance with Section 813.62 and stubbed 6″ above the concrete foundation. Not less than a #2 AWG bare copper grounding conductor from the neutral bus shall be run continuously to the ground rod.

Photo electric control devices shall be mounted with the light sensitive unit facing toward the north sky. Method of mounting shall be as indicated or as specified in Section 820.42-I. Control switch contactors and time clocks shall be mounted as specified herein before.

Test switches shall be mounted as specified. When mounted in lighting pole base it shall be supported on an "L" shape galvanized steel bracket secured by anchor bolt and nut.

820.61 Tests Required Before Acceptance.

The Contractor will be required to test the entire system for continuity, grounds, resistance to ground, insulation resistance, and make provisions for high voltage dielectric strength tests, before any equipment is connected. This shall be done by means of a 500 Volt megohm-meter test which will indicate the insulation of any circuit or group of circuits. When the insulation resistance is less than 100 megohms between insulated conductor and ground (system ground point at the load center), the Contractor shall locate the point or points

at fault, make proper corrections and then demonstrate by further tests the elimination of such fault. With all equipment connected to the wiring system, a functional test shall be performed by the contractor using the system power, if not available the Contractor shall provide temporary power where and as required. The tests shall be performed in the presence of the Engineer to demonstrate that the system as a whole, and all parts thereof, function as specified or intended. Any defective materials, equipment or faulty or improper installation shall be permanently corrected by repairs or replacements to be made by the Contractor. All tests and any necessary repairs which are indicated by them to produce a fault-free system shall be performed at the Contractor's expense.

Operation Tests — After satisfactory completion of the required tests, the system shall be placed in operation. Final acceptance will not be made until the system has operated satisfactorily, as designed, for a period of not less than 30 days from a date designated by the Engineer. This test period shall be included within the specified contract time. Operation of the system shall not in any way be construed as an acceptance of the system, or any part of it, or as a waiver of any of the provisions of the contract. The Contractor shall be responsible for the system during this period of operation and he shall make any adjustments or repairs that may be required and remedy defects or damages which may occur, at his own expense.

Any other incidental work or materials for which no basis of payment is provided will be considered as completely covered by the unit price bid.

COMPENSATION

820.80 Method of Measurement.

Highway lighting poles, area lighting poles and high mast towers, with the specified mounting heights, bracket arm of specified length and anchor bolts; luminaires of the size and type specified; photo electric control (including test switch); multiple control switch; multiple circuit contactor; time clock; and highway lighting load center, with all necessary nuts, bolts, connectors, clamps, equipment grounding connector, and incidental material to form a complete unit shall each be measured for payment as a unit.

Highway lighting shall be measured as a complete installation and paid at a contract lump sum price.

820.81 Basis of Payment.

The lump sum price for "Highway Lighting" and "Highway Lighting Load Center" shall be full compensation for all work necessary or incidental to the construction of the highway lighting installation, modifying existing installations, or both including excavation, backfilling, compaction, concrete foundations, conduit, wiring, and salvaging existing materials. All additional materials and labor required to complete the highway lighting installation shall be considered as incidental to the construction and be included in the respective lump sum contract price. All materials shall conform to Section 800 and Division III of these specifications.

The accepted quantities of highway lighting poles, area lighting poles, high mast towers, luminaires, photo electric control (including test switch), multiple control switch, multiple circuit contactor and time clock will be paid for at the contract unit price each, for the length, type and size specified, which price shall include full compensation for anchor bolts and miscellaneous hardware.

No direct payment will be made for the following incidental materials: conduit fittings, all bolts, nuts and washers and wiring.

820.82 Payment Items.

820.10	Highway Lighting — Roadway	Lump Sum
820.11	Highway Lighting — Underpass	Lump Sum
820.12	Highway Lighting — Area	Lump Sum
820.13	Highway Lighting — Sign	Lump Sum
821.10 to 821.15	Highway Lighting Pole (Anchor Base) *(— ft. Bracket)	Each
821.20 to 821.25	Highway Lighting Pole (Anchor Base) Twin *(— ft. Bracket) *(4–15 ft.)	Each
821.30 to 821.70	Highway Lighting Pole (Anchor Base) DBL *—+— ft. Brackets *(4+6 to 12+15)	Each
822.10 to 822.15	Highway Lighting Pole (Transformer Base) *— ft. Bracket	Each
822.20 to 822.25	Highway Lighting Pole (Transformer Base) Twin *— ft. Bracket *(4–15 ft.)	Each
822.30 to 822.70	Highway Lighting Pole (Transformer Base) DBL *—+— ft. Brackets *(4+6 to 12+15)	Each
822.80 to 822.82	Area Lighting Hinged Pole *— ft. Mounting Height *(40–50 ft.)	Each
822.83 to 822.88	Area Lighting Mast Pole or Tower *— ft. Mounting Height *(40–100 ft.)	Each

822.89 to 822.98	Area Lighting Mast Pole or Tower *— ft. Mounting Height *(110–200 ft.)	Each
823.10 to 823.14	Highway Lighting Luminaire *— Watt *(175–1000 Watt)	Each
823.15 to 823.21	Area Lighting Luminaire *— Watt *(175–4000 Watt)	Each
823.22	Flood Lighting Luminaire Less than 500 Watt	Each
823.23	Flood Lighting Luminaire 500 Watt and Over	Each
823.30 to 823.32	Underpass Lighting Luminaire *— ft. Fluorescent	Each
823.33 to 823.35	Sign Lighting Luminaire *— ft. Fluorescent *(4–8 ft.)	Each
823.40	Sign Lighting Luminaire 175 Watt	Each
823.41	Sign Lighting Luminaire 250 Watt	Each
823.50	Photo Electric Control	Each
823.51	Multiple Control Switch	Each
823.52	Multiple Circuit Contractor	Each
823.53	Time Clock	Each
823.60	Highway Lighting Load Center	Lump Sum
823.70	Highway Lighting Pole and Luminaire Removed and Reset	Each
823.71	Highway Lighting pole and Luminaire Removed and Stacked	Each
823.72	Highway Lighting Pole and Luminaire Removed and Transported	Each

SECTION 824
FLASHING BEACONS, ILLUMINATED WARNING SIGNS, AND LIGHTED BARRIER ARROWS

DESCRIPTION

824.20 General.

This work shall consist of furnishing and installing or modifying flashing beacons, highway illuminated warning signs and lighted barrier arrows at designted locations as shown on the plans and detail sheets in conformance with these Specifications and the Standard Drawings.

Included in the work is the furnishing and installing, modifying, removing, resetting, stacking or transporting existing control equipment, signal heads, electric lamps, posts and bases, poles, pedestals, mast arms, barriers, barrier arrows, service connections, wire and cable, pull and junction boxes, electrical conduits, and all incidental materials necessary for operating and controlling the beacons, signs and arrows.

The locations of beacons, signs, barriers, control equipment and appurtenances shown on the plans are approximate and the exact location will be established by the Engineer in the field.

MATERIALS

824.40 General.

When existing systems are to be modified, the existing equipment and materials shall be incorporated in the revised system, salvaged or abandoned as directed.

Equipment and materials shall meet the requirements specified in Section 800 for Signals & Wiring.

824.41 Highway Illuminated Warning Signs and Barrier Arrows.

Illuminated warning signs and barrier arrows shall be designed so that lamps, tubes, electrodes, transformers or ballasts and all wiring shall be totally enclosed and protected from the weather. Each sign or arrow shall be delivered to the project completely finished and assembled, ready for erection.

824.42 Flasher.

The flasher unit shall be two-circuit jack mounted using solid state circuiting (no moving parts) designed to operate on 105–130 volt, 60 hertz, alternating current. The output load rating with incandescent traffic signal lamps or an inductive load shall not be less than 10 amperes. The unit shall be capable of providing alternating flashing opertion at the rate of 50 to 60 flashes per minute. The flasher unit shall be individually housed and protected from the weather and must not present a shock hazard to maintenance personnel.

Filter — Each flasher shall be equipped with a suitable filter wired or built into the flasher in the manner recommended by the Manufacturer. Any filter not completely eliminating radio interference shall be replaced.

Housing — The combined flasher and filter shall be installed in an approved weatherproof housing equipped with a disconnect block for shutting off the system. The cabinet shall be fastened to a standard 8 foot signal post by means of a suitable saddle or backplate. The flasher and filter shall be fastened to a backboard and the combined assembly shall be removable from the housing intact.

COMPENSATION

824.80 Method of Measurement.

Flashing beacons, highway illuminated warning signs and lighted barrier arrows will be measured as completed units.

824.81 Basis of Payment.

Flashing beacons, highway illuminated warning signs and lighted barrier arrows will be paid for at the respective contract unit price complete in place.

824.82 Payment Items.

824.10	Flashing Warning Beacon Type D	Lump Sum
824.20	Flashing Warning Beacon Type A	Lump Sum
824.30	Flashing Warning Beacon Type B	Lump Sum
824.40	Flashing Warning Beacon Type C	Lump Sum
824.50	Flashing Warning Beacon Removed and Reset	Lump Sum
824.51	Flashing Warning Beacon Removed and Stacked	Lump Sum
824.60	Highway Warning Sign — Illuminated	Each
824.61	Highway Warning Sign — Illuminated	Lump Sum
824.70	Highway Warning Sign — Illuminated R+R	Lump Sum
824.71	Highway Warning Sign — Illuminated R+S	Lump Sum
824.72	Highway Warning Sign — Illuminated Removed and Transported	Lump Sum
824.80	Lighted Barrier Arrows	Each
824.81	Lighted Barrier Arrows	Lump Sum
824.90	Lighted Barrier Arrows Removed and Reset	Lump Sum
824.91	Lighted Barrier Arrows Removed and Stacked	Lump Sum
824.92	Lighted Barrier Arrows Removed and Transported	Lump Sum
824.93	Lighted Barrier Arrows Removed Transported and Reset	Lump Sum

SECTION 828
TRAFFIC SIGNS

DESCRIPTION

828.20 General.

The provisions of this section shall apply to the fabricating, furnishing and erecting warning clusters and signs, overhead and roadside guide signs, warning and regulatory signs, route and project markers and supports for delineators and markers.

Traffic Signs are officially erected devices, mounted on fixed or portable supports, whereby specific messages are conveyed by means of words or symbols, for the purpose of regulating, warning or guiding traffic.

Unless a definite type of material is specified, the Contractor must designate in the Option Items of the Proposal his choice of panel, either plywood galvanized steel, or aluminum type A or B.

The signs, foundations and supports shall be fabricated and erected in conformity with the following:

A. The Massachusetts Department of Public Works manual on "Uniform Traffic Control Devices" (Current Edition) hereinafter referred to as MUTCD.

B. The AASHTO publication entitled "Specifications for Design and Construction of Structural Supports for Highway Signs, Luminaires and Traffic Signals" (Current Edition).

C. The Massachusetts Department of Public Works Standard Drawings for Signs and Supports (Current Edition).

828.21 Plans.

The Contractor shall develop plans for the foundations, structural supports and sign panels, including the spacing of panels, excepting for the designs shown as typical on the standard drawings and plans. The message and size of legend for sign panels shall be as specified by the Department.

MATERIALS

828.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III. Materials:

Reflective Sheeting	M9.30.0
Acrylic, Prismatic Reflectors and Embossed Aluminum Frames for Signs	M9.30.3
Acrylic Plastic Reflector Type "A"	M9.30.4
Demountable Reflectorized Delineator-Guard Rail	M9.30.7
Reflectorized Flexible Delineator Post	M9.30.8

828.41 Relective Sheeting.

Reflective sheeting shall meet the requirements of Section M9.30.0.

A. Panel Sheeting — Type II (Engineering Grade)

B. Legend Sheeting — Type III (High Intensity)

C. Channelizing Sheeting — Type IV (High Intensity Flexible)

828.42 Panels.

A. Aluminum Sign Panels.

Aluminum sign panels shall be either Type A or Type B. Sign supporting hardware shall be aluminum or stainless steel.

Aluminum Sign Panels (Type A).

Type A Panels shall be fabricated from flat sheet Aluminum Alloy of the following types:

A-1 — Flat sheet aluminum sign panels shall be fabricated from aluminum sheeting, ASTM B209, Alloy 6061-T6 or Alloy 5052-H38 of the following thickness and mounting unless otherwise specified.

AREA SQUARE FEET	MOUNTING	THICKNESS
Up to 10	Single post	0.080″
Over 10 to 20	Two posts	0.080″
Over 6 to 20	Single post (Top Mounted)	0.250″

A-2 — Flat sheet sections with extruded tabs shall be fabricated from:

1. Sheeting 0.125″ thick, ASTM B209, Alloy 3033-H18.
2. Extruded parts ASTM B221, Alloy 6063-T6.

A-3 — Flat sheet sections with welded or flush riveted locking tabs and clips shall be fabricated from:

1. Flat sheet ASTM B209, Alloy 6061-T6 or Alloy 5052-H38.
2. Extruded parts as specified by the Manufacturer.

Aluminum Sign Panels (Type B).

Type B Panels shall be fabricated of extruded Aluminum ASTM B221. Alloy 6063-T6 shall be 0.125″ thick, 12″ wide and of bolted joint design. Only one 6″ panel shall be used where the overall height of a sign requires one panel less than 12″.

B. Plywood Sign Panels and Plywood Route Markers.

Plywood sign panels and independent plywood Route Markers shall be fabricated from 5 ply 3/4" High Density Overlaid (HDO) Marine Exterior Type, A-B both sides surface in natural color and the whole conforming with the requiremens and tests as set forth in U.S. Product Standard PS1 for Construction and Industrial Plywood. All Plywood shall bear the grade trademark of an approved testing agency.

C. Route Markers and 24" Warning Clusters (H1-2).

These items on aluminum panels shall be fabricated from aluminum sheeting ASTM B209, Alloy 6061-T6 or Alloy 5052-H38 0.080" thick of the size shown on the plans.

Route marker overlay on directional sign panels may be fabricated from Aluminum Alloy 5052-H38 0.080" thick or 5 ply 1/2" thick High Density Overlaid (HDO) Marine Exterior Type, A-B both sides surface in natural color and the whole conforming with the requirements and tests as set forth in U.S. Product Standard PS1 for Construction and Industrial Plywood. All plywood shall bear the grade trademark of an approved testing agency.

Material for attachment shall conform to the following specifications:

Part	Aluminum: ASTM	Stainless Steel: AISI
Bolts	B211 6061-T6 Alloy	Type 304 or 305
Rivets	B316 6061-T6 Alloy	Type 304 or 305
Nuts	B211 6061-T6	Type 304 or 305
Washers	B209 Alclad 2024-T4	Type 304 or 305

828.43 Legends (Type A, B, C and D).

The type of legend shall be as specified and shown on the plans except as follows:

a. State and U.S. Route Markers shall have Type D Silk Screen Processed Legends.

b. Interstate Route Markers on Guide Signs on Feeder roads shall have Type C Permanently Applied Legends.

c. Individual Interstate Route Markers shall have Type C Permanently Applied Legends with the required Silk Screen Processed Legend superimposed thereon.

d. Individual Interstate Route Markers on Overhead Signs shall have Type B Permanently Applied Legends.

Finished legends shall show careful workmanship and be clean-cut and sharp.

A. Legend Type A — Demountable Flat.

Legends shall be reflective or opaque sheeting as specified conforming with the photometric and other requirements of Subsection 828.41. Legends shall be applied to sheet aluminum in a manner specified by the sheeting Manufacturer.

Base material shall be of sheet aluminum ASTM B209, Alloy 3003 H14.

Demountable legends shall be of sheet aluminum, those up to and including 12" in height shall be .040" in thickness; those over 12" in height shall be .064" in thickness.

B. Legend Type B — Demountable Prismatic Reflectors.

Reflective letters, numerals, symbols and borders shall consist of embossed aluminum frames fitted with circular plastic prismatic reflex-reflectors.

The reflectors shall meet the requirements of Subsection M9.30.3.

C. Legend Type C — Permanently Applied Legend.

Legends shall be reflective or opaque sheeting applied directly to a clean, dust-free background in a manner specified by the sheeting manufacturer.

Legends shall be cut neatly at intersect on panel edges.

Heat activated adhesive-coated material shall be applied only by mechanical means.

Finish shall be as specified in Subsection 828.51B.

D. Legend Type D — Silk Screen Processed.

The legends and shields shall be of the series and size specified in the AASHTO Manual for "Signing and Pavement Markings" (Current Edition), and the dimensions, details of the letters with respect to each series as specified in the FHWA publication: "Standard Alphabets for Highway Signs" (Current Edition), or as specified and shown on the plans.

828.44 Demountable Reflectorized Delineators.

A. Type "A" Acrylic Plastic Reflector.

The reflector shall conform to Subsection M9.30.4

B. Type "B" Reflective Sheeting Reflector (Wide Angle).

The silver-white #2 and yellow (amber) reflectors shall be of adhesive coated reflective sheeting permanently adhered to a sheet aluminum backing. The reflective sheeting shall meet the requirements of Subsection M9.30.0.

The sheet aluminum backing shall be ASTM B290 Alloy 6061-T6 or Alloy 5050-H38, .040" in thickness properly degreased and etched or treated with a light tight amorphous chromate type coating.

1. Photometric Requirements.

See Subsection 828.41 (Legend Sheeting).

C. Type "C" Demountable Circular Reflector (Wide Angle).

Each reflector shall conform to Subsection M9.30.5. Demountable Reflectorized Delineators shall conform with the rquirements for one of the following types: "A", "B" or "C" as stipulated. The Manufacturer shall certify that all reflectors conform with these specifications and that he will replace or repair without cost all which fail to meet requirements. Finished reflectors shall show careful workmanship and be clean-cut, sharp and have essentially plane surfaces.

828.45 Reflectorized Flexible Delineator Posts.

Reflectorized Flexible Delineator Posts shall meet the requirements of Subsection M9.30.8.

FABRICATION

828.50 General.

Sign fabrication shall be done in a plant properly equipped for the production of the types of signs specified.

Sign panels shall show careful workmanship and present a reasonably plane surface with the message and outlines clear and sharp.

Finished sign panels shall be shipped in such manner as to ensure arrival on the project in undamaged condition, where they shall be properly protected from dirt, scratches, hand-marks and other blemishes until erected and accepted.

828.51 Reflective Sheeting.

A. Application

Reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified for the manufacture of traffic control signs by the sheeting manufacturer. Heat activated adhesive coated sheeting shall be pre-perforated.

Sign faces, comprising two or more pieces or panels of reflective sheeting, must be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance both day and night. Alternate, successive width sections of either sheeting or panels must be reversed and consecutive, to insure that corresponding edges of reflective sheeting lie adjacent on the finished sign. Nonconformance may result in nonuniform shading and an undesirable contrast between adjacent widths of applied sheeting, which will not be acceptable.

Pressure sensitive adhesive coated sheeting shall be overlapped at splices not less than 3/16". Heat activated adhesive coated sheeting may be spliced with overlap not less than 3/16" or butted, gap not to exceed 1/32". Only butt splices shall be permitted on signs screen-processed with transparent color. Sheeting applied to extruded sections shall extend over top edges and down side legs a minimum of 1/16". No splices shall be allowed on sign panels under 20 square feet.

B. Finish (Protective Coating).

1. When pressure sensitive adhesive coated reflective sheeting is used all sheeting splices and sign edges shall be sealed with materials recommended by and in a manner specified by the sheeting manufacturer.

2. Dry heat activated adhesive coated reflective sheeting when applied to aluminum or high-density plywood shall be edge sealed as specified by the sheeting manufacturer.

828.52 Panels.

White numerals 1" in height, designating the size of sign panel, date of fabrication, fabricator, manufacturer and type of sheeting shall be affixed at the bottom left rear corner of all ground mounted guide, historical, cultural, recreational and specific information service signs.

All other ground mounted signs shall have black numerials 1/2" in height, designating the size of sign panel, date of fabrication, fabricating manufacturer and type of sheeting affixed to the bottom left rear of each panel.

White numerals 1½″ in height, designating the size of sign panel, date of fabrication, fabricator, manufacturer and type of sheeting shall be affixed at the bottom left corner of the face of each overhead sign panel.

The code numbers of fabricators and manufacturers will be obtained from the Department Bureau of Transportation Planning and Development Systems Operations Unit.

Black numerals shall be used in place of white numerals where the background they are affixed to is white or aluminum.

Panel surfaces upon which reflective sheeting is to be applied shall not be painted.

The painting of traffic signs, if required, shall conform to the following:

a. Wooden signs shall be cleaned with steel wool, lightly rubbed with either Xylol or V.M.&P. Naptha solvent and wiped dry.

b. Aluminum signs shall be treated by solvent cleaning and a wash coat of basic zinc chromate-vinyl butyral (M7.04.10).

c. After pre-treatment as specified above, the faces if required, backs, and all exposed edges of the signs shall be given a prime coat of enamel primer conforming with Federal Specifications TT-P-636.

d. After priming, the face side of all signs requiring painted backgrounds shall be given two color coats of enamel conforming to Subsection M7.03.02.

e. The backs and exposed edges of plywood sign panels shall be given one coat of color enamel matching that specified for the background of the sign face, same to conform with the foregoing paint specifications.

f. Bolt heads on the face of sign panels shall be primed as designated under "c" to accept a permanent coat of matching paint.

A. Plywood.

All possible fabriction, including cutting, drilling, edge sealing and painting on each plywood panel shall be completed prior to assembly and applcation of reflective sheeting and legend.

Panels shall be cut to size and shall be free from warping, open cracks, splits, joints, checks, loose knots or other defects which interrupt the smooth continuity of the panel surface. The composite surface of all sign panels shall be flat. All edges and back sides shall be sealed with two coats of primer and two (2) coats of finish color matching that of the respective panel face. All cracks, open checks, splits or other defects occurring on the edge surfaces shall be filled with plastic wood and sanded smooth prior to sealing and painting.

Enamel shall conform to the requirements of Subsection M7.03.02.

Panels, stiffeners and battens shall be as shown on the typical detail plans.

Battens shall be required at all joints in each panel assembly. Battens shall not be eliminated when size of sign permits use of single plywood panel.

Corners shall be rounded as shown on the plans.

No routing of panels or route markers to countersink bolts will be permitted. Bolt heads shall be drawn flush to the panel.

Supporting hardware shall conform with the requirements of ASTM A36 and shall be galvanized in accordance with the requirements of ASTM A123.

Legends shall be affixed to plywood panels by #7 round-head aluminum tap screws. 5/8″ long, conforming with the requirements and recommendations of the legend manufacturer.

The background for Route Markers shall be Reflective Sheeting.

Route Markers shall be attached to Plywood Sign Panels with 1/4″ × 1¾″ hot dipped galvanized, slotted-head bolts with washers and square nuts, properly treated to accept a permanent coat of matching paint. Steel bolts, nuts and washers shall conform with ASTM A307; galvanizing shall conform with ASTM A153.

B. Aluminum.

Fabricated sections with extruded legs shall be manufactured in accordance with the typical detail plans. The face shall have a reasonably plane surface free from protrusions and depressions.

Panels shall be composed in increments 48″ wide. Panels less than 48″ wide shall be composed of one sheet. Signs greater than 48″ shall have no more than 2 sheets less than 48″ wide.

Sheet increments shall be continuous from top to bottom of sign panel. No horizontal joints will be permitted. Panel assembly shall include all fasteners and backing strips also fabricated from aluminum sheeting ASTM B209, Alloy 6061-T6.

Backing strips shall be provided at every joint and held firmly in place with proper fasteners as recommended by the manufacturer. Caution shall be used in assembly to prevent any projections, dents or gouging of the panel face. The corners of signs shall be rounded to a radius equal to the minimum dimension of the sign except that a minimum corner radius of 12″ shall be used, unless otherwise noted on the plans.

Route markers shall be attached to aluminum sign panels with aluminum or stainless steel 1/4″ diameter slotted-head bolts with nuts and washers or 1/4″ diameter rivets.

Treatment of Aluminum Sign Panels Prior to Application of Reflective Sheeting.

1. Degreasing.

a. Vapor degreasing: by total immersion of the panel in a saturated vapor or trichloroethylene. Trademark printing shall be removed with lacquer thinner or controlled alkaline cleaning system.

b. Alkaline degreasing: by total immersion of the panel in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specification

2. Rinsing. After satisfactory degreasing, the panels shall be thoroughly washed with running water.

3. Drying. The panel shall be thoroughly dried by use of a forced hot air dryer.

4. Metal shall not be handled between cleaning and etching operation and the application of reflective sheeting, except with devices or clean canvas gloves.

5. Metal shall not come in contact with greases, oils or other contaminants prior to the appliction of reflective sheeting.

C. Panels for 24″ Warning Cluster (H1-2).

Panels shall be attached to the posts with standard bolts as specified on the plans. The panels shall have one coat of primer and two coats of paint conforming to Subsection M7.03.02 of Division III, Matrials, and protected prior to painting in accordance with the manufacturer's recommendations.

828.53 Legends.

A. Type A.

The letters, numerals, symbols and borders shall be attached to the sign background as specified in Subsection 828.52.

B. Type B.

The reflectors shall be affixed to the aluminum frames by an approved method to prevent loosening. The use of tape to hold reflectors in place will not be permitted.

Reflector size shall be determined by the dimensions of the legend and space 1 ½ diameters on center and 1/2 diameter from the edge of the letters.

After fabrication, the aluminum shall be properly degreased and etched, then treated with a light, tight, amorphous chromate type coating. All units shall have an embossed height of approximately 1/8″.

Embossed aluminum frames, following amorphous chromate coating, shall be primed and enameled with high quality synthetic baking primer and white or black enamel.

Each letter, numeral, symbol and border shall be supplied with mounting holes and shall be secured to the sign surface with aluminum or stainless steel screws or rivets. Mounting holes shall be spaced as required under Subsection 828.52.

C. Type C.

See Subsection 828.43-C.

D. Type D.

The legends shall be applied by the Silk Screen Process or by using cutouts from an approved type black film superimposed on reflective sheeting.

The flexible black gloss silk screen ink shall conform to the manufacturer's recommendations.

828.54 Demountable Reflectorized Mile and Tenth-of-Mile Markers.

A. The mile marker panels shall be fabricated from aluminum sheeting conforming to ASTM B209, Alloy 6061-T6 or Alloy 5052-H38 and 0.080″ in thickness. They shall be 8″ wide and of a length required to display the number of numerals shown on the plans.

The green reflective sheeting shall conform to the requiremens of Section 828.41.

The silver-white numerals shall be Type C "permanently applied" as specified under Subsection 828.43-C.

B. The aluminum panel for tenth-of-mile marker shall be 4″×4″ diamond shape as shown on the plans. The sheeting and legend shall conform to the applicable requirements of Subsection 828.41 and Subsection 828.43 and the following:

The panel shall be fabricated from aluminum sheeting conforming to ASTM B209, Alloy 6061-T6 or Alloy 6052-H38 and 0.063″ in thickness, properly degreased and etched or treated with a light, tight, amorphous chromate-type coating. The panel shall be punched or sheared to size, with 1/4″ radius corners having two square or round 1/4″ mounting holes. Mounting holes shall be spaced on 4″ centers so as to present a diamond-shape when installed.

The reflective sheeting shall conform to Encapsulated Lens Reflective Sheeting in accordance with Subsection 828.41.

The reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified by the sheeting manufacturer.

The numerals shall be Type D, black, die-cut, pre-spaced, conforming to the FHWA Standard Series. Numerals shall have a pre-coated, pressure-activated adhesive and applied as recommended by the manufacturer of the reflective sheeting or be opaque black 3M permanent inks applied on approved high intensity sheeting, Type III.

828.55 Hazard Markers.

A. H1-1 Demountable Reflectorized Hazard Marker.

The attaching of the backplate to the P-9 post shall conform to the following requirements:

Two rivets, each consisting of pin and collar, shall be used to attach the marker to the post. The collar shall be cold-swaged into annular locking grooves on the pins by a method recommended by the manufacturer.

Pin rivets shall be 3/16″ diameter of aluminum ASTM B316. Alloy 2024-T4; collars shall be 3/16″ diameter aluminum of ASTM B209, alloy 6061-T4 with a minimum washer face of 1/2″ diameter. The pin rivets shall have truss heads and grip range of 1″ ± 1/16″.

B. H1-2 24″ Warning Cluster.

Fabrication shall conform to Subsection 828.51.

C. H1-3 Abutment Warning Panels.

The stripes shall be alternate yellow and black. The yellow stripes shall be reflectorized as required under "Reflective Sheeting," Section 828.41. Black paint shall conform to the requirements of Subsection M7.03.02.

828.56 Demountable Reflectorized Delineator.

A. Type A.

Housings shall be of aluminum ASTM B209, Alloy 5052-H-38, .020″ thickness, formed to encase a reflector having a minimum diameter of 3″ and be .235″ in depth to retain the acrylic reflector. Housing shall be provided with four embossed circular reinforcement ribs and marked with name and part number of the manufacturer.

Aluminum grommets of 3/16″ inside diameter shall be expanded within the reflector mounting holes to accommodate 3/16″ aluminum ASTM B316, Alloy 2024-T4 bolts.

The aluminum housings shall be free from buckles, warps, burrs, corrosion, white rust and dirt.

B. Type B.

The reflective sheeting shall be pre-coated with either a pressure sensitive adhesive (Type I), or a tack-free adhesive (Type II) designed for mechanical application to properly prepared surfaces only when activated by heat. The sheeting shall adhere securely at temperatures of −30°F to +200°F, and be elastic enough at low temperatures to resist shock when struck at −10°F without an appreciable decrease in adhesion, vandal resistant and strong enough to resist peeling from the surface. The pre-coated adhesive shall have no staining effect on the reflective sheeting and must be mildew resistant.

The reflective sheeting shall be mechanically applied in the manner and with equipment prescribed by the sheeting manufacturer.

The reflective material when processed shall be in accordance with Subsection 828.41.

The sheeting surface shall be such that it may be readily refurbished by cleaning in accordance with the manufacturer's recommendations.

C. Demountable Reflectorized Guard Rail Delineators.

Demountable reflectorized delineators shall conform to M9.30.7.

828.57 Reflectorized Flexible Delineator Posts

Shall be installed in accordance with the manufacturer's recommendations at locations indicated on the Plans and/or as directed.

828.58 Demountable Reflectorized Project Markers.

The panels shall be fabricated from aluminum sheeting conforming to ASTM B209, Alloy 6061-T6 and shall be 0.063″ in thickness. They shall be 4″ wide and of a length required to display the station numerals shown on the plan. The length shall be a minimum of 8″.

The reflective background sheeting attached to the aluminum sheeting shall conform to the requirements fo Subsection 828.41. The color of the background sheeting shall be orange for Beginning and End project markers and white for intermediate Station project markers.

The panel shall be punched or sheared to size, with 3/4" radius corners, having two square or round 1/4" mounting holes.

The numerals shall be type D, black, die-cut, pre-spaced conforming to the FHWA Standard Series i ½" C. Numerals shall have a pre-coated pressure activated adhesive and be applied as recommended by the manufacturer of the reflective sheeting.

ERECTION

828.60 General.

24" warning clusters (H1-2) shall be mounted on one standard P-5 breakaway post assembly. The reflectors shall be amber (Type A), conforming to the requirements of Subsection 828.44-A.

Abutment warning sign (H1-3) shall be constructed of plywood panel or aluminum panel (Type A) as specified or as optioned in the proposal. Posts shall be one standard P-5 breakaway assembly, conforming to Department standards.

Demountable reflectorized project markers shall be fabricated and erected as shown on the plans and/or as directed by the Engineer.

Demountable reflectorized mile and tenth-of-mile markers shall be mounted on new P-9 Steel posts or on existing posts as shown on the plans and as directed.

Demountable reflectorized hazard marker (H1-1) shall be mounted on a standard P-9 post. The reflectors shall be yellow (amber) (Type A) as specified under Section 828.44-A unless otherwise noted in the Special Provisions.

Demountable reflectorized guard rail delineators shall be attached to the bolts located in the valley of the guard rail beam at the spacings as follows:

1. Delineators are to be installed on every tenth (10th) guardrail post.

In guardrail runs of less than ten (10) posts two (2) delineators shall be used, one (1) at either end.

2. On curves delineators will be spaced at a minimum of every third (3rd) guardrail post based on the degree of curve. No less than three (3) delineators shall be visible at normal viewing distance from the travel lane adjacent to the guardrail section.

3. Leading and trailing ends at bridges — three (3) delineators — one (1) at the connection of the terminal connector and the twenty-five feet (25') plate; one (1) at the middle of the twenty-five feet (25') plate and one (1) at the connection of the twenty-five (25') plate and the normal guard rail panel.

4. In no instance shall delineators be installed on sections of guard rail which deviate substantially from the alignment (vertical or horizontal) of the roadway or which are located more than eight feet (8') from the edge of the paved surface.

5. Exceptions and/or modification to the above shall be made only with the approval of the Engineer in the field.

When roadway alignment permits, the reflector potion of each delineator shall be positioned so that it will be clearly visible for a distance of 1000 feet under normal weather and atmospheric conditions when illuminated by the high beam of standard automobile headlights on vehicles in the lane adjacent to the delineator.

828.61 Attachment to P-9 Posts.

Demountable reflectorized mile and tenth-of-mile markers and project markers shall be attached to the P-9 posts by a connection fabricated as follows:

Two rivets, each consiting of pin and collar, shall be used to attach the marker to the post. The collar shall be cold-swaged into annular locking grooves on the pins by a method recommended by the manufacturer.

Pin rivets shall be 3/16" diameter of aluminum ASTM B316. Alloy 2024-T4, collars shall be 3/16" diameter aluminum of ASTM B209, Alloy 6061-T4 with a minimum washer face of 1/2" diameter. The pin rivets shall have truss heads and grip range of 1" ± 1/16".

An approved two piece rivet type sign fastener installed by expanding the blind rivet component inside the semi-tubular rivet component may be used.

When demountable reflectorized tenth-of-mile marker (excluding post) is specified, the marker shall be attached to existing delineator post. The existing delineator reflectors may be removed or retained as directed.

COMPENSATION

828.80 Method of Measurement.

The quantity of Overhead Guide Signs, Roadside Guide Signs, Warning Signs, Regulatory Signs and Route Markers (Shields) shall be the actual total number of square feet of panel in each sign classification.

The area of Route Markers when attached to destination sign panels will not be added to the total area of panels.

Demountable Reflectorized Hazard Marker (H1-1) will be measured by the unit including P-9 post complete in place.

Each Abutment Warning Sign with 1 Breakaway P-5 Post Assembly shall be considered as one unit.

Each 24" Warning Cluster mounted on one P-5 Breakaway Post Assembly shall be considered as one unit.

Demountable Reflectorized Mile Marker, Tenth-of-Mile Marker with P-9 Post and Tenth-of-Mile (excluding post) will be measured by the respective unit complete in place.

Demountable Reflectorized Delineators shall be measured by the unit, complete in place, with P-9 post or bracket.

Demountable Reflectorized Project Marker including P-9 Post (where applicable) will be measured by the unit complete in place.

Reflectorized Flexible Delineator Posts will be measured by the unit complete in place.

828.81 Basis of Payment.

Payment for each classification of sign panels will be made at the contract unit price per square foot which shall be full compensation for fabricating, furnishing, erecting and attaching the completed sign panel, preparing all reflectorized materials, backgrounds, legends, borders, arrows, shields, paints, hardware and all other materials and labor required for the completion of the signs as specified.

Demountable Reflectorized Hazard Marker (H1-1) will be paid for under the contract unit price each complete in place.

Payment for Abutment Warning Panels will be made at the contract unit price each complete in place.

Payment for 24" Warning Clusters will be made at the contract unit price each complete in place.

Demountable Reflectorized Mile Marker with P-9 Post, Tenth-of-Mile Marker with P-9 Post and Tenth-of-Mile Marker (excluding post) will be paid for under the contract unit price each complete in place.

Demountable Reflectorized Delineators will be paid for under the contract unit price each complete in place.

Demountable Reflectorized Project Marker with P-9 Post (where applicable) shall be paid for under the contract unit price each complete in place.

Reflectorized Flexible Delineator Posts will be paid for under the contract unit price each complete in place.

828.82 Payment Items.

827.21	24" Warning Cluster (H1-2) — Aluminum Panel (Type A)	Each
827.3	Abutment Warning Sign (H1-3) — Option	Each
827.31	Abutment Warning Sign (H1-3) — Plywood Panel	Each
827.33	Abutment Warning Sign (H1-3) — Aluminum Panel (Type A)	Each
828.	Overhead Guide Sign — Option	Square Foot
828.1	Overhead Guide Sign — Aluminum Panel — (Type B)	Square Foot
828.2	Overhead Guide Sign — Plywood Panel	Square Foot
829.	Roadside Guide Sign — (MR) — Option	Square Foot
829.1	Roadside Guide Sign — (MR) — Aluminum Panel — (Type B)	Square Foot
829.2	Roadside Guide Sign — (MR) — Plywood Panel	Square Foot
830.	Roadside Guide Sign — (FR) — over 20 square feet — Option	Square Foot
830.1	Roadside Guide Sign — (FR) — over 20 square feet — Aluminum Panel (Type B)	Square Foot
830.2	Roadside Guide Sign — (FR) — over 20 square feet — Plywood Panel	Square Foot
831.	Roadside Guide Sign — (FR) — 20 square feet and under — Option	Square Foot
831.1	Roadside GuideSign — (FR) — 20 square feet and under — Aluminum Panel (Type A)	Square Foot
831.2	Roadside Guide Sign — (FR) — 20 square feet and under — Plywood Panel	Square Foot

832.1	Warning — Regulatory and Route Marker — Aluminum Panel (Type A)	Square Foot
833.1	1-WH Demountable Reflectorized Delineator (H1-4)	Each
833.11	1-AM Demountable Reflectorized Delineator (H1-8)	Each
833.2	2-WH Demountable Reflectorized Delineator (H1-7)	Each
833.3	2-AM Demountable Reflectorized Delineator (H1-5)	Each
833.4	3-AM Demountable Reflectorized Delineator (H1-4)	Each
833.5	Demountable Reflectorized Delineator — Guard Rail	Each
834.	Demountable Reflectorized Mile Marker	Each
834.1	Demountable Reflectorized Tenth-of-Mile Marker	Each
834.11	Demountable Reflectorized Tenth-of-Mile Marker (Excluding Post)	Each
834.17	Reflectorized Flexible Delineator Post (Amber)	Each
834.18	Reflectorized Flexible Delineator Post (White)	Each
835.	Demountable Reflectorized Hazard Marker (H1-1)	Each
836.	Demountable Reflectorized Project Marker with P-9 Post	Each
836.1	Demountable Reflectorized Project Marker (Excluding Post)	Each

SECTION 840
SIGN SUPPORTS

DESCRIPTION

840.20 General.

The work to be done hereunder consists of the fabrication and erection of steel structural supports on 4000 psi, 1½" 565 Cement Concrete Masonry Foundations.

The Contractor may select any structural sign support system meeting the design criteria of the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" (Current Edition) unless otherwise standardized by the Department. Acceptance of the structural sign supports system will be contingent upon the review and approval of Shop Drawing submitted by the Contractor.

The plans for foundations and ground mounted supports shall be based on the data included on plans titled "Standard Sign Support Foundations" and "Standard Ground Mounted Sign Supports — Breakaway Design." The plans for overhead structures shall conform to the requirements of Section 828.21.

In the absence of boring samples, or the actual determination of the soil properties at the proposed footing location, the Department will accept an assumed soil bearing pressure of two kips per square foot for the design of the footing.

All unsuitable material within the limits of the footing must be removed at the direction of the Engineer. (Peat, organic material, material that has been dumped. etc.).

The concrete for the footing shall be placed immediately after excavation to prevent water from collecting in the excavated area.

All overhead and cantilever sign support structures shall be designed so as to be supported by single poles or end frames having not more than two (2) vertical main members.

All overhead and cantilever sign structures shall have as an integral part of the structure, a Department approved damping device, which shall be installed during erection of the structure.

The damping devices shall be installed as follows:

Overhead structures shall have the damping devices installed at the midpoint of the span (plus or minus one foot), regardless of sign panel location.

Two-chord structures shall have the damper attached to the top chord at mid-span.

Tri-chord structures shall have the damper attached to the middle chord at mid-span.

Box truss structures shall have the damper attached to the rear top chord at mid-span.

Cantilever structures shall have the damper attached to the outer end of the horizontal member.

Existing structures which do not have damping devices shall have dampers installed as part of the Contract.

Existing structures, which have dampers not attached as specified above, shall have them removed and attached as specified above.

The approximate locations for the new signs are shown on the plans, the exact locations are to be determined by the Engineer on the project.

The Department will mark or stake the center point for each sign foundation only once whereupon it shall be the responsibility of the Contractor to furnish and set at his own expense all tie and construction stakes necessary for the erection of the sign.

All measurements to fabricate and erect the overhead sign structures and supports for ground mounted signs shall be made by the Contractor. Field measurements needed to determine the exact span and height of each structure should be taken immediately upon award of the Contract for incorporation in the structural layout on the shop drawings prior to submission for review.

The Contractor shall submit all design work, together with computations and plans used for design purposes, to the Department; these to become the property of the Department and for which he shall receive no additional compensation. All design work shall bear the seal of a Registered Professional Engineer registered in Massachusetts.

Certificates of compliance shall conform to the requirements of Subsection 6.01.

Before fabricating the sign support structures the Contractor shall submit erection plans and shop drawings for approval of the Engineer in accordance with Subsection 5.02, 828.21 and 960.60 of these Specifications. Span lengths, post heights, vertical and horizontal clearances, material specifications (grade and/or alloy), anchor bolt layout, and all pertinent information shall be included on the shop drawings. Provisions for cambering shall also be shown to insure that horizontal cross beams will not deflect below the horizontal.

A handhole 4″×6½″ (minimum size) with frame and cover shall be installed in each overhead support structure post and positioned approximately 12″ above the top of footing. The frames and covers shall be the same material as the posts. A removable cap with set screws shall be furnished on the top of each overhead support structure post.

All supports for ground mounted signs shall be of the "Breakaway" type. The design, fabrication and erection shall conform with the plans.

The work to be done hereunder shall include the furnishing and installation of Breakaway Post Assemblies for ground mounted signs, (not guide), in accordance with Department Standard Drawings and as shown on the plans.

This specification covers the use of standard, tapered, square, rectangular, round and special shape structural metals for sign supports.

Breakaway Sign Supports shall be designed and fabricated in conformance with plans titled "Standard Ground Mounted Supports Breakaway Design."

All vertical supports shall be erected plumb.

Both ends of each truss spanning a roadway shall be set at the same elevation.

Sign panels shall be mounted symmetrically about the horizontal truss or beam and provide a minimum vertical clearance above the roadway surface as shown on the plans.

MATERIALS

840.30 General.

All materials shall be new and shall meet the requirements specified in the following Subsection of Division III, Materials.

4,000 psi, 1½″, 565 Cement Concrete Masonry	M4.02.00
Reinforcing Steel	M8.01.0
Anchor Bolts	M8.01.5
Steel Sign Supports	M8.18.5

FABRICATION

840.40 General.

Welding shall conform to the applicable provisions of Subsectiom 960.61 of the Standard Specifications.

No transverse welds will be permitted in the tubular shafts, except at the base plate and flange plate connections or where reinforcing sleeves are required. The shaft shall telescope the flange and the base plate and be welded by two continuous welds, one on the inside of the plate at the end of the shaft and the other on the outside surface of the plate. All welds shall develop the full strength of the section at the point of connection.

CONSTRUCTION METHODS

840.60 General.

Work hereunder includes excavation, reinforcing steel. 4000 psi, 1½", 565 cement concrete masonry, anchor bolts, backfilling, grading and all other labor, material and equipment required to construct foundations conforming to the details shown on the plans and as directed.

Single pole foundation holes, except in ledge, shall be excavated by the auger method to the neat lines of the outside dimensions of the footings without disturbing the soil around or below the proposed footing.

In areas where rock or ledge is encountered the bottom of the footing shall be placed to the design depth shown on the typical detail plan. Concrete for footings where rock has been excavated, shall fill the entire volume of the excavation to the full depth of footing as designed.

Concrete foundations shall be poured monolithically to grade, except that where the foundation requires a spread footing it may be poured separately and the pedestal then poured to grade. The lower portion of the footing may be poured separately and the pedestal then poured to grade. The lower portion of the footing may be poured against the embankment but the top 6" below finished grade shall be formed.

Anchor bolts shall be set to conform with the base-plate template as furnished in conformance with the typical detail plans.

The top of the foundation shall be properly finished and dressed to assure that full bearing will be provided on the leveling nuts which are to be set in concrete. All exposed edges shall have a 1/2" chamfer. Drain grooves shall be provided as shown on the typical plans.

Backfill for foundations, if required by the Engineer, shall be gravel borrow conforming to the requirements of Subsection M1.03.0 of the Standard Specifications, except that no stone having any dimension greater than 1¼" shall be allowed.

The gravel shall be placed in layers not exceeding 6" in depth before compaction. Each layer of backfill shall be thououghly compacted by use of power tampers to a minimum 95% density. All backfilling and compaction shall be in accordance with the applicable provisions of Subsection 150.64 of these Specifications.

COMPENSATION

840.80 Method of Measurement.

The foundation, excavation, backfilling and compaction for foundations and the structural supports shall be considered as one lump sum unit.

Breakaway P-5 Post Assembly, single or double, complete in place, shall be considered as one unit.

840-81 Basis of Payment.

Compensation for the work done under Items 840 through 846 shall be by the lump sum bid price and compensation for Items 847 and 848 shall be at the contract bid price each for Sign Support (not Guide) and Route Marker including Breakaway Post Assembly.

The contract price shall be full compensation for designing, furnishing and erecting the supports, including construction of the concrete bases, steel reinforcement and anchor bolts; furnishing and installing post assembly and all excavation including Class B Rock, gravel backfill and compensation.

840.82 Payment Items.

840.101 to 840.110	Supports for Overhead Guide Sign (OD-1 thru OD-10) Steel	Lump Sum
841.101 to 841.105	Supports for Guide Sign (D6-1 thru D6-5) Steel	Lump Sum
842.101 to 842.105	Supports for Guide Sign (D9-1 thru D9-5) Steel	Lump Sum
843.101 to 843.105	Supports for Guide Sign (D10-1 thru D10-5) Steel	Lump Sum
844.101 to 844.105	Supports for Guide Sign (G1 thru G5) Steel	Lump Sum
845.1	Supports for Guide Sign (E1-1) Steel	Lump Sum
846.1	Supports for Guide Sign (E1-1) (I) Steel	Lump Sum
847.1	Sign Support (not guide) and Route Marker W/1 Breakaway Post Assembly — Steel	Each
848.1	Sign Support (not guide) and Route Marker W/2 Breakaway Post Assemblies — Steel	Each

SECTION 850
TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

DESCRIPTION

850.20 General.

Work under this Section consists of providing, installing and maintaining various traffic control devices for the protection of the traveling public and working personnel during construction and maintenance operations, and includes channelizing, signs, barricades, markings, lighting devices, and hand signal devices. The design, application, and installation of all devices shall conform to the Massachusetts Manual on Uniform Traffic Control Devices latest edition. Part VI, hereinafter referred to as MUTCD, and/or as directed.

The Contractor shall be responsible for the installation of adequate safety precautions for the protection of the traveling public and his own personnel.

All materials provided by the Contractor under the items of this section shall remain the property of the Contractor upon completion of the project.

All work order this Section shall conform to the approved Traffic Control Plan.

850.21 Safety Controls for Construction Operations.

Safety Controls for Construction Operations consists of furnishing, positioning, repositioning, maintaining and removing, as needed and/or as directed: traffic cones, high level warning devices, delineators, floodlights, Type I and II barricades, portable flashing and steady burning lights, hand signal devices, lanterns, and pilot cars.

850.22 Safety Signing for Construction Operations.

Safety Signing for Construction Operations consists of furnishing, positioning, repositioning, maintaining, and removing as needed and/or as directed: regulartory, warning, and guide signs together with their supports.

Signs over 50 square feet will require approval of design calculations and shop drawings of the breakaway support system where the sign will be unprotected.

850.24 Temporary Pavement Markings and Raised Pavement Markers

Temporary Pavement Markings and Raised Pavement Markers consists of furnishing, applying, maintaining and removing temporary white and/or yellow reflectorized and/or black non reflectorized pavement markings during construction and maintenance operations.

For the purpose of this specification, temporary markings shall mean an effective marking for a period of 90 days.

850.25 Hazard Identification Beacon (Flashing Warning Beacon).

Hazard Identification Beacon (Flashing Warning Beacon) consists of furnishing and installing complete-in-place and in operation, a flashing beacon at a location designated by the Engineer.

850.26 Special Lighting Unit.

Special Lighting Unit consists of providing, operating, and maintaining a portable truck mounted or trailer mounted flashing arrow unit on the project at designated locations.

850.27 Reflectorized Drums.

Reflectorized Drums with or without warning light shall be furnished positioned, repositioned, maintained, and removed as needed and/or directed

850.28 Pavement Marking Removal.

Pavement Marking Removal consists of obliterating existing pavement markings as required and as directed.

850.29 Temporary Precast Concrete Median Barrier.

Temporary Precast Concrete Median Barrier consists of furnishing, installing, maintaining and removing temporary precast concrete median barriers including delineation when positive barriers are needed for traffic control in construction zones.

850.30 Temporary Precast Concrete Median Barrier Removed and Reset

Temporary Precast Concrete Median Barrier Removed and Reset consists of removing temporary precast concrete barrier units from alignments established along the roadway to new alignments as required by the construction and stage construction operations for the control of traffic.

850.31 Portable Breakaway Barricades Type III.

Portable Breakaway Barricades Type III shall be furnished, installed, moved, maintained and removed where indicated on the plans and as directed.

850.32 Temporary 24-inch Anti-Glare Screen (Paddle Type)

Temporary 24 Inch Anti-Glare Screen (Paddle Type) consists of furnishings, installing and maintaining new approved anti-glare screen paddles where indicated on the plans or as directed.

850.33 Temporary Anti-Glare Screen Removed and Reset

This work consists of removing and resetting anti-glare screen where indicated on plans or as directed.

850.34 Temporary Anti-Glare Screen Removed and Stacked

This work consists of removing and stacking anti-glare screen, off the project, as directed.

850.35 Temporary Impact Attenuators and Temporary Impact Attenuators Removed and Reset.

This work consists of installing, maintaining, removing and resetting approved temporary impact attenuators where indicated on the plans or as directed.

MATERIALS

850.40 General

Materials required under this Section need not be new but must be in first class condition and acceptable to the Engineer. Any materials that in the judgment of the Engineer are unsatisfactory in appearance and/or performance shall be removed and immediately replaced by acceptable units.

850.42 Safety Signing for Construction Operations.

Materials shall conform to Section 828 and 840 except the plywood material shall conform to the following: Plywood sign panels and independent Route Markers shall be fabricated from 5 ply 5/8" thick Medium Density Overlaid (MDO) Exterior Type, A-B both sides surface in natural color and the whole conforming with the requirements and tests for the above as set forth in US Product Standard PS1-74 for Construction and Industrial Plywood. All plywood shall bear the grade trade mark of an approved testing agency. The entire sign face shall be reflectorized with reflective sheeting conforming to M9.30.0, Type III.

850.43 Barricades.

The entire area of white and orange stripes shall be reflectorized with reflective sheeting as described under Subsection 850.42. The predominant color for other barricade components shall be white. Wood posts and other incidental materials shall conform to Section M9.

850.44 Temporary Pavement Markings.

Paints, tapes and glass beads used for temporary pavement markings shall conform to Subsections M7.01.07, M7.01.10, M7.01.11, M7.01.14, M7.01.15 and M7.01.16. Other materials which will provide satisfactory durability and reflectivity may be used with prior approval of the Engineer.

The reflectivity of Temporary Pavement Markings material shall be equal to or better than the Department minimum requirements for a period of 90 days.

The minimum reflectivity quality shall be determined by comparing the applied marking to the minimum reflectivity standard which is located at the Commonwealth of Massachusetts Department of Public Works Research and Materials Laboratory in Wellesley. The comparison shall be made with low beam headlights at a distance of 120 feet. Final determination as to pavement marking quality shall be made by the Engineer.

The colors of the marking materials shall be the standard highway colors of white, yellow or black commonly used for pavement markings and as outlined in the MUTCD

Raised pavement markers shall conform to Subsection M9.30.6.

850.45 Hazard Identification Beacon (Flashing Warning Beacon)

Materials shall conform to Section 824. Signal heads shall be 8 inches in diameter. Beacon configuation shall be as follows: Type A contains 2 horizontally mounted yellow lenses. Type B contains 2 vertically mounted yellow lenses. Type C contains 2 horizontally and 2 vertically mounted yellow lenses. Type D contains a single yellow lens.

850.46 Special Lighting Unit (Flashing Arrow)

The unit shall consist of a black background panel meeting the requirements of Massachusetts Manual On Uniform Traffic Control Devices Section 6E-9, Table VI-3 for Type C and shall contain at least 15 #4412A (or equal) amber lamps of approximately 8000 initial maximum candlepower each.

Arrow panels shall have the capability of the following mode selections: (1) left or right flashing or sequential arrows; or (2) left or right sequential chevrons; and (3) double flashing arrows; and (4) caution. The caution mode consists of four or more lamps, arranged in a pattern which will not indicate a direction.

Arrow panels shall automatically provide for a minimum of 50 percent dimming from their rated lamp voltage at night. The flashing rate of the lamps shall not be less than 25 nor more than 40 flashes per minute.

Minimum mounting height should be 7 feet above the roadway to the bottom of the panel, except on vehicle mounted panels which should be as high as practicable.

850.47 Reflectorized Drums

Non-metallic Reflectorized Drums shall conform to Subsection M9.30.9. Newly developed products providing equivalent target value and stability that are acceptable to the Engineer may be used under this item.

Warning lights shall conform to the MUTCD Subsection 6D-5 for Type A or Type C.

All drums shall be maintained in a satisfactory manner including the removal of dirt or road film that cause a reduction in sign reflective efficiency.

850.48 Pavement Marking Removal

Pavement marking removal methods shall not cause damage to the pavement or cause drastic change in texture, which could be construed as delineation at night, and shall be approved by the Engineer.

850.49 Temporary Precast Concrete Median Barrier.

Temporary precast concrete median barriers shall be manufactured in accordance with the plans and Section 629.

The Contractor will be allowed the use of precast barrier he may presently own, providing it meets these specifications and is in good condition.

850.50 Portable Breakaway Barricades Type III.

Portable Breakaway Barricades shall conform to the plans and the following requirements:

1. MUTCD Section 6C-8.

2. Reflectorized sheeting conforming to M9.30.0. Pipe shall be Polyvinyl Chloride (PVC) pressure rated SDR 21 or SDR 26 ASTM D2241. Fittings may be PVC-ASTM D2665 or Acrylonitrile Butadiene Styrene (ABS) ASTM D2661 (Drainage Waste and Vent).

The alternating 6″ wide reflectorized stripes shall be orange and white and shall slope downward at 45° toward the end by which traffic is to pass.

850.51 Temporary 24 Inch Anti-Glare Screen (Paddle Type)

The anti-glare screen (paddle type) shall conform to the requirements or M8.20.3.

CONSTRUCTION METHODS

850.61 Safety Controls for Construction Operations.

All warning devices shall be subject to removal, replacement and/or repositioning as often as necessary.

Cones or non-reflectorized warning devices shall not be left in operating position or on the highway when the days operations have ceased. If it becomes necessary for the Department to remove any construction warning devices or their appurtenances from the project due to negligence by the Contractor, all costs for this work will be charged to the Contractor.

All automotive equipment not protected by cones or drums that is working on a project which is open to traffic shall have one amber flashing light mounted on the cab roof or on the highest practical point of the machinery. The light shall be in operation whenever the equipment is working on the highway and/or traveling in the work area at a speed of 25 MPH or less.

Amber flashers must be visible to both oncoming and overtaking vehicular traffic and shall have a minimum of 32 candlepower and a flashing frequency of 50 to 60 times per minute.

All vehicles excepting passenger cars, which are assigned to the project and which operate at speeds of 25 MPH or less shall have an official SLOW MOVING VEHICLE emblem displayed.

All personnel who are working on the traveled way or breakdown lanes, unless protected by positive barriers such as precast concrete, shall wear Department approved safety vests.

The Contractor shall furnish such vests and maintain a sufficient supply of such at the work site for the Contractor's and Department personnel assigned to the project as well as those visiting the work site.

All vests shall remain the property of the Contractor.

850.62 Safety Signing for Construction Operations.

Signs which are damaged or are missing from their location shall be replaced by the Contractor without additional compensation.

All signs shall be maintained in a satisfactory manner including the removal of dirt or road film that cause a reduction in sign reflective efficiency.

All erected signs not consistent with the use of the roadway shall be removed or covered each day.

850.63 Portable Barricade Type III.

An 8-foot portable barricade shall be constructed in accordance with Construction Standard Drawing 406.1.0 with the following revisions:

The alternating 6" wide reflectorized diagonal stripe shall be orange and white and shall slope downward at 45° toward the end by which traffic is to pass. Barricades that block the passage of traffic or designate the end of the traveled way shall have alternating vertical orange and white stripes on the rails. Portable barricades shall be maintained in good and serviceable condition throughout the project.

Barricades shall be moved from place to place as required during construction and as directed by the Engineer.

850.64 Temporary Pavement Markings.

The Contractor shall provide all necessary temporary pavement markings, temporary raised pavement markers, or both following the completion of each day's operations or prior to opening the roadway to traffic. Temporary raised pavement markers shall be supplemented with tape or painted markings to assure lane delineation. The Contractor will be expected to make all necessary arrangements for this work so that it may be properly coordinated with construction operations.

850.65 Hazard Identification Beacon (Flashing Warning Beacon).

The Contractor shall supply the necessary power and shall be responsible for the maintenance of all devices and appurtenances with no additional compensation other than as provided under the contract unit price.

The beacon shall be mounted separately in a stable position on a suitable support and at an approved height.

When the Engineer determines that its use is no longer required at the given location, the Contractor shall remove the beacon and its appurtenances including power service, and restore the area to an acceptable condition.

850.66 Special Lighting Unit (Flashing Arrow).

The special lighting unit shall be available for immediate use throughout the duration of the project and be positioned at the direction of the Engineer. The unit shall be properly maintained throughout its use on the project.

850.67 Illuminated Portable Barricade.

Construction of the barricades shall be as shown in the latest issue of the Department's Construction Standards and shall include the necessary arrows, lights, flasher mechanism, power supply and all incidental equipment complete in place.

The installation shall be equipped with a flashing mechanism conforming to Subsection 824.41, and 824.42.

The housings for the flashing lights on the illuminated arrow shall have 6" amber lenses. The lights shall have 25 watts lamps with a minimum of 175 initial lumens each.

The Contractor shall provide power or utilize the power supply facilities for highway lighting available, or he shall arrange for the necessary services to the locations of the lighted barricades through the local utility company. Each location shall be provided with a separate service and controlled with a separate flasher.

The weatherproof control cabinets shall be provided and located as directed by the Engineer. These cabinets shall house the flashers and filters and the necessary equipment for shutting off the system.

Installation of all posts and flasher housings shall conform to the relevant requirements of Section 801. The conductors from the flasher mechanism to the electrical service shall be of adequate size to insure operations of the flasher mechanism. A battery operated system will not be acceptable.

Relocating a unit up to 300 feet or reversing the arrow which does not require a new power drop shall be included under this item.

The Contractor shall be responsible for the maintenance of all these devices and appurtenances with no additional compensation therefor, other than as provided under the contract unit price.

850.68 Illuminated Portable Barricade Relocated.

In the course of the construction of the project, it may be necessary for the Contractor to remove and relocate the barricade and appurtenances to location designated by the Engineer so as to coordinate the flow of traffic with the construction operations. A relocation of over 300 feet or one requiring a new power drop will be classified as Illuminated Portable Barricade Relocated.

Care must be used in removing and relocating the barriers, temporary wire and cable connections, pole service connections, meters, flasher mechanism, housing posts and all other appurtenances to retain them in proper position. If required, the direction of arrows shall be reversed.

If the lighted barricade or any of the appurtenances removed and relocated are found defective for any reason, they shall be replaced, restored or repaired with like materials or equipment at the Contractors expense.

850.69 Pavement Marking Removal.

Pavement Markings shall be removed to the fullest extent possible by an approved method. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired by the Contractor at his expense by methods acceptable to the Engineer. Approved methods include but are not limited to:

1. Sand blasting using air or water
2. High pressure water
3. Steam or superheated water
4. Mechanical devices such as grinders, sanders, scrapers, scarifiers and wire brushes.

Painting over a pavement marking line by use of asphaltic liquids or paints will not be permited.

Pavement markings shall be removed before any change is made in the traffic pattern.

Material deposited on the pavement as a result of removing markings shall be removed as the work progresses. Accumulations of sand or other material which might interfere with drainage or could constitute a hazard to traffic will not be permitted.

Where blast cleaning is used for the removal of pavement markings and such removal operation is being performed within 10 feet of a lane occupied by traffic, the residue including dust shall be removed immediately after contact between the sand and the surface being treated. Such removal shall be by a vacuum attachment operating concurrently with the blast cleaning operation, or by other methods approved by the Engineer.

850.70 Temporary Precast Concrete Median Barrier.

The Temporary Precast Concrete Median Barrier shall be installed as shown on the details indicated on the plans, in accordance with these provisions and/or as directed by the Engineer.

Each run, or bay, of temporary precast concrete barrier units shall be fastened together to form a continuous chain.

Delineators shall be installed in conformance with manufacturer's recommendations on the barriers at their terminii; at 20 foot intervals on tangent sections; and 10 foot intervals on curved sections depending on radius as determined by the Engineer.

Delineators mounted on top of barriers separating opposing traffic shall have two sided amber reflectors delineating left edge. Side mounted delineators shall have amber delineating left edge, white delineating right edge and have red as the back color.

Delineators shall be mounted at appropriate angles which provide maximum reflectorization.

Approved temporary impact attenuators with delineation shall be installed at ends of barriers within 30′ of approaching traffic.

The Contractor shall not leave a barrier leading end unprotected.

850.71 Temporary Precast Concrete Median Barrier Removed and Reset.

Temporary Precast Concrete Median Barriers shall be removed from existing locations and reset in accordance with above requirements, as directed.

850.72 Portable Breakaway Barricades Type III.

The Contractor shall furnish, set up, move and remove Portable Breakaway Barricades Type III as required or directed by the Engineer.

Portable Breakaway Barricades Type III shall be maintained in a good and serviceable condition throughout the project and shall be moved from place to place as required during construction and as directed by the Engineer.

850.73 Temporary Anti-Glare Screen (Paddle Type).

The anti-glare screen (paddle type) shall be attached to the barrier in accordance with the manufacturer's recommendations and the following:

1. The paddles shall be installed on top of the barrier at an appropriate angle to eliminate all direct and peripheral glare while eliminating most of the intermittent glare.
2. The overall paddle height for most construction zone applications should be 36″ above the roadway. Unusual deviation from work zone practices involving excess radius and elevations may warrant the increase or decrease in overall height or spacing.
3. The method of attachment will be such that the glare screen units can be easily removed and reinstalled on the barriers.

850.74 Temporary Anti-Glare Screen Removed and Reset.

This work consists of removing temporary glare screen furnished above from the barriers and re-installing it on barriers at new locations. Any glare screen damaged during this work shall be replaced at no additional cost to the Department.

850.75 Temporary Anti-Glare Screen Removed as Stacked.

This work consists of removing and stacking temporary glare screen furnished above, deemed no longer necessary, from the project to locations as directed.

COMPENSATION

850.80 Method of Measurement.

Safety signing for construction operations will be measured by the square foot and the quantity shall be only that which is actually used on the project. Regardless of the number of times that a sign may be reused on the project, it will not be measured for payment more than once.

Each 8 foot section of portable barricade Type III shall be considered as one unit. Each 16 foot section of illuminated portable barricade shall be considered one unit.

Temporary pavement markings shall be measured by the procedure outlined in Subsection 860.80.

Temporary Raised Pavement Markers will be measured by the unit.

Pavement Marking Removal shall be measured by the square foot of pavement marking actually removed.

Temporary Precast Concrete Median Barrier and Temporary Precast Concrete Median Barrier Removed and Reset will be measured by the linear foot.

Each 4 foot section of Portable Breakaway Barrier Type III will be measured as one unit each.

Temporary 24-inch anti-glare screen (paddle type), Temporary Anti-Glare Screen Removed and Reset and Temporary Anti-Glare Screen Removed and Stacked will be measured by the linear foot along the top of the barriers receiving the installation, from ousides of the end paddles for each continuous run.

850.81 Basis of Payment.

The contract prices under these items shall constitute full payment for all material, labor and equipment required or incidental to the satisfactory completion of the work as described above. Any devices provided under this section which are lost, stolen, destroyed or deemed unacceptable while their use is required on the project shall be replaced without additional compensation.

Lump sum payments will be made in equal amounts on each estimate based on the number of months estimated to complete the work.

Payment for Temporary Pavement Markings and Raised Pavement Markers will include full compensation for furnishing, installing, maintaining and removing as specified the markings and markers.

The contract unit price for Hazard Identification Beacon will include full compensation for excavation, backfilling, foundations, conduit, wiring, supports, power service costs, removal and restoration of the area.

The contract unit price for Illuminated Portable Barricades will include full compensation for all charges by utility companies, including service, installation and removal of temporary lines, poles, meters, etc. These same costs incurred at a relocated side will be compensated for under the unit price of Illuminated Portable Barricade Relocated.

Reflectorized Drums, with or without lights, will be paid for at the contract bid price per Drum-Day and Special Lighting Units at the contract bid price per Unit-Day. Payment will be made at the unit bid price for any portion of a day during which these devices were actually used on the project.

Temporary Precast Concrete Median Barrier and Temporary Precast Median Barrier Removed and Reset will be paid for by the linear foot for furnishing, installing, re-aligning, maintaining and removing the temporary median barrier including delineation, as specified above. The Contractor will not be compensated for any work necessary to maintain or re-align units or replace damaged units.

The contract unit price for Temporary Impact Attenuators and Temporary Impact Attenuators Removed and Reset includes full compensation for furnishing, installing, maintaining and removing the attenuators.

Portable Breakaway Barricades Type III will be paid for by the unit price each which shall constitute full payment for all material, labor and equipment necessary to furnish, install, maintain, move and remove the barricades.

Temporary 24-inch anti-glare screen (paddle type), Temporary Anti-Glare Screen Removed and Reset, and Temporary Anti-Glare Screen Removed and Stacked will be paid for by the linear foot, which price will include full compensation for all labor, materials and equipment to complete installations and removal. The anti-glare screen shall remain the property of the Department upon completion of project.

850.82 Payment Items.

851.	Safety Controls for Construction Operations	Lump Sum
852.	Safety Signing for Construction Operations	Square Foot
853.	Portable Barricade Type III	Each
853.1	Portable Breakaway Barricade Type III	Each
853.2	Temporary Precast Concrete Median Barrier	Linear Foot
853.21	Temporary Precast Concrete Median Barrier Removed and Reset	Linear Foot
853.4	Temporary Impact Attenuator	Each
853.41	Temporary Impact Attenuator Removed and Reset	Each
853.5	Temporary 24-Inch Anti-Glare Screen (Paddle Type)	Linear Foot
853.6	Temporary Anti-Glare Screen Removed and Reset	Linear Foot
853.7	Temporary Anti-Glare Screen Removed and Stacked	Linear Foot
854.	Temporary Raised Pavement Markers	Each
854.014	Temporary Pavement Markings — 4 In. (Painted)	Linear Foot
854.016	Temporary Pavement Markings — 6 In. (Painted	Linear Foot
854.024	Temporary Pavement Markings — 4 In. (Non-Removable Tape)	Linear Foot
854.026	Temporary Pavement Markings — 6 In. (Non-Removable Tape)	Linear Foot
854.034	Temporary Pavement Markings — 4 In. (Removable Tape)	Linear Foot
854.036	Temporary Pavement Markings — 6 In. (Removable Tape)	Linear Foot
854.1	Pavement Marking Removal — Paint	Square Foot
854.2	Pavement Marking Removal — Thermosplastic	Square Foot
854.3	Pavement Marking Removal — Tape	Square Foot
855.1	Hazard Identification Beacon Type B	Each
855.2	Hazard Identification Beacon Type D	Each

856.	Special Lighting Unit (Flashing Arrow)	Unit-Day
857.	Illuminated Portable Barricade	Each
858.	Illuminated Portable Barricade Relocated	Each
859.	Reflectorized Drum	Drum-Day
859.1	Reflectorized Drum with Flasher (Type A)	Drum-Day
859.2	Reflectorized Drum with Light (Type C)	Drum-Day

SECTION 860
REFLECTORIZED PAVEMENT MARKINGS

DESCRIPTION

860.20 General.

This item of work consists of furnishing materials and the application of Reflectorized Pavement Markings in accordance with the Commonwealth of Massachusetts, Department of Public Works, Manual on Uniform Traffic Control Devices, current edition.

MATERIALS

860.40 General.

Materials shall be as specified under the particular payment item being used and shall meet the appropriate requirements specified in the following Subsections of Division III, Materials:

General Requirements for Paints and Protective Coatings	M7.00.00
White Thermoplastic Reflectorized Pavement Markings	M7.01.03
Yellow Thermoplastic Reflectorized Pavement Markings	M7.01.04
White Traffic Paint	M7.01.05
Yellow Traffic Paint	M7.01.06
Glass Beads	M7.01.07
White High Heat Rapid Drying Traffic Marking Material	M7.01.08
Yellow High Heat Rapid Drying Traffic Marking Material	M7.01.09
Fast Drying White Traffic Paint	M7.01.10
Fast Drying Yellow Traffic Paint	M7.01.11
Striping Powder	M7.01.12
Preformed Permanent Plastic Pavement Markings or Legends	M7.01.18
Thermoplastic Pavement Marking Compound, Alkyd	M7.01.20
Green Pavement Coatings	M7.01.21

CONSTRUCTION METHODS

860.60 Equipment.

All equipment used for the application of pavement markings shall be of standard commercial manufacture. All other equipment and devices necessary for the application of the pavement markings and protection thereof and for the protection to the traveling public shall be as usually required for work of this type and shall be furnished by the Contractor.

The pavement marking equipment shall be operated at the speed and in accordance with other requirements of the manufacturer, unless otherwise directed by the Engineer.

Truck mounted equipment is approved for the application of pavement markings except in such cases where in the Engineer's judgment travel will be unreasonably delayed and/or the quality of the work performed by the machine is unsatisfactory.

860.61 Layout of Work.

A schedule of pavement marking operations shall be furnished by the Contractor for the approval of the Engineer prior to the application of any pavement markings. This schedule must be in the office of the Engineer 7 days prior to the proposed date of application of any pavement markings.

The Engineer will provide at a convenient location on the roadway a line of reference for use by the Contractor in establishing the location of markings. The line of reference shall be at a maximum of 50 foot intervals by means deemed satisfactory by the Engineer. All markings shall follow the line of reference without deviation. Any line deviating from the establishing control of incorrect width shall be reapplied, as directed by the Engineer in accordance with Subsection 860.62.

860.62 Application of Markings.

Pavement markings shall be applied as follows:

Material	Material Application Temperature	Line Thickness	Reflectorized Bead Application
M7.01.05	115 °F-125 °F	15 mils	6 lbs/gal
M7.01.06	115 °F-125 °F	15 mils	6 lbs/gal
M7.01.08	180 °F-195 °F	15 mils	6 lbs/gal
M7.01.09	180 °F-195 °F	15 mils	6 lbs/gal
M7.01.10	40 °F-120 °F	15 mils	6 lbs/gal
M7.01.11	40 °F-120 °F	15 mils	6 lbs/gal
M7.01.03	400 °F-425 °F	128-188 mils	1 #/10 SF Drop on
M7.01.04	400 °F-425 °F	125-188 mils	1 #/10 SF Drop on

No thinners shall be used for the above listed pavement marking applications except in accordance with the manufacturer's specifications and at the direction of the Engineer.

No paint or pavement marking material shall be heated above the temperature marked on the container.

Markings shall be applied only in seasonable weather and in accordance with good painting practices. The surface shall be dry and free of sand, grease, oil or other foreign substances prior to the application. The Contractor shall prepare the surface to accept the application as part of this item, with no additional compensation. The Engineer will make the final determination for all of the foregoing.

Bituminous concrete pavements shall have been in place for 48 hours prior to the application of pavement markings except preformed permanent plastic pavement markings which can be applied immediately. When it is necessary to expedite the flow of traffic, the Engineer may reduce the waiting period as is deemed necessary.

If for any reason material is spilled or tracked on the highway, or any markings applied by the Contractor, in the Engineer's judgment, fail to conform to Subsection 860.61, because of a deviation from the desired pattern, the Contractor shall remove such material by a method that is not injurious to the roadway surface and is acceptable to the Engineer, clean the roadway surface and prepare the surface for a reapplication of markings and reapply the markings as directed without additional compensation for any of the foregoing corrective operations.

The ambient (air) temperature for thermoplastic application is to be a minimum of 45 °F and rising at the time of marking operations. If work has started and air temperatures fall below 45 °F and continuous cooling is indicated, work shall be stopped. In cool weather conditions, temporary drops down to 40 °F will be tolerated, providing temperatures also vary upwards. Sustained striping (greater than one hour) at 40 °F shall not be allowed. Starting work at air temperatures lower than 45 °F shall not be allowed.

860.63 Protection of Markings.

Markings shall remain protected until sufficiently dry to bear traffic on highways that are open to traffic. Markings shall be protected by traffic cones of not less than 28" in height except in the case of markings which cure to a no track condition in 180 seconds or less in the latter case protection may be provided by a convoy of vehicles with suitable warning devices to warn overtaking or on coming traffic that the pavement marking operation is in progress.

A. Broken Lines.

On tangents and on curves of 1000 foot radius or greater at least 1 cone shall be placed on every other bar. On curves of less than 1000 foot radius 1 cone shall be placed on every bar unless otherwise directed by the Engineer.

B. Solid Lines.

On tangents and on curves of 1000 foot radius or greater, cones shall be spaced not over 80 feet apart and on curves of less than 1000 foot radius the spacing shall be not over 50 feet unless otherwise directed by the Engineer. On edge line adjacent to the median wider spacing may be used at the direction of the Engineer. In order to control the proper positioning of the cones during the drying period, the Contractor shall assign sufficient personnel as determined by the Engineer. Such control is dependent on traffic density, cone widths, etc.

860.64 Accommodation of Traffic.

All warning signs and traffic control devices as required shall be in accordance with Section 850 of these Specifications.

No work shall be done on this item on roadways open to traffic on Saturdays, Sundays, the day before a holiday or on a holiday except when otherwise specifically directed by the Engineer.

Both lanes of two-lane highways shall remain open to traffic at all times. On multi-lane highways only one lane shall be closed to traffic at any time.

Work under this item may be suspended, at the discretion of the Engineer, during peak traffic hours or at any other time when, in his judgment, traffic is being unduly hampered or delayed by the work, under this item.

COMPENSATION

860.80 Method of Measurement.

Markings are to be paid for on the actual length of lines applied under the various items of the Contract. The lengths of solid lines will be obtained by:

1. Calculation from established base line stations or
2. Use of a measuring wheel or
3. Vehicle odometer readings.

The length of broken lines (except for broken lines less than 10 feet, the actual length shall be used) will be obtained by using 1/4 of the results obtained above for solid lines. Patterns, other than lines, are to be paid for by the square foot area under the item in the Contract.

860.81 Basis of Payment.

The work under these items will be paid for at the contract unit price under each item of the Contract based on the measurements as determined by the Engineer.

The contract prices shall include all material, labor, and equipment required or incidental to the satisfactory completion of the work.

860.82 Payment Items.

860.04-860.12	*— inch reflectorized white line (painted)	Linear Foot
861.04-861.12	*— inch reflectorized yellow line (painted)	Linear Foot
	* (4 In.-12 In.)	
864.00	Pavement arrow reflectorized white (painted)	Square Foot
864.01	Pavement arrow and legends reflectorized white tape (inlay)	Square Foot
864.02	Pavement arrow and legends (surface applied tape)	Square Foot
866.04-866.12	* — inch reflectorized white line (thermoplastic)	Linear Foot
867.04-867.12	* — inch reflectorized yellow line (thermoplastic)	Linear Foot
	* (4 In.-12 In.)	
870.04	4 In. white reflective tape (inlay)	Linear Foot
871.04	4 In. yellow reflective tape (inlay)	Linear Foot
872.04	4 In. white reflective tape (surface applied)	Linear Foot
873.04	4 In. yellow reflective tape (surface applied)	Linear Foot

SECTION 900
STRUCTURES

SECTION 901
CEMENT CONCRETE MASONRY

DESCRIPTION

901.20 General.

Cement concrete masonry with or without reinforcement as required for bridges, culverts, walls, steps, drop inlets and other work shall be constructed to the designs and dimensions indicated on the plans or as directed and to close conformity with the lines and grades established by the Engineer.

Where necessary, at the direction of the Engineer, the dimensions or design may be adjusted to fit foundation, slope or construction conditions as encountered.

MATERIALS

901.40 Materials

Materials shall meet the requirements specified in the following Subsections of Division III. Materials:

Cement Concrete	M4.02.00
Latex Modified Mortar and Concrete Overlayments	M4.07.0
Reinforcing Steel	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Stay-in-Place Bridge Deck Form	M8.21.0
Preformed Expansion Joint Filler	M9.14.0
Preformed Bituminous Fiber Joint Filler	M3.05.3
Preformed Compression Joint Seals (Bridges)	M9.14.1
Polyurethane Joint Sealer (Flow Type)	M9.14.3
Polyurethane Joint Sealer (Non-Sag Type)	M9.14.4
Plastic Water Stops	M9.07.0
Shear Connectors	M8.04.1
Curing Materials	
Impervious Liquid Membrane	M9.06.5
Waterproof Paper	M9.06.0
Burlap	M9.06.3
White Polyethylene for Curing	M9.06.1B
Polyethylene Coated Burlap	M9.06.4
Concrete Penetrant/Sealer	M9.15.0

For any project using 500 cubic yards or more of cement concrete, the Contractor shall supply to the project for the use of the Engineer the following equipment as an incidental item, if not already provided for in a previous section.

1. Concrete cylinder molds, 6″ diameter by 12″ high, meeting the requirements of AASHTO M-205.
2. One complete slump test set meeting the requirements of AASHTO T-119 consisting of one each of the following:
   a. slump cone (AASHTO T-119)
   b. tamping rod (AASHTO T-119)
   c. sheet metal pan 24″ × 24″ × 3″
   d. cement mold brush
   e. large scoop
   f. mixing trowel
3. One air meter meeting the requirements of AASHTO T-152, Type B.
4. One concrete curing box-Curamold (LA-1300-1).
5. Two 14 quart heavy duty buckets.

CONSTRUCTION METHODS

901.60 Forms.

Approved centers and forms shall be provided by the Contractor. Piles shall be used for falsework if required by the Engineer. No extra compensation for falsework or falsework piling shall be allowed, such work being considered part of the form work. Falsework shall be set to give the structural camber indicated on the plans or as specified, plus allowance for shrinkage, shortening under load or settlement. Forms, falsework and centering shall be designed for a liquid head, equal to the maximum height of the liquid concrete in the forms for various placing conditions assuming the weight of the liquid concrete at 150 pounds per cubic foot, and in addition thereto a live load allowance of 50 pounds per square foot on horizontal surfaces.

When not otherwise specified on the plans, or in the special provisions, forms for all exposed portions of bridges and structures shall be lined with approved material, or form sheathing which shall consist of five-ply water-proof plywood, approved metal sheathing or other approved material in order to give the concrete a smooth even finish, and uniform appearance.

This requirement shall not apply to the underside of the deck of a bridge over a waterway, the underside of a bridge over a railroad, or any part of a structure that will be at least 2 feet below the surface of adjacent ground in the completed project. Any material that will provide tight forms will be acceptable for such locations.

Full sheets of plywood or other approved material shall be used wherever possible and shall be placed in a regular pattern. The use of small pieces and leftovers will not be permitted except as they may be needed to complete the design. Forms in good condition may be reused, but forms for any one exposed face shall be all new or all used material and a mixture of old and new forms will not be permitted. Forms for cylindrical pier columns shall be smooth and reasonably free of joints.

The sheathing shall be jointed tightly to prevent leakage from the mix and it shall be of sufficient strength to hold the concrete without bulging between supports. Forms shall be properly braced and tied so as to maintain proper dimensions. Bolts, rods or other satisfactory form ties shall be used for internal ties. Wire ties will not be permitted except when directed or where concrete is not exposed to view. The Engineer may require the Contractor to employ screw jacks or hard wood wedges in connection with the centering of falsework in order to take up any distortion or settlement in the form work either before or during the placing of the concrete.

Approved inserts shall be used in connection with all ties in the region of exposed surfaces of the concrete. They shall be so designed as to permit their removal from the concrete without injury to the concrete, and the metal remaining in the concrete shall be not closer than 1 ½ inches to the surface. The inserts shall be truly round, not more than 1 ½ inches in outside diameter and shall be treated with nonstaining mineral oil or other satisfactory material adequate for preventing any adherence to surrounding concrete. Special tools and methods shall be used to remove the inserts from the concrete in a manner to prevent damage to the concrete.

Form ties of a design with a weakened section 1 ½ inches back from the concrete face may be used at places of minor pressure when permitted by the Engineer, but such ties shall be provided with special inserts so as to assure the breaking off of the ties at the proper depth inside the face of the concrete. When such ties fail to break off at the designed depth, the tie metal shall be drilled out before the tie hole is patched.

The use of wooden struts within forms; or of metal ties without approved inserts, as required, will not be permitted.

The centers shall be true to the lines, satisfactorily supported and firmly secured. They shall remain in place as long as directed and shall be replaced with new ones if they lose their proper dimensions and shape.

Forms for the roadway deck slabs shall be so constructed that under full dead load, the thickness of the slabs shall be the required thickness shown on the plans and the surface of the pavement will accurately conform to the profile grades, cross sections and alignment shown on the plans. Allowance shall be made for the camber of the floor members as erected and for the additional dead load deflections of the floor members.

Slab haunches shall be provided over steel girders, floor beams and stringers. The depth of haunches shall be variable as required to maintain the uniform thickness of slab between the steel supports.

All exposed edges and corners of concrete not otherwise specified on the plans shall be formed with a wooden triangular 45° chamfer strip 3/4 inch on the sqaure sides. These triangular chamfer strips shall be machine surfaced on all sides and shall be of uniform dimensions throughout the project. Any chamfered or beveled corners of conrete specified on the plans of larger size, shall be formed and finished as required for other parts of the adjacent forms.

Where rustications are called for on the plans, as for abutments and wingwalls, the moldings for rustications shall be machine surfaced on all sides true to line, plans and dimensions in accordance with the full sized detail. The moldings shall be fastened to the forms in such a manner that the moldings will remain in the concrete

when the forms are removed. These moldings shall not be removed until the concrete has hardened sufficiently so that the edges of the concrete adjacent to the moldings shall not be damaged.

Bridge bearing anchor bolts in piers shall be set accurately by template prior to placing concrete. Anchor bolts in abutments may be set by template or by drilling and grouting. Grout shall be a non-shrinking type.

The shape, strength, rigidity, water-tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber must be resized before being used. Forms which are unsatisfactory in any respect shall not be used and shall be removed immediately from the work.

The inside of forms shall be coated with non-staining mineral oil or other approved material to prevent adherence of the concrete to the forms, immediately before placing the concrete. When oil is used, it shall be applied before the reinforcing steel is placed. Any material which will adhere to, discolor or affect the concrete in any manner shall not be used. Forms for bridge decks shall not be oiled but shall be dampened with water ahead of concrete placement.

In the construction of copings, railings and other intricate sections, extreme care shall be taken in the construction to insure true lines.

Prior to placing concrete in the forms all foreign matter and any extraneous materials shall be removed.

Forms shall be inspected immediately preceeding and during the placing of the concrete. All dimensions shall be checked carefully and any errors, bulges, warping or other defects shall be remedied before any concrete is placed.

Temporary openings shall be provided for inspection at the base of column and wall forms and near the bottom of all deep members.

The foregoing specifications for forms as regards design, mortar-tightness, chamfers or moldings, bracing, alignment, treatment by coating with oil or other approved material, removing and reuse, shall apply to metal forms when such forms are approved for use. The metal forms used shall be of such strength that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or which do not line up properly shall not be used. Special care shall be exercised to keep metal forms free from rust, grease or other foreign matter that will tend to discolor the concrete. Metal forms shall be provided with an adjustable metal section or occasional sections where wooden forms may be inserted to compensate for slight inaccuracies in measurement.

Removable or stay-in-place forms for bridge decks may be used as alternates except in hazardous locations where stay-in-place forms shall be used. Hazardous locations are defined as high volume roadways and all railroads under the bridge.

Removable forms shall be used for forming end diaphrams, bays with longitudinal construction joints, and overhanging portions of decks.

Material to prevent concrete from adhering to the forms shall not be used when stay-in-place forms are used.

Design of Permanent Steel Bridge Deck Forms

The following criteria shall govern the design of permanent steel bridge deck form:

1. The steel forms shall be designed on the basis of dead load of form, reinforcement and plastic concrete plus 50 pounds per square foot for construction loads. The unit working stress in the steel sheets shall not be more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 pounds per square inch.

2. Deflection under the weight of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or 1/2 inch whichever is less, but in no case shall this loading be less than 120 PSF total.

The permissable form camber shall be based on the actual dead load condition. Camber shall not be used to compensate for deflection in excess of the foregoing limits.

3. The design span of the form sheets shall be the clear span of the form plus 2 inches measured parallel to the form flutes.

4. Physical design properties shall be computed in accordance with requirements of the American Iron and Steel Institute Specification for the Design of Cold Formed Steel Structural Members, latest published edition.

5. All reinforcement shall have minimum concrete cover of 1 inch.

6. The plan dimensions of both layers of primary deck reinforcement from the top surface of the conrete deck shall be maintained.

7. Permanent steel bridge deck form shall not be considered as lateral bracing for compression flanges of supporting structural members.

8. Permanent steel bridge deck form shall not be used in panels where longitudinal deck construction joints are located between stringers.

9. Welding shall not be permitted to flanges in tension or to structural steel bridge elements fabricated from non-weldable grades of steel.

10. Fabricators shop and erection drawings shall be submitted to the Engineer for approval. These plans shall indicate the grade of steel bridge deck form sheets and a clear indication of locations where the forms are supported by steel beam flanges subject to tensile stresses.

All forms shall be installed in accordance with approved fabrication and erection plans.

Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1 inch at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. All attachments shall be made by permissable welds, bolts, clips of other approved means. However, welding of form supports to flanges of steels not considered weldable and to portions of flange subject to tensile stresses shall not be permitted. Welding and welds shall be in accordance with the provisions of AWS D2.0 pertaining to fillet welds except that 1/8 inch fillet welds will be permitted.

Any permanently exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned, wire brushed and painted with two coats of zinc oxide-zinc dust primer, Federal Specification TT-P-64 ld, Type II, no color added, to the satisfaction of the Engineer. Minor heat discoloration in areas of welds need not be touched up.

The Contractor's method of construction should be carefully observed during all phases of the construction of the bridge deck slab. These phases include installation of the metal forms; location and fastening of the reinforcement; composition of concrete items; mixing procedures, concrete placement and vibration; and finishing of the bridge deck. Should the Engineer determine that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, the Contractor shall remove at least one section of the forms at a location and time selected by the Engineer for each span in the contract. This should be done as soon after placing the concrete as practicable in order to provide visual evidence that the concrete mix and the Contractor's procedures are obtaining the desired results. An additional section shall be removed if the Engineer determines that there has been any change in the concrete mix or in the Contractor's procedures warranting additional inspection.

After the deck concrete has been in place for a minimum period of 2 days, the concrete shall be tested for soundness and bonding of the forms by sounding with a hammer as directed by the Engineer. If areas of doubtful soundness are disclosed by this procedure, the Contractor will be required to remove the forms from such areas for visual inspection after the pour has attained adequate strength. This removal of the permanent steel bridge deck forms shall be at no cost to the project. At locations where sections of the forms are removed, the Contractor will not be required to replace the forms, but the adjacent metal forms and supports shall be repaired to present a neat appearance and assure their satisfactory retention. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombing and other defects. If irregularities do not justify rejection of the work, the concrete shall be repaired as the Engineer may direct and shall be given an Ordinary Surface Finish, in accordance with the contract specifications. If the concrete where the form is removed is unsatisfactory, additional forms, as necessary, shall be removed to inspect and repair the slab, and the Contractor's methods of construction shall be modified as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed or repaired as directed by the Engineer.

The amount of sounding and form removal may be moderated, at the Engineer's discretion, after a substantial amount of slab has been constructed and inspected, if the Contractor's methods of construction and the results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slabs.

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedure.

901.61 Reinforcement.

The Contractor shall submit for approval detailed plans and schedules of the bar reinforcements so that the reinforcement may be properly placed and its weight readily computed. If impracticable to obtain or use bars of the full length required, bars shall be lapped 24 diameters to make a splice except that main reinforcing bars near the top of slabs and beams having more than 12 inches of concrete under the bars shall be lapped 35 diameters.

The steel shall be bent in the shop true to templates and shall be placed accurately as shown on the plans with the following tolerance:

1. Cover (clearance from face of concrete to bar) $\pm$ 1/4 inch.

2. Horizontal spacing of bars ±2 inches (however the required number of bars must be placed). The minimum spacing cannot be decreased. The reinforcement shall be placed so as to insure its remaining in the correct position during the placing and hardening of the concrete. No splicing shall be at points of maximum stress and the clear distances between spliced bars shall not be less than 1½ times the nominal diameter of the bars, 1½ times the maximum size of the coarse aggregate, nor less than 1½ inches.

The required distance between reinforcing steel and the forms shall be maintained by means of stays, blocks, ties, hangers or other approved supports. The spacing of reinforcing supports shall not exceed four feet.

Steel reinforcing mats shall be firmly secured against displacement by tying every other intersection point with a maximum of twelve (12) inches between tied joints. In addition, steel reinforcing mats (top and bottom) shall be securely connected together so that uniform vertical spacing can be maintained throughout. This connection may be accomplished by tying with coated tie wires or other means as approved by the Engineer. Connections shall be placed no farther apart than 4'-0" o.c. Support devices may be utilized for this purpose. Connection devices shall neither deflect the steel reinforcing nor interfere with the smooth flow of concrete.

Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Blocks for spacing reinforcing bars shall also be precast mortar blocks of approved designs and short enough to permit their ends to be adequately covered with concrete. The precast mortar blocks shall be made from the same materials and of the same proportions of sand and cement as that of the concrete in which they are to be used. They shall be cast and properly cured before use and shall have a wire of copper or other non-rusting metal or other approved device cast into each block suitably placed so that the block can be securely fastened to the reinforcement. Layers of bars shall be separated by such blocks, which may be reinforced, and which shall have slots to receive the bars and hold them in place, or by other approved means. Any parts of metal supports that are left in place within 3 inches of an exposed surface of the concrete shall be non-rusting metal or coated with non-rusting metal. Galvanizing of such parts will be acceptable provided the weight of the zinc coating per square foot of actual surface shall average not less than 2 ounces, and no individual specimen shall show less than 1.8 ounces. The use of pebbles, pieces of broken stone, metal pipe or wooden blocks will not be permitted.

Reinforcement in any member or section shall be in place and approved by the Engineer before the placing of concrete begins. In no case shall reinforcing steel be driven or forced into the concrete after it has taken its initial set; and any reinforced concrete placed in violation of this provision will be rejected by the Engineer, and then shall be removed and replaced by the Contractor entirely at his own expense.

When wire mesh is used as reinforcement, it shall be furnished and placed in accordance with the plans. If the wire mesh is shipped in rolls, it shall be straightened into flat sheets before being used.

Dowels, where required, shall be furnished and placed as indicated on the plans and as directed.

Reinforcement that extends continuously within the concrete of the superstructure and the concrete of the superstructure, or any other reinforcement that might stain the exposed surface of the bridge shall be given a light coat of neat cement grout on the surfaces of the reinforcement that will be exposed for more than three weeks before being encased in concrete. Subsequent coats of grout may be required.

901.62 Anchors.

Bent plate edging, steel curbing, expansion dams at back of parapet and fixed dam assemblies shall be anchored to the concrete by use of headed anchors. Headed anchors shall conform to the requirements of stud shear connectors.

901.63 Partition Tile.

The tile under the sidewalk above the bridge deck slab shall be light weight hollow partition tile. The blocks shall be closely butted. The end blocks shall be left open at the lower end of the sidewalk.

901.64 Shear Connectors.

All shear connections shall be the stud reinforcement type and the following requirements shall apply:

A. Stud shear connectors shall be end welded to steel beams or girders with automatically timed stud welding equipment connected to a suitable power source.

B. If two or more stud welding guns are to be operated from the same power source, they shall be interlocked so that only one gun can operate at a time and so that the power source has fully recovered from making one weld before another weld is started. The power source shall be adequate to meet the requirements of the size of stud being welded.

C. At the time of welding, the studs shall be free from any rust, rust pits, scale, oil or other deleterious matter which would adversely affect the welding operation.

D. Welding shall not be done when the base metal temperature is below 0 °F, or when the surface is wet or exposed to rain or snow.

E. While in operation the welding gun shall be held in position without movement until the welded metal has solidified.

F. When necessary to obtain satisfactory welds, the areas on the beam or girder to which the studs are to be welded shall be wire-brushed, peened, prick-punched, or ground free of scale or rust.

G. Longitudinal and lateral spacings of studs with respect to each other and to edges of beam or girder flanges shall not vary more than one-half inch from the dimension shown on the plans except that a variation of 1 inch will be permitted where required to avoid obstruction with other attachments on the beam or where a new stud is being welded to replace a defective one. The minimum distance from the edge of a stud to the edge of a beam shall be 1 inch, but preferably not less than 1½ inches.

H. The first two studs welded on each beam or girder, after being allowed to cool, shall be bent 45° by striking the stud with a hammer. If failure occurs in the weld of either stud, the procedure shall be corrected and two successive studs successfully welded and tested before any more studs are welded to the beam or girder. The Engineer shall be promptly informed of any changes in the welding procedure at any time during construction.

I. When the temperature of the base metal is below 32 °F, one stud in each 100 studs welded shall be bent 45° in addition to the first two bent as specified in H above.

J. Studs on which a full 360° weld is not obtained may, at the option of the Contractor, be repaired by adding a 3/16″ fillet weld in place of the lack of weld, using the shielded metal-arc process with low-hydrogen welding electrodes.

K. If the reduction in the height of studs as they are welded become less than normal, welding shall be stopped immediately and not resumed until the cause has been corrected.

L. Before welding a new stud where a defective one has been removed, the area shall be ground smooth and flush, or in the case of a pullout of metal, the pocket shall be filled with weld metal using the shielded metal-arc process with low-hydrogen welding electrodes and then ground flush. In compression areas of flanges, a new stud may be welded adjacent to the defective area in lieu of repair and replacement on existing weld area. (See G above.)

M. Inspection Requirements.

1. If visual inspection reveals any stud which does not show a full 360° weld, any stud which has been repaired by welding, or any stud in which the reduction in height due to welding is less than normal, such stud shall be struck with a hammer and bent 15° off the vertical. For studs showing less than 360° weld, the direction of bending shall be opposite to the lack of weld. Studs that crack either in the weld or the shank shall be replaced.
2. The Engineer, at his option, may select additional studs to be subjected to the bend test specified above.
3. The studs tested that show no signs of failure may be left in the bent position.
4. If during the progress of the work, inspection and testing indicates in the judgment of the Engineer that the shear connectors being obtained are not satisfactory, the Contractor will be required at his expense to make such changes in welding procedure, welding equipment and type of shear connector as necessary to secure satisfactory results.

901.65 Handling and Placing Concrete.

The Contractor shall notify the Engineer at least 24 hours in advance of his intention to place concrete.

All concrete shall be placed during daylight, and the placing of concrete shall not be started unless it can be completed and finished during daylight hours, except that when an adequate and approved lighting system is provided beforehand, the Engineer may waive this requirement.

No concrete shall be placed in a bridge or other structure where piles are required until all piles in the structure have been driven, unless otherwise directed by the Engineer. However, the placing of concrete in the steel shells for cast-in-place concrete piles and steel pipe piles shall be done as specified in Subsection 940.69.

No concrete shall be placed until the depth, character and water conditions of the foundations, the adequacy of falsework and forms, the absence of debris in the forms, the condition of the construction joints, and the condition and spacing of the reinforcing steel have been inspected and approved by the Engineer.

The placing of concrete shall be so regulated that the pressures caused by the wet concrete shall not cause distortion or movement of the forms.

The operation of handling and placing the concrete shall be conducted so as to form an artificial stone of maximum density and impermeability and of uniform texture which shall show smooth surfaces when the forms are removed.

Concrete shall be deposited in such manner that the total deflection or settlement of supporting members and the final finishing of the surface shall have occurred before initial set of the concrete takes place. An approved admixture shall be used as necessary to retard setting.

Calcium Chloride or any other admixture containing chloride salts shall not be used in the concrete placed on permanent steel deck forms.

A. Transportation.

The concrete shall be transported from the mixer and placed in the forms by a method which will permit handling concrete of the slump required without segregation. Buggies and wheelbarrows used for this purpose shall be equipped with pneumatic tires. Chutes may be used but the use of long chutes will be permitted only on authority from the Engineer. If such conveyors are allowed and the quality of the concrete as it reaches the forms or the methods of placing or working it therein are not satisfactory, the Engineer may order their use discontinued and the substitution of a satisfactory method of placing. Chutes shall be metal or metal lined, inclined so as to have a slope of between 2 and 3 horizontally to 1 vertically; and shall extend as nearly as possible to the point of placing concrete. Long chutes shall be provided with reverse flow or remixing hoppers in order to correct for segregation. All chutes shall be kept clean and free from coatings of hardened concrete.

Transportation of concrete by pumping will be permitted provided that the required slump and air content can be maintained at the discharge end of the hose and there is no adverse effect to the mix design. The equipment shall be suitable in kind and adequate in capability for the work. The operation shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline shall be ejected in such a manner there will be no separation of the ingredients.

Pumping through aluminum piping will not be permitted.

At the conclusion of placement, the entire equipment shall be thoroughly cleaned.

B. Depositing.

The concrete shall be placed in the form in the approved manner to prevent stone pockets, voids or segregation and to reduce rehandling and flowing in the forms to a minimum. The concrete shall not be dropped more than 3 feet or dragged more than 10 feet in the forms. Points of deposit shall be spaced not more than 20 feet apart nor more than 10 feet from the ends of the forms. Concrete shall be properly distributed in the forms by hand shoveling. The forms shall be filled at a rate of 1 to 3 feet in depth per hour unless an alternate form design is submitted and approved by the Engineer. Care shall be taken to avoid splashing the forms and reinforcing above the level of the concrete as placed. Beams and slabs shall be placed in one continuous operation.

C. Consolidation.

Each layer shall be thoroughly consolidated by rodding and vibration. The face of the forms shall be carefully spaded, if possible, to bring a dense mortar to the face, and produce a good finish.

All concrete for masonry structures, unless otherwise directed, shall be compacted by means of approved mechanical vibrators operated within the mass of the concrete. The Contractor shall provide approved methods of vibration to fully consolidate the mix. Vibrators shall be of internal type of standard make and approved capacity, and shall be capable of transmitting vibrations of the concrete at frequencies of not less than 4500 impulses per minute.

Vibration of forms or reinforcing shall not be permitted except where internal vibration is not practicable and then only with the approval of the Engineer.

The vibrator shall be applied directly to the mass at the point and time of deposit and moved throughout the mass continuously from point to point in the mix using care to avoid over vibration, causing segregations, over finished surface and excess water gain. Vibrators shall not be used close to the forms.

When concrete is placed in lifts, vibrators shall be inserted into at least half the depth of the underlying lift so to thoroughly consolidate the two lifts into an integral mass without streaks or hardened lift lines. Vibrators shall not be used to move concrete in the forms.

A sufficient number of vibrators shall be provided to obtain proper compaction in accordance with the rate of deposit.

Extreme care shall be taken to prevent penetrating or disturbing previously placed concrete which has become partially set.

D. Placing Concrete Under Water.

Concrete may be deposited in water only when provided by the plans or in the Special Provisions or by approval in writing by the Engineer; and only under the direct supervision of the Engineer.

The concrete shall be of the class required except that an additional 10 percent of cement shall be added to all concrete deposited under water except that mass concrete shall be placed with the cement content required by Special Provisions.

The method and equipment to be used shall be approved by the Engineer before work is begun.

Concrete deposited under water shall be carefully placed in a compacted mass in its final position and shall not be distrubed after being deposited. Special care must be taken to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be watertight. The consistency of the concrete shall be carefully regulated and special care shall be taken to prevent segregation of the materials. The concrete shall be distributed uniformly over the entire area between forms in order to maintain a level surface.

The work shall be carried out in a continuous operation and with sufficient rapidity to prevent the formation of layers or inclined seams. Concrete shall not be placed in water having a temperature below 35 °F. Pumping of water will not be permitted while the concrete is being deposited nor before it is sufficiently hardened.

One of the following methods may be used:

1. Bottom Dump Bucket.

The bucket shall be open top type and have a capacity of not less than one cubic yard, and shall also be of a type that cannot be dumped until it rests on the surface on which the concrete is to be deposited. The bottom doors, when tripped, shall open freely downward and outward. The bucket shall be filled to strike-off capacity and shall be slowly lowered to avoid back wash. It shall then be raised very slowly as the concrete is discharged, only to the height necessary to permit emptying of the bucket, after which the bucket shall be slowly withdrawn to well above the surface of the water, in order to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture. The bottom dump bucket shall not be used in a pile footing or where deposited through reinforcing steel.

2. Tremie.

The tremie shall be watertight, consisting of a tube constructed in sections with flange couplings fitted with gaskets, and the inside diameter shall be sufficiently large to permit a free flow of concrete. The spacing of tremie tubes shall not exceed 20 feet on centers or 10 feet from the forms. Tremie tubes shall not be moved horizontally or the seal purposely broken once placing of concrete is started.

The radius of influence of a tremie shall not be assumed to exceed 10 feet. The means of supporting the tremie shall be such as to permit it to be rapidly lowered when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of the work so as to prevent water from entering the tube and shall be kept entirely sealed at all times and the tremie tube kept full to the bottom of the hopper during the depositing of the concrete. When a batch is dumped into the hopper the tremie shall be slightly raised, but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. The flow shall then be stopped by lowering the tremie. Special care shall be taken to maintain as nearly as practicable a uniform flow and to avoid dropping the concrete through the water. The flow shall be continuous until the work is completed. If the charge is lost during depositing, the tremie shall be withdrawn and refilled.

Dewatering may start when the concrete seal has reached a compressive strength of 1200 PSI.

All laitance and scale shall be removed so that sound, durable concrete is exposed and the area on which the construction is to be based shall be leveled off with epoxy bonded concrete or mortar.

E. Concrete Exposed to Sea Water.

Concrete structures so located as to be subject to the action of sea water shall be constructed in a manner to provide a maximum resistance to its disintegrating action.

The concrete shall be of the class required with an additional 10 percent of cement and shall be mixed for a period of time 50 percent more than the time specified in Subsection M4.02.10. The water content shall be carefully controlled and so regulated as to produce concrete of maximum impermeability. In placing concrete, care shall be taken to avoid the formation of pockets and the concrete shall be thoroughly compacted to the satisfaction of the Engineer. The original surface of the concrete shall be left undisturbed. In order to secure a thick and dense surface film, the surfaces of the forms shall be heavily coated with shellac or an approved form oil. The range of possible disintegration of the concrete from an elevation below that of low tide to an elevation above that of extreme high tide shall be determined by the Engineer, and, except with his special

permission, no construction joints shall be located within this range. In the determination of this range, due consideration shall be given to wave action, ice formation and other conditions affecting the extreme limits of possible deterioration and disintegration.

Concrete in sea water within the range as above determined shall, except when especially provided for by the plans or in the Special Provisions, be deposited in the dry and no sea water shall be allowed to come in direct contact with the concrete until it has been permitted to harden for at least 10 days and preferably for a longer period.

901.66 Joints.

A. Construction Joints.

Concrete in structures shall be placed in such a manner that all construction joints shall be exactly horizontal or vertical, as the case may be, and that they shall be straight and as inconspicuous as possible.

When construction joints are definitely shown on the plans, all concrete between consecutive joints shall be placed in a continuous operation.

In order to allow for shrinkage, concrete shall not be placed against the second side of the construction joints for at least 12 hours after that on the first side has been placed.

Approval of the Engineer in writing must be secured before the placing of any construction joints not shown on the plans, except in case of emergency as specified in paragraph D hereinafter.

The plans on which a day's work is to terminate shall be predetermined before depositing of concrete begins. They shall in general be perpendicular to the lines of principal stress and in regions of small shears. Horizontal joints will not be permitted in concrete girders, beams, abutments, or retaining walls, unless otherwise indicated on the plans. Slabs acting with concrete beams or girders shall be placed continuously as a unit, unless otherwise indicated on the plans.

Unless otherwise indicated on the plans, interlocking or keying at construction joints shall be provided by use of keyways or dowels in a manner approved by the Engineer.

Horizontal joints in piers or abutments shall generally be avoided and when used shall not be located within 3 feet of the normal water level.

In piers or abutments or walls requiring a construction joint it shall generally be a keyed vertical joint extending the full height above the footing. In piers, abutments or retaining walls the second portion placed at a vertical joint shall be placed not earlier than 24 hours after the first portion is placed, except with special permission of the Engineer.

Construction joints, not shown on the plans and above ordinary low water level in abutments and retaining walls that retain earth fills shall have approved waterstops and shall be furnished at the Contractor's expense.

Joints in cantilevered members, unless shown on the plans, shall be avoided.

When making a horizontal construction joint, care shall be taken to have the concrete below the joint as dry as possible and any excess water or creamy material shall be removed before the concrete sets. Within 12 hours after the concrete below the joint has been placed, the top surface shall be thoroughly cleaned by the use of wire brushes and all laitance and loose material removed so as to expose clean, solid concrete. Care must be taken not to loosen any of the coarse aggregate in the concrete. If for any reason this laitance is not removed before the concrete has hardened in place, it shall be removed using such tools and methods as may be necessary to secure the results specified above. Immediately before placing concrete above the joint, the surface of the concrete below the joint which has been cleaned as specified above shall be thoroughly wetted and coated with mortar of the same proportions used in the concrete. This mortar shall be thoroughly brushed into all openings and crevices with a stiff broom and new concrete shall be placed before this mortar has taken initial set. On all exposed surfaces, the line of the proposed joint shall be made truly straight by tacking a temporary horizontal straight edge on the inside of the form with its lower edge on the line of the joint and then placing the concrete sufficiently higher than this edge to allow for settlement. Immediately before placing the new concrete, the forms shall be drawn tightly against the concrete already in place.

In construction joints, approved waterstops of plastic material shall be placed not less than 3 inches from the face of concrete and shall extend a minimum of 2½ inches into the concrete unless otherwise shown on plans.

Prior to the use of plastic waterstops, the manufacturer's installation instructions shall be furnished to the Engineer.

B. Expansion Joints.

Expansion joints constructed in bridges, walls and other structures shall be of the thickness shown and as located on the plans. The joint filler shall be cut to the same shape as the area to be covered except that it

will be 1/4 of an inch smaller along all surfaces that will be exposed in the finished work unless shown otherwise on the plans. The filler shall be fixed firmly against the surface of the concrete already in place in such a manner that it will not be displaced when the concrete is deposited against it. When necessary to use more than one piece to cover any surface, the abutting pieces shall be placed in close contact and the joint between the separate pieces shall be covered with a layer of two-ply roofing felt, one side of which shall be covered with hot asphalt to insure proper adhesion. The 1/4 inch spaces along the edges at exposed faces shall be filled with wooden strips of the same thickness as the joint material. These wooden strips shall be saturated with oil and have sufficient draft to make them readily removable after the concrete is placed.

Whatever material is used, the exposed edge of the filler shall be the finished edge as it comes from the fabricator in order to avoid exposure of material roughened by cutting. Each piece of filler shall be fastened to the concrete on one side of the joint with a single line of No. 10 gauge cork insulation nails 3 inches long and 12 inches on centers.

Immediately after forms are removed, the expansion joint shall be carefully inspected and any concrete or mortar that has sealed across the joint shall be cut neatly and removed. The outer edge of the joint shall be straight, parallel and satisfactory in appearance.

In expansion joints, approved waterstops of plastic material shall be placed not less than 3 inches from the face of the concrete and shall extend a minimum of 4½ inches into the concrete, measured from the centerline of the joint, unless shown otherwise on the plans.

Prior to the use of plastic waterstops, the manufacturer's installation instructions shall be furnished to the Engineer.

All surfaces to which sealants are to be applied shall be thoroughly cleaned to remove all loose concrete, dirt, oil, grease, paint, lacquer, rust, scales, bituminous or other foreign materials. Projections of concrete into joint space shall be removed. Steel surfaces shall be sandblasted or mechanically brushed to obtain a bright, clean, metal surface. Loose particles or dirt shall be removed and the joint shall be dried before application of primer and/or sealer. A bond breaker shall be used so that the joint sealer shall not be placed in direct contact with bituminous material or bituminous filler.

A primer shall be used, when so designated in the manufacturer's instructions. The sealant shall be mixed and applied in accordance with manufacturer's instructions. Application shall be made only when air temperature is 50 °F or over. The sealant shall be installed in neat and workmanlike manner to the depth specified on the plans. The sealant surface shall be either flush with, or be not more than 1/8 " above adjacent joint surfaces.

Any material that does not adhere or bond to the applied surface, or fails to set up properly, will be removed and replaced at the expense of the Contractor. Any material improperly mixed or which sets up before placement will likewise be rejected and be replaced at the expense of the Contractor.

C. Bonding to Concrete Already Set.

In bonding new concrete to concrete already set, the surface of the concrete shall be thoroughly cleaned, roughened, wetted with clean water, and then flushed with a mortar composed of equal parts of the cement and sand specified for the new concrete, before new concrete is placed adjacent thereto. New concrete shall be placed before mortar has taken initial set. In lieu of the mortar, an epoxy adhesive suitable for bonding fresh concrete to hardened concrete may be used. The epoxy adhesive shall be applied in accordance with the manufacturer's recommendations.

D. Emergency.

When the work of placing concrete is unexpectedly interrupted by breakdowns, storms or other causes and the concrete as placed would produce an improper construction joint, the Contractor shall form a construction joint to the satisfaction of the Engineer. When such a joint occurs at a section on which there is a shearing stress, the Contractor shall provide an adequate mechanical bond across the joint by forming a key, inserting reinforcing steel or by some other satisfactory means, which will prevent a plane of weakness.

901.67 Weep Holes and Drains.

Weep holes shall be provided through all structures as indicated on the plans, and as directed. Ends of weep holes that are to be covered by filling material shall be protected by 1/4 inch mesh galvanized wire screen 23 gauge and not less than one cubic yard of screened gravel or crushed stone conforming to Subsection M2.01.1.

Drains shall be provided for bridge superstructures as indicated on the plans.

901.68 Protection, Curing and Finishing.

A. Protection.

Suitable precautions shall be taken to thoroughly protect the concrete from any damage by weather conditions or otherwise during and after placing.

1. Hot and Dry Weather.

During hot dry weather, and as directed, all new concrete shall be kept shaded from the sun, shielded from the wind and kept wet with water, or protected by other approved methods to retain the moisture in the concrete throughout the curing period.

2. Rainy Weather.

During rainy weather all new concrete shall be properly covered, as may be necessary to prevent damage. Sufficient approved material for covering shall be available at the site of the work for immediate use as may be needed.

3. Cold Weather.

During cold weather all new concrete shall be fully protected, by methods approved by the Engineer, until properly set and hardened to prevent damage. See Subsection 901.72.

B. Curing.

All concrete shall be kept fully saturated and protected against any drying action by methods of curing specified herein or as otherwise approved by the Engineer for not less than 5 days after placing standard cement concrete or for not less than 2 days after placing high early strength cement concrete.

All surfaces of concrete which are to receive a rubbed surface finish or on which bitumen is to be placed, and concrete at construction joints and exposed bridge deck concrete shall be cured in accordance with requirements below for water curing. All other concrete may be cured in accordance with requirements below for water curing or waterproof membrane curing.

1. Water Curing.

Curing of concrete shall begin by fog spraying immediately after the initial set. Fog spraying shall continue until the burlap cover has been placed. The amount of fog spray shall be strictly controlled, so that accumulations of standing or flowing water on the surface of concrete shall not occur.

Should atmospheric conditions render the use of fog spray impractical, the Contractor shall use plastic covers of suitable weight and securely weighted down, but not directly in contact with deck concrete. The covers shall be used only until the initial set has taken place. The burlap covers shall be placed immediately thereafter. On the windward side of the panel being cured, the Contractor shall erect canvas barriers of suitable height when necessary to protect the curing concrete from the direct force of the wind.

The area of concrete to be cured shall be covered by wet burlap blankets when concrete has set sufficiently, but in no case later than 5 hours after placing of concrete. Fog spray or covers shall be used continuously during this period.

The materials for the coverings shall conform to the pertinent requirements for the same provided under Subsection M9.06.3. The coverings shall be kept thoroughly wet by sprinkling with a fine spray of water until they may be removed. Wooden forms without liners, if left in place longer than 2 days after the placing of the concrete, shall be throroughly wet down at least once each day for the remainder of the required curing period. Formed surfaces shall, after the removal of forms, be cured in like manner for the remainder of the required period, the entire surface of the concrete being thoroughly drenched with water and covered immediately after the forms are removed. Portions of the covering material may be removed temporarily when and as necessitated by any required finishing or waterproofing operation.

2. Impervious Liquid Membrane Curing.

Immediately after the free water has disappeared on surfaces not protected by forms and immediately after the removal of forms, if such are removed before the end of the required curing period, the concrete shall be sealed by spraying as a fine mist a uniform applicatin of the membrane curing material in a manner as to provide a continuous uniform, water impermeable film without marring or otherwise damaging the concrete. The impervious liquid membrane material used shall conform to the requirements for the same provided under Subsection M9.06.5 except that only AASHTO M148, Type I shall be permitted.

The membrane curing shall be applied in one or more separate coats at the rate of at least one gallon per 150 square feet. If, in the Engineer's judgment, discontinuities or pinholes exist or if rain falls on the newly coated surface before the film has dried sufficiently to resist damage, an additional coat of the material shall be applied immediately to those affected areas at the specified rate. If a slight delay in application shall occur, which permits the concrete surface to dry, the surface of the concrete shall be thoroughly moistened with water, immediately prior to the application of the membrane curing material. Application of membrane curing may be delayed for 12 hours if the concrete surface is protected and kept moist by the use of wetted burlap.

The membrane compound shall be thoroughly agitated immediately before application. The liquid shall be applied under pressure by means of an approved pressure spray which shall be held not more than 2 feet away from the concrete and the spray protected from any wind by suitable means as may be necessary, so as to apply the material directly onto the concrete surface.

The sprayed surface film shall be protected from abrasion or damage for the duration of required curing period. The placing of materials or unnecessary walking on the surface will not be allowed until the film is at least 2 days old; and then only if no damage is caused to the surface film during the required curing time.

3. Curing by other Methods.

a. Waterproof Paper. Subject to approval by the Engineer, waterproofed paper may be used for curing particular surfaces of concrete and, if allowed, shall be furnished and used entirely in accordance with the provisions for such under Subsection 476.74, except that the length of time for the curing period shall be as specified herein.

b. Other methods of curing may be used but only when approved in writing by the Engineer prior to any use in the work.

C. Finishing.

The external surface of all concrete shall be thoroughly vibrated and spaded during the operation of depositing the concrete by means of tools of an approved type. The vibrating and spading shall be such as to force all coarse aggregate away from the surface and slowly work the mortar against the forms to produce a smooth finish free from water and air pockets or honeycomb.

Unless otherwise shown on the plans or provided in the Special Provisions, the final finish required on particular concrete shall be as follows:

1. Formed Surfaces not Exposed to View.

Immediately after forms have been removed and form ties cut back from the face of the concrete, all voids and cavities shall be filled with a stiff mortar of the same composition and air-entrainment as the mortar in the original concrete mix. The mortar for filling shall have been mixed and let set for 30 minutes and then remixed before placing in the work. In case the operation of filling is delayed, the surface of the concrete shall be thoroughly cleaned and washed with water, if necessary, before the mortar is applied.

2. Formed Surfaces Exposed to View.

Within 48 hours after the forms have been removed and form ties cut back from the face of the concrete, all fins, projections and irregularities shall be carefully removed and all voids and cavities shall be carefully and completely filled with a stiff mortar of the same composition and air-entrainment as the mortar in the original concrete mix. The same brand and color of cement, and the same kind and color of aggregate as was used in the original concrete mix shall be used in this mortar. The mortar for filling shall have been mixed and let set for 30 minutes and then remixed before placing in the work. The surface film of all such pointed surfaces shall be carefully removed before setting of the mortar occurs.

If the Engineer determines these surfaces as prepared above do not present a uniformly smooth, clean surface of even texture and appearance, the surface shall be treated and rubbed to obtain a satisfactory finish. The Engineer shall be the sole judge of the amount of rubbing which will be required.

If rubbing is required, the rubbing will start within 48 hours of notification that rubbing is required, the surface shall be wetted with clean water and rubbed with a No. 16 carborundum brick or other abrasive of equal quality until even and smooth and of uniform appearance, without applying any cement or other coating. If additional finishing is necessary it shall be obtained by a thorough rubbing with a No. 10 carborundum brick or other abrasive of equal quality. Subject to approval by the Engineer, rubbing may be performed by use of satisfactory power equipment and tools, providing that the operational procedures shall be the same as those outlined above for hand rubbing.

Rubbing will be kept to a minimum found necessary to produce smooth, even surfaces of uniform appearance. Rubbing will not be required to fill very small surface air bubble holes, to remove a uniform wood grain pattern left by forms, nor to remove inconspicuous lines of marking between form panels. Rubbing will not be required for the underside of bridge decks.

Patches required for form ties, if carefully and properly done, may not necessitate rubbing. If however, this work is done in such a manner that these patches are conspicuous, the entire exposed face on which they occur, shall be rubbed.

After the final rubbing is completed, and the mortar has set up, the surface shall be thoroughly drenched and keep wet with clean water for a period of 5 days, unless otherwise directed.

No rubbing will be permitted when the air temperature is below 40°F.

3. The use of mortar, cement water mixture or neat cement for topping or treatment of any concrete surface will not be permitted.

4. Bearing Areas for Superstructure Metal.

The surfaces of concrete on bridge seats, piers and pedestals, which are to support shoes or bearing plates of the superstructure, unless otherwise shown on the plans, shall be finished 1/8 to 1/4 inch higher than the

required elevations, over areas extending 3 inches outside of the shoes or bearing plates. After the concrete has been cured and thoroughly hardened, these areas shall be dressed down by tooling, rubbing, grinding, or otherwise, as may be approved, so as to provide true level surfaces at the required elevations. Satisfactory drainage shall be provided where necessary to prevent water accumulation at bearing areas.

5. Sidewalks and Median Strips on Bridges.

After being placed, the horizontal concrete surfaces shall be properly screeded and finished to true grade and surface. The finish shall be with an approved float, followed by light brushing with a fine brush but without the addition of any water to remove the cement film, leaving a fine grained, smooth but sanded texture. The surfaces shall then be cured as specified herein.

6. Roadway Surfaces on Bridges and Bridge Approach Slabs.

(a) *To be Covered with Bituminous Material or Membrane Waterproofing.* After concrete is placed, the top surface shall be struck off to the proper crown and longitudinal profile with an approved template. Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the template so that the surface shall be finished to the required elevations. These supports shall be carefully removed from the concrete before any set of the concrete occurs, and the spaces left by such removal shall be immediately filled and finished to the level of the adjacent surfaces. The surface shall be checked, by means of an approved straight-edge (not less than 10 feet in length), furnished by the Contractor, as the Engineer may direct. Any irregularities, measuring more than 1/4 inch vertically, shall be corrected and the whole surface shall be made smooth and even. No load of any kind shall be placed on the concrete after setting of the concrete has begun, and any work on the concrete than required shall be performed from approved bridges furnished by the Contractor, which will not rest on the new concrete in any manner.

Where membrane waterproofing is to be used the surface of the concrete shall be screeded to the true cross section and left without any projections that might puncture the membrane or depressions that could retain liquid.

(b) *To be Used as the Wearing Surface for Vehicular Traffic.* The placing and finishing of these surfaces shall be performed as specified herein.

(1) The Contractor shall submit for approval by the Engineer a detailed schedule showing the time schedule and the sequence he intends to use in placing of deck concrete. Also at least 15 days before the erection of screed rails, the Contractor shall submit his screed erection plans and details for review and approval by the Engineer. These plans shall also include details of finishing operation equipment and equipment for placement of the concrete.

No concrete shall be placed in any part of the work until steel reinforcement, shear connectors, anchors, drainage piping, conduit lines, etc. have been inspected and approved by the Engineer. The Contractor shall schedule his work in such a manner that all forms and reinforcement and other appurtenances shall be set by him, and checked by the Engineer on the day preceding the day of pour. The daily placement for the deck slab shall begin early in the morning.

(2) Setting Screed Rails and Checking of Reinforcement Bars.

(a) The screed rails and their support shall be of steel and be accurately set so that the finished surface shall conform to the profiles shown on the plans. The supports shall be adjustable, of substantial construction, and shall be placed and adjusted to properly provide for the deflection of forms, supporting beams, falsework, floor beam stringers and weight of finishing machine which may occur during placement of the concrete. The supports shall be placed in order to fit the concrete placing procedures and furnish continuity in the required contours for the finished surface.

(b) Prior to placing of concrete all reinforcement bars shall be rigidly tied or welded to their supports, after being accurately positioned with proper clearances from the final surfaces of concrete. The required concrete cover over the top bars shall be checked by riding the screed over the bars and measuring the distance from bottom of screed to top of bars every 10 feet longitudinally and all bars transversely. Discrepancies so found, which are in excess of 1/4 inch shall be rectified by repositioning the top bars to secure the required cover.

(3) Placing of Concrete.

Concrete shall be placed in a uniform manner across the entire width being cast. Dumping of mix in concentrated accumulations shall be avoided. Concrete shall be uniformly placed in front of the screed so that moving of the concrete is kept to a minimum.

Concrete shall not be placed when the ambient temperature is below 40 °F, except as stipulated in Section 901.72, or above 85 °F. At no time shall the internal temperature of the concrete being placed be higher than 70 °F.

(4) Finishing of Concrete (Exposed Concrete Surface).

(a) Only mechanized methods of finishing the freshly placed concrete shall be allowed except at locations inaccessible for mechanical screed and only when approved by the Engineer. Machine finishing of deck slab will not be required in areas outside of curb line, which will support the second lift of concrete for the safety walks and the median.

(b) Finishing Machines shall be mechanically operated, of rigid construction, riding on rails placed parallel to the bridge centerline and securely fastened to the supporting steel. They shall be of an approved type and shall be operated on that when concrete is properly consolidated and finished, the surface of the pavement will be at the elevation indicated on the plans, or ordered by the Engineer. The finishing machine shall set on the screed rails and be aligned parallel to abutments and piers and shall not be so light that it tends to ride the concrete rather than the rails. Only two passes of screed will be allowed over a given area of deck, and the lap of consecutive passes shall be limited to a minimum.

(c) After the concrete has been struck off it shall be further smoothed by means of a longitudinal float of suitable design approved by the Engineer. The float shall be worked from a bridge with a dragging motion while held in position parallel to the road centerline, and passed gradually from one side of the deck to the other.

(d) When all the irregularities have been removed, a wet burlap drag, consisting of a double thickness of approved burlap without seams, about 42 inches in drag width and long enough to span the entire width of surface being finished, shall be pulled along the surface, in a sweeping manner, longitudinally by workmen operating from outside the edges of pavement, if such a burlap drag is not attached to finishing machine. In case narrow areas adjacent to edges of surface shall not have been reached in the above operation, such areas shall be satisfactorily finished with approved burlap as may be directed by the Engineer.

(e) The pavement surface shall then be given a final finish by pulling a light broom, (about 30 inches wide and having two thin rows of flat bristles) gently and squarely across the surface from one edge to the other so as to remove any laitance and other surface blemish and so as to produce uniform corrugations, not more than 1/8 inch in depth.

(f) As specified herein and as may be found further necessary, in the judgment of the Engineer, any required work of finishing shall be done from adequate bridges furnished by the Contractor and they shall not be in contact with the surface of the concrete in any manner.

(g) While the concrete is still plastic the surface of the pavement shall be tested with a 10 foot straight-edge attached to a handle of sufficient length to permit testing of the full width of the slab. The straight-edge shall be laid parallel to the centerline of the pavement and any irregularity of 1/8 of an inch or greater shall be corrected immediately.

(h) Within 24 hours after completion and hardening the surface shall again be checked by the Contractor in the presence of the Engineer, with the straight-edge held parallel to the centerline, and variations exceeding 1/8 inch shall be plainly marked and shall be corrected at the Contractor's expense in a manner satisfactory to the Engineer.

(i) Hand Finishing. When hand finishing is used the surface of the concrete shall be struck off by means of a wooden or steel template of approved section. The template shall be constructed to produce the desired surface contour and shall have sufficient strength to retain its shape under all working conditions. For its proper use, the template should be at least 2 feet longer than the width of surface to be struck off. In general, vibrating templates shall be used for this operation. Subject to prior approval by the Engineer, non-vibrating templates may be used; the approval for such use to depend on the extent of the work and design requirements.

Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the template so that the surface of the concrete shall be finished to the required elevations for the finished surface. The supports shall be carefully removed from the concrete as soon as possible during the finishing operations, and the spaces left by such removal shall be immediately filled and finished to the level of the adjacent surface.

After the concrete has been deposited, spread and consolidated as required herein, it shall be struck off immediately with the template above the grade so that there will be sufficient concrete to fill low and porous spots. The template shall be operated by moving forward with a combined longitudinal and transverse motion and so manipulated that it bears fully on the control supports. A slight excess of material shall be kept in front of the cutting edge. The concrete shall be worked so as to embed coarse aggregate and to remove porous spots but not so as to force excess mortar or water to the surface. Low spots shall be filled and the material worked into place. The resulting surface shall be only slightly above the required grade and shall be uniform in appearance, density and composition.

The concrete shall then be brought to the required grade and density, and all surplus material removed, by striking off the concrete with the template in the operational manner required above except that the template shall be held firmly on the supports and operated at a slow, even speed. Finishing with the template and removing of any projections or depressions shall be continued until the required surface is obtained.

As soon as possible after finishing as specified, the surface of the concrete shall be finished in accordance with the operations and requirements prescribed herein after completion of the machine finishing under the subsection "Machine Finishing."

Satisfactory supports, furnished by the Contractor, shall be set and maintained in place for proper operation of the machines so that the surface of the concrete shall be finished to the required elevations.

Unless otherwise shown on the plans, the roadway concrete shall be placed and finished the entire width of the roadway area. When shown on the plans, longitudinal keyed and reinforced construction joints shall be constructed at such locations and in accordance with the details required by the plans or as approved by the Engineer.

901.69 Removal of Forms and Loading on Structures.

The word forms as used herein shall include all supports of the actual forms enclosing the concrete.

The forms for any portion of the structure shall not be removed until the concrete is strong enough, as determined by the Engineer, to avoid possible injury from such removal. Forms shall not be removed or disturbed without the prior approval of the Engineer. Form (supports) shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

When test cylinders are taken from the concrete in the members of a structure, the forms shall be left in place until the concrete has attained the strength designated in the following table, and, regardless of strength attained, for the minimum period indicated. In the absence of cylinder tests, the forms shall remain in place for the period specified under minimum loading period. However, in order to facilitate any particular finishing operations, side forms carrying no load may be removed 24 hours to 72 hours (depending on weather conditions and class of concrete) after the placing of the concrete has been completed, subject to the approval of the Engineer and with the complete curing process to be continued as required.

No superimposed load of any kind or for any purpose will be allowed on a structure before the expiration of the period of time prescribed in the table, whether or not the forms have been removed; except as follows:

(A) A superimposed live load not exceeding 5500 pounds, operated at a speed not to exceed 5 miles per hour, may be allowed on bridge deck concrete 5 days after standard cement concrete is placed and 3 days after high early strength cement concrete is placed provided the concrete has reached a compressive strength of 3300 pounds per square inch.

(B) A superimposed dead load not exceeding 80 pounds per square foot may be allowed under the same time and strength requirements as for a live load, provided the load is placed near the ends of the beam spans. Where possible, the load shall be spread over two or more beams.

FOR STANDARD CEMENT CONCRETE

	Minimum Strength of Concrete in Pounds Per Square Inch	Minimum Days for Forms in Place	Minimum Days Before Design Loading
Length of Span			
Up to 10 feet	3,300	8	10
Over 10 feet — Up to 20 feet	3,300	10	14
Over 20 feet — Up to 30 feet	3,300	12	18
Over 30 feet	3,300	14	22

FOR HIGH EARLY STRENGTH CEMENT CONCRETE

	Minimum Strength of Concrete in Pounds Per Square Inch	Minimum Days for Forms in Place	Minimum Days Before Design Loading
Length of Span			
Up to 10 feet	3,300	5	5
Over 10 feet — Up to 20 feet	3,300	5	5
Over 20 feet — Up to 30 feet	3,300	8	8
Over 30 feet	3,300	10	10

In case a particular increase in strength of concrete in a particular period of time is required by the Contract, or is directed or approved by the Engineer, and is between the strength attained by the use of standard cement concrete and the strength attained by the use of high early strength cement concrete, the time periods as required in tables above shall be adjusted proportionally to fit the particular time in which the stated strength is attained by such procedure. The strength shall be attained by an extra amount of Standard Cement or by the use of particular elements of approved admixtures.

The time requirements provided in both the above tables date from the completed placing of concrete in the member, and are the minimum requirements for the most favorable weather conditions. Longer periods, as directed by the Engineer, will be required to compensate adequately for adverse weather conditions.

For a concrete deck supported on steel stringer beams or floor beams, the span will be considered as the distance between center of beams. For composite concrete and steel beams the span governing the "Minimum Days for Forms in Place," shall be the distance between center of beams, and the span governing the "Minimum Days Before Design Loading" shall be the distance between center lines of main bearings. For concrete slabs, T-beams, and girders the distance shall be between center lines of main bearings; and for arches and rigid frames, the distance between springing lines.

If a placing sequence is not stated on the plans or in the Special Provisions of a contract which includes the construction of a continuous span structure, the forms for the entire continuous group shall remain in place until every span of the group has been supported for the minimum required period of time.

No backfill or any other operation that could in any way cause stress in the concrete shall begin prior to the period of time required before loading of the structure.

Any defective work discovered after the forms have been removed shall be immediately removed and replaced. If the surface of the concrete is bulged, uneven or shows excessive voids or form joint marks which cannot be repaired satisfactorily, the entire section shall be removed and replaced. All repairs and renewals due to defective work shall be done at the expense of the Contractor.

901.70 Protection of Pipes and Conduits.

The Contractor shall care for and protect from injury all pipes, wires and conduits encountered in the work by furnishing and maintaining suitable supports, including steel bars, where directed on the bridge during construction.

The Contractor shall provide suitable openings in the abutments, walls, piers, and superstructures as shown on the plans and as may be directed. If required, the opening shall be filled with brick masonry in a satisfactory manner.

901.71 Date, Seal, Bench Marks and Ornaments.

A. Date.

The Contractor shall place a date on bridges as shown on the plans or as directed. The date shall be cast or cut in masonry as directed. Detail drawings of the date will be furnished by the Department.

B. Seal.

If indicated on the plans, the Contractor shall place a bronze replica of the State Seal on Bridges, as directed by the Engineer. The seal will be furnished by the Department.

C. Ornaments.

Concrete ornaments shall be furnished and placed by the Contractor on bridges when indicated on the plans. The ornamental castings may be either cast in place or precast.

901.72 Concrete Construction During Cold Weather.

Any concrete placed during cold weather shall be placed at the Contractor's risk and any damaged or unsatisfactory concrete shall be removed and replaced at the Contractor's expense. Concrete mixed or placed when the air temperature is below 40 °F will be considered cold weather concrete and will require special treatment. In general the special treatment is indicated below.

No concrete shall be placed when the atmospheric temperature in the shade and away from artificial heat is below 35 °F or when the temperature may be expected to drop below 30 °F within 24 hours, except upon permission in writing by the Engineer, which shall not be granted until satisfactory provisions have been made to protect the work.

If the air temperature in the shade and away from artificial heat may be expected to reach 40 °F or lower at any time during the day or night of the 24 hours following the placing of the concrete, protective cover, heating or protective cover and heating will be required on all exposed surfaces. When the air in the shade

and away from artificial heat is 40 °F or lower temperature, the mixing water and/or aggregates may be heated (prior to cement being added) by approved methods so that the temperature of the aggregates and water mixture is not less than 70 °F nor more than 140 °F. The temperature of the concrete shall not be less than 60 °F nor more than 90 °F at the time of placing it in the forms. The heating shall be done in a manner to preclude the occurrence of overheated areas which might result in damage to the materials. Any material containing frost or lumps of hardened material shall not be used.

Where it may be expected that considerable heat will be generated by the hydration of the concrete, and in some cases where heat is not rapidly dissipated, suitable coverings shall be used to protect concrete. Heavy footings in which the concrete is placed at a temperature of 70 °F and protected by the surrounding earth, except on top, shall be protected down to an air temperature of about 15 °F by a tarpaulin placed over the top with an air space between the concrete and the tarpaulin. Mass concrete, when concrete as such is so specified on the plans or so defined by the Engineer, may be protected down to an air temperature of about 20 °F, by enclosure with tight wooden forms at least 5/8 inch in thickness and the concrete is placed at a temperature of 70 °F; except at corners and edges. Double sheating, insulation board or tarpaulins with a dead air space between the covering and the forms shall be placed to equally protect such edges and corners. Enclosures and added artificial heat will be required for such concrete placed at lower air temperatures.

The Contractor shall have readily available for installing on the work adequate material for the proper enclosure or covering of the concrete together with adequate equipment for satisfactory heating as may be necessary.

As much as possible of any enclosure for protection shall be in place before depositing of any concrete and the remainder shall be installed as rapidly as possible in order to reduce heat losses to a minimum.

The temperature of the concrete inside the enclosure shall be held above a minimum temperature of 50 °F, and the air surrounding the fresh concrete shall be kept at a temperature within a 50 °F to 80 °F range. The temperature of the concrete shall be maintained above 70 °F for the first three days or above 50 °F for the first five days after the concrete is completed in place, except periods of time may be reduced when satisfactory strength is attained sooner, as with the use of a high early strength cement concrete, then a minimum of 70 °F for two days or 50 °F for four days will be required. In any case the periods of time provided above are minimum requirements and extensions of these periods of time will be required provided that such may be necessary to develop satisfactory strength in the concrete.

After the concrete has been cured for the required length of time, the temperature within the housing shall be gradually reduced no faster than 1 degree per hour until it equals the surrounding air temperatures.

Heating within the enclosure shall be attained by such means of artificial heat as will maintain the temperatures specified continuously and with a reasonable degree of uniformity in all parts of the enclosures. All exposed surfaces of concrete within the enclosure shall be kept sufficiently moist to prevent any rapid drying of the surface concrete with possible resulting damage to the concrete in place. Heating appliances shall not be placed in such a manner as to endanger the enclosure, forms or supports, or expose any area of concrete to rapid drying out or other injury due to excessive temperatures.

Should the Contractor wish to secure permission to use other methods than those provided above for protective retaining of heat within the concrete or direct protective heating of the concrete by adequate facilities for same, such request shall be made in writing by him to the Engineer and shall include verifiable evidence of satisfactory results obtained by use of such methods. Other methods than those provided herein shall not be used unless approved in writing by the Engineer, and then only under the full responsibility of the Contractor.

901.73 Concrete Penetrant/Sealer.

Concrete penetrant/sealer shall be applied to bridge copings, beam seats, parapets, endposts, median barriers and other cement concrete surfaces as designated and shown on the plans and in accordance with these and the manufacturer's specifications. This work shall consist of furnishing all necessary labor, materials and equipment to treat concrete surfaces, including surface preparation and application.

The concrete penetrant/sealer shall conform to M9.15.0. Clear concrete penetrant/sealers after complete application, shall not stain, discolor or darken the concrete to any appreciable degree. Application of the penetrant/sealer shall not alter the surface texture and shall be compatible with the use of surface finish coatings and/or caulkings. The surface shall dry to a tack free condition. Application of the penetrant/sealer shall be in accordance with the manufacturer's recommendations, including condition and preparation of surfaces to be treated.

The preparation process shall not cause any undue damage to the concrete surface, remove or alter the existing surface finish, or expose the coarse aggregate of the concrete.

Concrete surfaces prepared for treatment shall be approved by the Engineer.

The concrete penetrant/sealer shall be used as supplied by the manufacturer and not diluted or altered in any way. The penetrant/sealer shall be applied onto the concrete surfaces at the manufacturer's recommended rate of coverage. Manufacturer's safety precautions shall be strictly adhered to.

The Contractor shall exercise all reasonable precaution to prevent the penetrant/sealer from coming in contact with any joint sealers, so as to prevent any possible loss of bond of the joint sealer.

COMPENSATION

901.80 Method of Measurement.

Cement concrete masonry will be measured by the cubic yard and the quantity shall be determined in accordance with dimensions shown on the plans and such alteration of the plans as are specifically ordered by the Engineer in writing. No deduction shall be made in bridges for rustications, chamfered corners of dimensions less than 4 inches on the square sides, or for the volume of pipes less than 18 inches in diameter, drainage inlets, or for anchor bolts or reinforcing bars. The volume occupied by pipe culverts in headwalls shall be deducted.

Reinforcement for cement concrete masonry structures shall be measured by the pound. The weight of bars shall be the product of the length as shown on the approved plans and schedules and the standard weight per foot of length as adopted by the Concrete Reinforcing Steel Institute. Wire, metal clips, metal chairs or other fastening and supporting devices used for keeping the reinforcement continuous and in correct position will not be considered reinforcement and the Contractor will receive no additional compensation for their use.

The weight of wire mesh (incorporated in the structure) shall be the computed weight in accordance with the plans based on the standard weight accepted by the trade for the unit area of the particular mesh.

901.81 Basis of Payment.

Cement concrete masonry will be paid for at the contract unit price per cubic yard under the particular item of Cement Concrete Masonry of the Class required, as shown on the plans or as directed, completed in place and accepted.

The Contractor shall have no claims for special allowances for extra cement or apparent shrinkage due to inaccurate proportioning or control, bulging of forms, spilling, waste or for any other project conditions within his control.

Payment for additional cement required to be used in proportioning by volume and in placing of concrete under water shall be included in the contract unit price paid for the particular class of cement concrete masonry specified, or directed.

When high early strength cement concrete masonry is used (where originally standard cement concrete was specified) by order of the Engineer after the Contract has been executed, the Contractor will be paid in addition to the contract unit price for such standard cement concrete masonry the sum of $4 per cubic yard for all high early strength cement concrete masonry as is so directed to be used. When the contract has specified that high early strength cement concrete shall be used, or if the Contractor is permitted to choose such concrete as an option, then no additional payment will be made for such concrete.

Steel reinforcement including wire mesh will be paid for at the contract unit price per pound under the item for Steel Reinforcement for Structures, complete in place. No payment will be made for any fastening devices or supports that may be used for keeping the reinforcement in correct position.

Galvanized steel curb bars, and steel dowels will be paid for at the contract unit price per pound under the item for Steel Reinforcement for Structures.

The work specified under Subsections 901.70, 901.71 and 901.72 shall be done without extra compensation except when openings for pipes, wires and conduits are required to be blocked up, the brick masonry will be paid for at the contract unit price per cubic yard of the kind of masonry in which the opening occurs.

Holes for dowels shall be drilled by the Contractor without extra compensation.

901.82 Payment Items.

901.	4000 psi, 1½ in., 565	Cement Concrete Masonry	Cubic Yard
902.	3500 psi, 1½ in., 520	Cement Concrete Masonry	Cubic Yard
903.	3000 psi, 1½ in., 470	Cement Concrete Masonry	Cubic Yard
904.	4000 psi, 3/4 in., 610	Cement Concrete Masonry	Cubic Yard

904.1	5000 psi, 3/4 in., 705	Cement Concrete Masonry	Cubic Yard
905.	4000 psi, 3/8 in., 660	Cement Concrete Masonry	Cubic Yard
906.	5000 psi, 1½ in., 660	Cement Concrete Masonry	Cubic Yard
910.	Steel Reinforcement for Structures		Pound
910.1	Steel Reinforcement for Structures — Epoxy Coated		Pound
911.	Shear Connectors		Lump Sum
999.901	Allowance for High Early Strength Concrete		Cubic Yard

SECTION 930
PRESTRESSED CONCRETE BEAMS

DESCRIPTION

930.20 General.

The work consists of fabricating, delivering and placing prestressed concrete beams in accordance with the plans and specifications.

The work under this Section shall conform to the relevant requirements of the current AASHTO Specifications for Highway Bridges and shall be supplemented by the relevant provisions of the current AASHTO Standards and Inspection Manual for Prestressed Concrete, except as noted herein.

The horizontal alignment (deviation from a straight line parallel to the centerline of the member) for precast prestressed concrete box and deck beams shall not be more than 1/8 inch per each 15 foot of length and not to exceed 1 inch between adjacent butted units.

MATERIALS

930.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III.

Materials:

Prestressed Concrete Beams (Deck, Box, I-Sections)	M4.03.00
Anchor Rods	M8.01.6
Elastomeric Bridge Bearing Pads	M9.14.5
Prestressed Strand, Chuck and Washer	M8.15.0
Mortar (Keyways)	M4.04.0
Protective Sealcoat Emulsion	M3.03.3
Mortar	M4.02.15

CONSTRUCTION METHODS

930.60 General.

The prestressed concrete beams shall be lifted only by the handling hooks, and the utmost care shall be taken to prevent distortion of the beam during handling, transporting or storing. Suitable spreaders shall be used during the lifting so that only a vertical pull will be made on the hooks. Under no circumstances are the beams to be handled in other than an upright position. In storing and transporting the beams they shall be blocked near the ends.

930.61 Prestressed Concrete Deck and Butted Box Beams.

In order to assure the proper relation of the adjacent beams, a single 1/2 inch strand shall be pushed progressively through the sleeves as each beam is erected. The cable shall be supplied with a seamless polypropylene sheath which has corrosion inhibitor grease between the 1/2 inch cable and the sheath. The lifting hooks shall not be cut until all beams are placed, the complete prestressed deck assembly has been approved, and the beams are properly tensioned laterally. The lifting hooks shall be cut off below the top of the beam and the recesses shall be filled with mortar (M4.02.15). On the sidewalks, metal shall be cut off 1 inch below the top of the beam and the depressions shall be filled with mortar (M4.02.15). Holes in abutments for the anchor rods shall be drilled after the beams are in place.

930.62 Mortaring Keyways.

Before the mortar (M4.04.0) is placed, the keyways shall be thoroughly saturated by sprinkling with water.

The consistency of the mix shall be dry enough to withstand hard ramming without flushing of fines or water to the surface. The mix shall be placed in the keyways in thin layers, with each layer fully consolidated by ramming in a manner approved by the Engineer.

The keyways shall then be packed at least flush to the top of the beams with mortar and feathered out where necessary to avoid sharp projections which may injure the membrane waterproofing.

930.63 Curing.

The keyways and area of the beams adjacent to the keyways shall be cured with burlap, continuously well saturated, for a period of 72 hours.

Keyways shall not be packed in freezing weather unless heat and thermal protection are provided, and no vehicular traffic will be allowed on the bridge during the curing period.

930.64 Tensioning.

Each of the transverse cables shall be tensioned to 10,000 pounds and the chuck shall be tightened to maintain this tension.

Tensioning shall be done before the keyways are packed with mortar (M4.04.0).

After the tensioning has been completed and the anchor rods have been placed, the anchor sleeves at the fixed end shall be filled with mortar (M4.02.15) flush with the top of the beam. At the expansion end the anchor sleeves shall be filled with bituminous joint filler conforming to Subsection M3.05.1.

930.65 Final Work.

Further work on the deck shall not be started until the Engineer has approved the assembly. After the assembly has been approved, the Contractor shall remove projections and fill all depressions in the tops of the beams with mortar (M4.02.15) and shall then apply the membrane waterproofing in accordance with the requirements of Section 965.

Joint sealer placed between the sidewalk and curb beams shall conform to the provisions of Section 901 and shall be gray or cream in color.

COMPENSATION

930.81 Basis of Payment.

The above work shall be paid for at the contract lump sum price under the respective items of Prestressed Concrete Deck Beams, Prestressed Concrete Beams (I-Section), and Prestressed Concrete Box Beams complete in place and accepted.

930.82 Payment Items.

930.	Prestressed Concrete Deck Beams	Lump Sum
930.1	Prestressed Concrete Box Beams	Lump Sum
931.	Prestressed Concrete Beams (I-Section)	Lump Sum
932.	Elastomeric Bridge Bearing Pad	Square Foot
933.	Elastomeric Bridge Bearing Pad	Each

SECTION 940
DRIVEN PILES

DESCRIPTION

940.20 General.

This work shall consist of furnishing and driving piles to the required bearing capacity in accordance with these specifications and in close conformity with the lines and grades shown on the plans established by the Engineer.

The Contractor will be responsible for furnishing piling of sufficient length to obtain the penetration and bearing value required.

940.21 Pile Schedule.

The Contractor shall submit to the Engineer, for approval, a schedule of the length of piles he proposes to order, and the schedule shall designate the respective location of the piles. The scheduled length shall comprise the length expected to be left in the structure plus the length that might be necessary to provide fresh heading. When test piles and load tests are required, the data obtained from driving test piles and making test loads shall be used in conjunction with other available information to determine the lengths of piles to be furnished.

940.22 Precast-Prestressed Concrete Piles.

A. Required Submittals.

The Contractor shall submit to the Engineer, shop drawings and design calculations which demonstrate the pile complies with the Contract documents. The drawings shall include a schedule of pile lengths, all structural, reinforcing and prestressing details, pickup points, and splice designs. All designs shall be in accordance with the latest AASHTO "Standard Specifications for Highway Bridges."

B. Special Tips.

Piles driven to bed rock, into dense stratum or through strata with obstructions shall be equipped with embedded steel H sections or equivalent type protection to minimize damage to the pile tip.

C. Extensions.

Extensions on precast-prestressed piles shall be in accordance with details shown in the Contract Documents. The final cutting shall be perpendicular to the axis of pile at such an elevation that at least 40 diameters of reinforcing steel are exposed. The final cutting shall not cause undue spalling of the pile adjacent to the cut. Steel reinforcing and concrete for the extensions shall be of the same strength and quality as that used for the original pile.

MATERIALS

940.40 General.

A. Piles shall meet the requirements specified in the following Subsection of Division III.

Materials:

Untreated Timber Pile	M9.05.6
Treated Timber Pile	M9.05.6
Steel Pile	M8.05.1
Steel Pipe Piles	M8.05.5
Cast-in-Place Pile	M8.05.2
Precast-Prestressed Concrete Pile	M8.05.6
4000-3/4 inch-610 (Cement Concrete)	M4.02.00
Steel Reinforcement	M8.01.0
Mortar	M4.02.15

B. Length of Steel Pipe and H Piles.

When the proposed length is:

1. 60 feet or less, the pile shall be furnished in a single piece of the required length.
2. Greater than 60 feet, the Contractor will have the option of furnishing the pile in a single piece, or of furnishing each pile in 2 pieces, approximately equal in length, to make up the required length.
3. 100 feet or less, piles shall be spliced on the ground before being placed in the leads.

C. Length of Precast-Prestressed Concrete Piles.

1. 60 feet or less the pile shall be furnished in a single piece.

2. Greater than 60 feet, the Contractor shall have the option of furnishing the pile in a single piece or splicing 2 pieces approximately equal in length.

D. Storage and Handling of Piles.

Special care shall be used in the storage and handling of piles to avoid damage.

The method of handling of precast-prestressed concrete piling shall prevent cracking or fracture by impact or induced bending stresses. At the discretion of the Engineer, cracked or fractured piling shall be either rejected or repaired with epoxy. Fine cracks, which do not extend to the reinforcing steel as determined by the Engineer, will neither require repair or be cause for rejection. The Contractors proposed method for repair with epoxy or the like shall be submitted to the Engineer for approval.

E. Pile Shoes and Tips.

Pile shoes of the type and dimensions specified shall be provided and installed when shown on the contract documents.

Timber pile shoes shall be metal and be fastened securely to the pile. Timber pile tips shall be carefully shaped to secure an even uniform bearing on the pile shoes.

Steel pile shoes shall be fabricated from cast steel conforming to ASTM A 27.

CONSTRUCTION METHODS

940.50 Equipment for Driving Piles.

940.51 Hammers.

A. General.

Piles shall be driven by approved power hammers or by a combination of jetting and power hammers. Power hammers include single, double and differential acting air or steam hammers, and open or closed-end diesel hammers. Drop (Gravity) hammers may be used with the written permission of the Engineer to drive timber piles.

Valve mechanisms and other parts of power hammers shall be maintained in good condition. Hammers shall be capable of delivering the manufacturer's rated energy and shall be operated at the manufacturer's specified maximum blows per minute. Power sources such as steam boilers and air compressors shall be capable of continuously maintaining the hammer manufacturer's recommended pressure and flow rate at the intake of the hammer. Boilers and Compressors shall be equipped with pressure gauges or other devices, calibrated against the rated hammer energy. When directed by the Engineer, a gauge readable from the ground surface, shall be provided at the hammer intake to determine the actual pressure delivered to the hammer.

The Contractor shall equip open-end diesel hammers with a calibrated scale to enable accurate observation of ram stroke from the ground surface.

The Contractor shall also provide the Engineer a chart from the hammer manufacturer equating stroke and blows per minute for the open-end diesel hammer to be used.

Double acting diesel hammers (closed-end) shall be equipped with a gauge to measure pressure in the bounce chamber. The gauge shall be readable from the ground surface. Alternatively the gauge can be equipped with a hose sufficiently long to enable reading on the ground surface. The gauge and hose assembly shall be calibrated to allow for losses in the hose. The Contractor shall provide charts relating the throttle setting and/or bounce chamber pressure to rated hammer energy.

B. Minimum Energy Requirements.

Hammers for Timber Piles.

Power Hammers shall have a ram weight of not less than 2000 pounds and shall develop not less than 6000 foot-pounds of energy per blow. When driving to final resistance, the total energy to drive the pile the last 6 inches shall not exceed 32,000 foot-pounds times the pile tip diameter in inches.

Drop (Gravity) Hammers may be used only with the written permission of the Engineer. Such hammers shall weigh between 2000 and 3500 pounds, but in no case shall the weight of the hammer be less than the combined weight of driving head and pile. The fall shall be so regulated as to avoid damage to the pile and in no case shall exceed 15 feet.

To control excessive stress in concrete piling during driving, the Engineer may require:

1. Increase in cushion thickness, or change the materials comprising the cushion,

2. Reduction of ram stroke,

3. Reduced ram stroke for driving through very soft soil and increased ram stroke as soil resistance increases,
4. Combination of increased cushion thickness and reduced ram stroke,
5. Combination of increased cushion thickness and shorter stroke, or
6. Use of pilot holes or jetting when driving through hard or alternating hard and soft strata.

C. Submittals.

The Contractor shall submit to the Engineer for approval, a description of the proposed driving equipment with manufacturer's specifications. The equipment description shall include hammer type, hammer cushion, drivehead, and pile cushion, etc. as contained in the "Pile and Driving Equipment Data Form" included in the contract documents or supplied by the Engineer.

D. Approval Criteria.

Power hammers shall have an energy rating that will provide the required pile capacity with a penetration resistance between 3 and 15 blows per inch (3-15 BPI). The energy required for these rates shall be determined by the formula given in Section 940.61A for piles with a required capacity less than 50 tons. For piles with required capacity over 50 tons, or as directed by the Engineer, the Contractor shall submit to the Engineer the results of a Wave Equation Analysis performed in accordance with Section 940.61B for the proposed driving equipment. The analysis shall evaluate the acceptability of the driving equipment with regard to energy transfer to the pile top and the potential for impending pile damage due to induced driving stresses.

The pile stresses which are indicated by the wave equation to be generated by the driving equipment shall not exceed the values where pile damage impends, if the equipment is to be acceptable. That value is determined by the magnitude of the induced compressive stresses.

The point of impending damage in steel piles is defined herein as a compressive driving stress of 90 percent of the yield point of the pile material. For concrete piles, tensile stresses shall not exceed 3 multiplied by the square root of the concrete compressive strength, f'c, plus the effective prestress value, ($3\sqrt{f'c}$ + prestress) and compressive stresses shall not exceed 85 percent of the compressive strength minus the effective prestress value (0.85 f'c — prestress). For timber piles, the compressive driving stress shall not exceed three times the allowable static design strength listed on the plans. These criteria will be used in evaluating wave equation results to determine acceptability of the Contractor's proposed driving system. The results of the analysis, including input parameters, shall be subject to the review and approval of the Engineer prior to any pile installations.

The Contractor will be notified of the acceptance or rejection of the driving system within 14 calendar days of the Engineer's receipt of the "Pile and Driving Equipment Data Form." If the wave equation analyses show that either pile damage or inability to drive the pile with a reasonable blow count to the desired ultimate capacity will result from the Contractor's proposed equipment or methods, the Contractor shall modify or replace the proposed methods or equipment until subsequent wave equation analyses indicate the piles can be reasonably driven to the desired ultimate capacity, without damage.

Approval of the equipment by the Engineer will not relieve the Contractor of his responsibility to provide and install piles capable of supporting the design loads given on the contract documents.

940.52 Driving Appurtenances.

A. Pile Drive Head.

Piles driven with impact hammers require an adequate drive head to distribute the hammer blow to the pile head. The drive head shall be axially aligned with the hammer and the pile. The drive head should be guided by the leads and not be free-swinging. The drive head should fit around the pile head in such a manner as to prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

1. For steel and timber piling, the pile heads shall be cut squarely and a drive head, as recommended by the hammer manufacturer, be provided to hold the axis of the pile in line with the axis of the hammer.
2. For precast concrete and prestressed concrete piles, the pile head shall be plane and perpendicular to the longitudinal axis of the pile to prevent eccentric impacts.
3. For special types of piles, appropriate driving heads, mandrels or other devices shall be provided in accordance with the manufacturer's recommendations so that the piles may be driven without damage.

B. Bands.

Collars, bands, or other devices, to protect timber piles against splitting and brooming, shall be provided by the Contractor.

C. Hammer Cushion.

All pile driving equipment shall be equipped with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to insure uniform driving behavior. Hammer cushions shall be made

of durable, manufactured materials, provided in accordance with the hammer manufacturer's guidelines except that all wood, wire rope, and asbestos hammer cushions are specifically disallowed and shall not be used. A striker plate as recommended by the hammer manufacturer shall be placed on the hammer cushion to insure uniform compression of the cushion material. The hammer cushion shall be inspected in the presence of the Engineer when beginning pile driving at each substructure element or after each 100 hours of pile driving, whichever is less. Any reducton of hammer cushion thickness shall be replaced by the Contractor before driving is permitted to continue.

D. Pile Cushion.

The heads of concrete piles shall be protected by a pile cushion made of plywood or other similar material approved by the Engineer. The minimum plywood thickness placed on the pile head prior to driving shall not be less than 4 inches. A new pile cushion shall be provided for each pile. In addition during the driving of each pile, the pile cushion shall be replaced if during the driving the cushion is either compressed more than one half the original thickness or begins to burn. The pile cushion dimensions shall match the cross-sectional area of the pile top.

E. Leads.

The pile driver shall be equipped with fixed leads that are an integral part of the machine. The pile driving hammer shall ride in the ways of the leads. Fixed leads shall be used for driving all piles unless written approval to the contrary is obtained from the Engineer.

F. Followers.

Followers shall only be used when approved in writing by the Engineer, or when specifically stated in the contract documents. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full length piles. The final position and alignment of the first two piles installed with followers in each substructure unit shall be verified to be in accordance with the location tolerances in this specification before additional piles are installed.

G. Jets.

Jetting shall only be permitted if approved in writing by the Engineer or when specifically stated in the contract documents.

Jetting will not be allowed when driving through newly placed embankment.

The use of water jets will be permitted only when excess of water will not affect adjacent structures. In general, jetting will not be permitted near railroad tracks.

When jetting is permitted, the Contractor shall determine the number of jets and the volume and pressure of water at the jet nozzles necessary to freely erode the material adjacent to the pile without affecting the lateral stability of the final in-place pile. The Contractor shall control, treat if necessary, and dispose of all jet water such as to meet environmental considerations. The Contractor shall be responsible for all damage to the site caused by jetting operations. The jetting plant shall have sufficient capacity to deliver at all times a pressure equivalent to at least 100 pounds per square inch at two 3/4 inch jet nozzles. Unless otherwise indicated, jet pipes shall be removed when the pile tip is a minimum of 5 feet above prescribed tip elevation and the pile shall be driven to the required bearing capacity with an impact hammer.

H. Preaugering.

Preaugering shall only be permitted if approved in writing by the Engineer or when specifically stated in the Contract documents. When permitted, the Contractor shall provide the necessary equipment such as augers, well drilling machines, etc. to preauger holes at pile locations and to the depths required by the Engineer.

PILE INSTALLATION

940.60 Preparation for Driving.

A. Excavation.

When piles are located in an area where excavation is to be made or in an area where embankment is to be placed, the piles shall not be driven until the excavation has been made or the embankment has been placed. For either of the foregoing, the grade shall be brought to such an elevation as to compensate for possible uplift or subsidence of the surrounding earth. Adjustments in the grade shall be made after all the piles at the location have been driven. Additional excavation or embankment will be considered as part of the process of pile driving and will not be included in the payment for either excavation or borrow.

B. Preaugering.

Where timber, cast-in place, precast-prestressed concrete piles, or steel piles are to be driven through an embankment, and the depth of the embankment at the pile location is in excess of 5 feet, the Contractor shall make a hole for the full depth of the embankment for each pile with an auger or by other approved methods. The hole shall have a diameter of not less than the butt diameter of the pile. After driving, the annular space around the pile shall be filled to the ground surface with dry sand, fine gravel or pea stone. Material resulting from drilling holes shall be disposed of in accordance with Section 120, Excavation.

940.61 Driven Pile Capacity.

For piles with proposed capacities greater than 50 tons, the safe bearing values shall be determined by a Wave Equation Analysis conducted by a Registered Professional Engineer experienced in the method of analysis, at the expense of the Contractor. For piles with proposed capacities not greater than 50 tons, the safe bearing values may be determined by the following formula unless directed otherwise by the Engineer.

A. Formula Method.

$$Ru = 1.75 \sqrt{E} \log (10N) - 100$$

Where

Ru = Ultimate Pile Capacity (kips)

E = Manufacturer's rated energy of the hammer, at stroke observed in field, in foot-pounds.

Log (10N) = Logarithm to the base 10 of the quantity "10" multiplied by N, the number of hammer blows per inch at final penetration (blows per inch).

The above formula is applicable only when:

(a) A follower is not used.

(b) The hammer is operated within the range established by the manufacturer.

A design safety factor of 3.5 is to be used when using this formula to determine the safe design load, i.e., if a design load of 100 tons is required in the bearing layer, then an ultimate capacity of 350 tons should be used in the formula to determine the necessary hammer blow count.

The above formula may be modified by the Engineer if he deems it necessary on the basis of information obtained from a loading test or dynamic field measurements during pile driving.

B. Wave Equation Method.

When required in the contract documents, the ultimate pile resistance shall be determined by the Engineer based on a wave equation analysis. Piles shall be driven with the approved driving equipment to the ordered length or other lengths necessary to obtain the required ultimate pile resistance. Jetting, pre-augering or other methods to facilitate pile penetration, shall not be used unless specifically permitted either in the contract documents or approved by the Engineer after a revised driving resistance is established from the wave equation analysis. Adequate pile penetration shall be considered to be obtained when the specified wave equation resistance criteria is achieved within 5 feet of the tip elevation based on ordered length. Piles not achieving the specified resistance within these limits shall be driven to penetrations established by the Engineer.

The Contractor is required to perform a wave equation analysis upon each pile type, each pile size, at each significant variation in soil profile, and at each pile driven for the static load test as shown on the plans. When dynamic load tests are required than a wave equation analysis must be performed for each pile to be dynamic load tested by the "Pile Driving Analyzer" (PDA) as determined by the Department. The wave equation analysis shall be made as outlined in the FHWA publication entitled "Manual on Design and Construction of Driven Pile Foundations"-FHWA-DP-66-1.

If more than one driving system is proposed by the Contractor, a wave equation analysis shall also be made for each driving system. The driving system, as detailed on the "Pile Driving and Equipment Data Form," shall be completed by the Contractor and furnished for use as wave equation input data.

No change in driving equipment will be permitted after an evaluation by the Wave Equation Method without prior approval of the Engineer and a revaluation of the driving system. The Engineer may modify the results from the Wave Equation Analysis, if he deems it necessary on the basis of information obtained from loading tests or dynamic field measurement.

The wave equation analysis will be performed by an engineer, registered with the Commonwealth of Massachusetts as a Professional Engineer and experienced in such work. The Contractor's engineer shall be experienced in the performance of the wave equation analysis and its function as related to pile capacity determination. The Contractor's engineer conducting the wave equation analysis shall be thoroughly familiar with the Geotechnical report for the project, the subsurface conditions at the site, and with the proposed foundation design.

The Contractor shall submit a written report with a summary of each wave equation analysis to the Department at least 2 weeks prior to pile driving. That submission shall include a copy of the entire "wave equation analysis program" (WEAP) output in the form as specified, on pages 380 and 381 of the above referenced FHWA Manual. The summary in the report will contain the plotted curves (3) of ultimate resistance vs. blowcount and compressive stresses vs. blowcount and tensile stresses vs. blowcount for each WEAP output for each embedded length and for several stroke-lengths if a variable stroke (diesel) hammer is used.

The Contractor's engineer conducting the wave equation analysis shall also be the same engineer to conduct the dynamic load tests with the PDA when the Contractor is required to perform such dynamic load tests.

940.62 Pile Load Tests.

A. General.

The piles to be tested shall be driven in accordance with the requirements under the item for the type of pile to be used on the project. These tests shall be made before driving production piles.

Each pile to be tested shall be driven to the design load as determined by either the Formula in Section 940.61A or a Wave Equation Analysis in accordance with Section 940.61B and, at the discretion of the Engineer, by dynamic pile measurements in accordance with Section 940.62C.

B. Static Tests.

Static pile load tests shall be conducted in accordance with ASTM D1143, "Standard Method of Testing Piles under Static Axial Compressive Load," except as modified herein.

1. General.

The top elevation of the test pile shall be determined immediately after driving and again just before load testing to check for heave. Any pile which heaves more than 1/4 inch shall be redriven or jacked to the original elevation prior to testing. Unless otherwise specified in the contract, a minimum 3 day waiting period shall be observed between the driving of any anchor piles or the load test pile and the commencement of the load test.

Tell-tales shall be installed in all test piles to determine the percent of the applied test load being transferred to the bearing stratum. Number and location of tell-tales shall be as shown on the plans.

The Department will furnish levels and the personnel necessary to make all evaluations. All measuring devices and gauges that will be required, other than levels, shall be furnished by the Contractor.

Readings of settlement and rebound shall be referred to a fixed benchmark and shall be made using at least two micrometer dial extensometers graduated to one-thousandth of an inch and located 90 degrees apart along the axis of the exposed portion of the pile. Readings shall be taken at intervals specified in Sections 4, 5, or 6, Test Procedures. Readings shall be taken from gauges mounted on a reference beam supported at each end by reliable supports located at least 10 feet from the center of the test pile.

In addition to these readings, elevations to the nearest one-thousandth of a foot by use of an Engineers' level and rod shall be recorded. The entire measuring installation shall be protected from direct sunlight, frost action and other disturbances that might affect its reliability.

The head of each test pile shall be cut-off level or shall be capped in such a manner as to produce a plane, horizontal bearing surface.

All records obtained during the test shall be the property of the Department. Furnishing and driving the piles, complete in place, will be paid for under the item for the type of piles on which the test is made.

Before starting the work, the Contractor shall submit to the Engineer, for approval, a written description of the equipment and method which he intends to use. The method must be of an approved type and shall be altered as necessary to meet the approval of the Engineer.

2. Load Application.

The method of applying the load to the pile will be at the option of the Contractor, provided the method is adaptable to accurate measuring of the applied load, and the method avoids eccentric loading on the pile. The first increment of load shall include allowance for weight of the equipment. Hydraulic Jacks shall be of an approved type and capable of supplying a minimum jacking capacity equal to the maximum test load plus 20%. The Contractor shall provide a load cell, subject to the approval of the Engineer, which is capable of determining load transfer to the test pile. The load cell shall have a capacity equal to the jack capacity, and shall be calibrated by a certified testing laboratory. In addition, the Contractor shall provide a calibration certificate from a certified testing laboratory relating pressure gauge reading to jack load. The Contractor shall submit to the Engineer both calibration certificates prior to load testing.

3. Reaction Loads.

The total reaction load shall be not less than 250 percent of the design load for both the short duration and maintained load tests and 400 percent of the design load for the quick load test method.

Any one of the following devices for applying the vertical loads may be used:

a. *Load Supported Directly by Pile.* A loading platform or box shall be supported on top of the pile to be tested. The construction of the box and the application of the loads shall be such that no lateral forces will be applied to the top of the pile and no impact will occur as the loads are placed. In cases where the test pile is in an excavation below the natural ground surface, an extension column of structural steel or steel pile may be used to extend from the pile head up to the test box.

b. *Load from Weighted Box or Platform Applied to Pile by Hydraulic Jack.* A test box or test platform resting on cribbing shall be constructed over the pile and loaded with suitable material. A hydraulic jack with a recently calibrated pressure gauge shall be interposed between the pile head and the load box and load applied to the pile by operating the jack.

c. *Load Applied to Pile by Hydraulic Jack Acting Against Anchored Reaction Members.* Two or more piles to be used as anchor piles shall be driven at a minimum distance of five feet from the test pile. A girder of sufficient strength to act as a reaction beam shall be fastened to the upper ends of the anchor piles. A hydraulic jack with a recently calibrated pressure gauge shall be interposed between the head of the test pile and the underside of the reaction beam and the test load applied to the pile by operating the jack.

d. *Test Procedures.* The Contractor shall use the load sequence specified under "Short Duration Load Test" unless otherwise directed by the Engineer or the Contract Documents to use the load sequenc specified for "Quick Load Test" or "Maintained Load Test."

The application of the test load shall not begin sooner than 72 hours after placing concrete in Cast-in place and Steel pipe piles and no sooner than 48 hours after other type piles are driven.

A single pile shall be load-tested to not less than twice the design load. When two (2) or more piles are to be tested as a group, the total load shall be not less than one and one-half (1 ½) times the design load for the group.

4. Short Duration Test.

The load sequence shall be as follows:

a. Apply 25% of the design load every one-half hour up to the greater of the following: two hundred percent (200%) of design load; to an applied load which transfers one hundred percent (100%) of design load to the bearing strata as determined from tell-tale measurements but not greater than 90% of the reaction load. Longer time increments may be used, but each time increment should be the same.

b. At the maximum applied load, maintain the load for a minimum of one hour and until the settlement (measured at the lowest point on the pile at which measurements are made) over a one-hour period is not greater than 0.01 inches.

c. Remove 25% of the applied load every 15 minutes until zero load is reached. Longer time increments may be used. but each should be the same.

d. Measure rebound at zero load for a minimum of one hour. In no case shall a load be changed if the rate of settlement is not decreasing with time. For each load increment or decrement, take readings at the top of the pile and on the internal instrumentation at 1, 2, 4, 8, and 15 min. and at 15 min. intervals thereafter.

Provided that the design load does not exceed one hundred percent (100%) of the load transferred to the bearing stratum at the maximum test load, the design load from this test type shall be the greater of the following:

a. Design Load Based on Settlement During Loading:

1. For Piles 24 inches or less in diameter:

Fifty percent (50%) of the applied test load which cause a gross settlement at the pile cutoff grade equal to the sum of: a) the theoretical elastic compression of the pile in inches, assuming all the load on the butt is transmitted to the tip, plus b) 0.15 inches, plus c) one hundred twentieth of the pile tip diameter or pile width in inches, i.e.,

$$S_f = S + (0.15 + D/120)$$

Where:

S_f = Settlement at failure in inches
D = Pile diameter of width in inches
S = Elastic deformation of pile length in inches

2. For Piles greater than 24 inches in diameter or width:

$$S_f = S + D/30$$

If the settlement are so small that the load-settlement curve does not intersect the failure criterion, the maximum test load shall be taken as the failure load.

b. Design Load Based on Net Settlement After Rebound:

Fifty percent (50%) of the applied test load which results in a net settlement of the top of the pile of 1/2 inch, after rebound for a minimum of one hour at zero load.

5. Maintained Load Test.

The test loads shall be applied in at least five increments equal to 50, 100, 150, 175 and 200 percent of the design load. All intermediate load steps shall be maintained constant for a period of two hours. During the loading cycle, the contemplated design load and twice the design load, shall be maintained constant until settlement does not exceed 0.02 inches in 12 consecutive hours, or until the pile has failed as determined by the Engineer. The loading period for twice the design load shall be no less than 24 hours.

The total test load shall be removed in decrements not exceeding 1/4 of the total test load. Each step of unloading shall be maintained constant for a period of 4 hours.

During loading, record readings of time, load, and movement at intervals not exceeding 10 minutes during the first one-half (1/2) hour, 30 minute intervals up to two (2) hours at one (1) hour intervals up to 12 hours and 2 hour intervals thereafter.

During unloading, take readings at intervals not exceeding 20 minutes for the first hour and 1 hour intervals thereafter. Take a final rebound reading 4 hours after all load has been removed.

The design load shall be determined in accordance with the procedures specified in the Short Duration Load Test.

6. Quick Load Test.

This load test shall be performed on individual piles only.

The load shall be applied in increments of 5 to 10 tons and shall not exceed 10% of the design load. The time interval between readings shall be 2½ minutes or as otherwise specified. Add load increments until continuous jacking is required to maintain the test load or until the capacity of either the loading apparatus or reaction load is reached. Hold the failure load or maximum applied load for not less than five (5) minutes. Unload the pile in no less than four equal increments.

Record time, load, and movements immediately, before and after the application or removal of each load increment. Take a final rebound reading 15 minutes after removing all loads. The design load shall be determined in accordance with the procedures specified in the Short Duration Load Test.

C. Dynamic Load Tests.

1. Dynamic Load Test Preparation.

Dynamic measurements will be taken by the Engineer during driving piles designated as Dynamic Load Test (DLT) piles.

Prior to placement in the leads, the Contractor shall make each designated concrete and/or timber pile available for taking of wave speed measurements and for predrilling the required instrument attachment holes. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling. The Engineer shall furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. The instruments will be attached near the head of the pile with bolts placed in masonry anchors for the concrete piles or through drilled holes on the steel piles.

The Contractor shall provide the Engineer reasonable means of access to the pile for attaching instruments after the pile is placed in the leads. If, in the opinion of the Engineer, the instruments cannot be installed before pile is placed in the leads, then a platform with minimum size of 4 × 4 feet (16 square feet) designed to be raised to the top of the pile while the pile is located in the leads shall be provided by the Contractor. It is estimated that the Engineer will need approximately 1 hour per pile to install the dynamic load test equipment.

The Contractor shall furnish electric power for the dynamic load test equipment. The power supply at the outlet shall be 10 amp, 115 volt, 55-60 hertz, A.C. only. Field generators used as the power source shall be equipped with functioning meters for monitoring voltage and frequency levels.

The Contractor shall furnish a shelter to protect the dynamic load test equipment from the elements. The shelter shall have a minimum floor size of 8 × 8 feet (64 square feet) and minimum roof height of 7 feet. The inside temperature of the shelter shall be maintained above 45 °F. The shelter shall be located within 50 feet of the test location.

The pile shall be driven to the depth at which the dynamic analyzer indicates that the ultimate pile resistance shown in the contract plans has been achieved unless directed otherwise by the Engineer.

The stresses in the piles will be monitored during driving with the dynamic analyzer to ensure that the pile stresses determined do not exceed the values which would cause pile damage. The point of impending damage in steel piles is defined herein as a compressive driving stress of 90% of the yield point of the pile

material. For concrete piles, tensile stresses shall not exceed 3 multiplied by the square root of the concrete compressive strength, f'c, plus the effective prestress value, ($3\sqrt{f'c}$ + prestress) and compressive stresses shall not exceed 85% of the compressive strength minus the effective prestress value (0.85 f'c — prestress). For timber piles, the compressive driving stress shall not exceed three times the allowable static design strength listed on the plans. If necessary, the Contractor shall reduce the driving energy output of the hammer in order to maintain stresses below these values. If non-axial driving is indicated by dynamic analyzer measurements, the Contractor shall immediately realign the driving system.

When directed by the Engineer, the Contractor shall wait 12 to 24 hours and then after the instruments are reattached, retap the dynamic load test pile. It is estimated that the Engineer will require approximately 1/2 hour to reattach the instruments. A cold hammer shall not be used for the redrive. The hammer shall be warmed up before redrive begins by applying at least 20 blows to another pile. The maximum amount of penetration required during redrive will be 6 inches or the maximum total number of hammer blows required will be 50, whichever occurs first. After retapping, the Engineer will either provide the cut-off elevation or specify additional pile penetration and testing.

2. Dynamic Load Test by Contractor.

When directed in the Contract documents, dynamic measurements will be taken by the Contractor during pile driving and shall be subject to the Department's field review. Those piles to be tested will be designated as dynamic load test piles or "DLT" on the plans and shall be located by the Department. Preliminary location of piles to be tested are subject to revision by the Engineer. The piles to be static load tested and approximately 10% of the remaining driven piles will be tested by this method unless otherwise directed by the Engineer.

The dynamic tests are to be made by the Contractor's engineer who shall be registered with the Commonwealth of Massachusetts as a Professional Engineer. The same Contractor's Engineer conducting the wave equation analysis shall perform the dynamic load tests. Each dynamic test shall also include a "CAP-WAP" analysis in order to closely model actual field conditions. The damping, quake and soil resistance distribution values will be provided by the Contractor's Engineer. The Contractor's Engineer shall be experienced in the use of the Pile Driving Analyzer (PDA) and its purpose as related to pile capability determination. The Contractor's Engineer will also be proficient in the interpretation of the PDA and "CAP-WAP" data and shall determine the tested pile's capacity based upon this data.

The Contractor shall submit to the Department a written report with a summary of results upon completion of each PDA test including "CAP-WAP" analysis. A copy of the entire PDA and "CAP-WAP" analysis output will be submitted to the Department for review along with the Contractor's report of each PDA and "CAP-WAP" test. The PDA and "CAP-WAP" output will *not* substitute for a written report which includes a summary of the results, but will be submitted *with* such a report.

The Contractor shall submit evidence of the engineer's proficiency to the Department at least 2 weeks in advance of the work to allow the Department adequate time for review and approval or comments. No pile driving will be allowed until written approval has been received from the Engineer.

A. PDA Equipment.

The equipment to perform the dynamic tests shall be a Mode GC pile driving analyzer by Goble, Rausche, Likins and Associates, Inc., 4423 Emery Industrial Parkway, Cleveland, Ohio 44128, phone (216) 831-6131, or approved equal. The equipment shall be complete with all pertinent peripheral equipment necessary to complete and record the test data and complete the analysis of pile capacity.

B. Pile Testing Program.

At least 2 weeks prior to initiating the pile driving operation, the Contractor shall submit a "pile testing program" outline to the Department for review and approval. The following procedure is suggested as an example of a pile testing program which incorporates the wave equation analysis and the dynamic pile driving analysis including the "CAP-WAP" portion of the dynamic testing.

The testing should be performed by experienced engineers. The scope and sequence of testing services is suggested as follows:

1. Perform initial wave equation analysis based on subsurface conditions, pile type, pile capacity, and pile driving equipment to be utilized. See the previously referenced FHWA Manual for examples of the WEAP analysis procedure from static analysis to parameter selection. Submit written report of each wave equation analysis with complete print-out to the Department for review.

2. Drive piles to be static load tested first at locations specified on the plans using the driving criteria established by the wave equation. That driving criteria, however, is subject to change due to actual hammer performance and expected soil strength changes. Dynamic testing with the "PDA" shall be made during the driving of all piles to be static load tested.

3. After performing dynamic load testing on the piles to be static load tested, evaluate static load test piles after a minimum waiting period, to be determined by the Engineer, by restriking the piles with simultaneous dynamic testing by the Pile Driving Analyzer. Restrike testing is considered essential for service load capacity determinations if they are to include setup/relaxation effects since the analyzer gives the pile capacity at the time of testing.

4. The remaining 10% of the piles at each abutment which have been designated for PDA testing should be tested during additional construction control visits. They should be tested on initial installation and restrike, as soil conditions dictate at the discretion of the Engineer. Other than these tests, the Engineer will determine if further dynamic tests should be made when the hammer system is replaced or modified, etc.

5. Perform supplementary, rigorous laboratory wave analysis of the measured data using "CAP-WAP" on all of the piles tested to verify and refine field results, and upon restrike testing.

6. Submit to the Department a written report including a written summary of results in addition to a copy of the actual print-outs. This report will show all pertinent information, upon completion of the PDA testing and "CAP-WAP" analysis of each pile.

7. Based on field results, the following will be reviewed, analyzed and the results of this analysis will be printed in a report by the Contractor's Engineer:

   a. Driving stresses (compression or tension)
   b. Hammer system efficiency
   c. Pile structural damage/integrity
   d. Bearing capacity

8. It should be recognized that each site has unique and often unforeseen characteristics. Judgements are to be made, even during the testing program by the Contractor's experienced engineer performing the test as to deletions or additions to a "standard" program which will result in the most benefit to the foundation design.

940.63 Test Piles (Indicator Piles).

Test piles shall be driven when shown on the plans at the locations and to the lengths specified by the Engineer. All test piles shall be driven with impact hammers unless specifically stated otherwise on the plans. In general, the specified length of test piles will be greater than the estimated length of production piles in order to provide for variation in soil conditions. The driving equipment used for driving test piles shall be identical to that which the Contractor proposes to use on the production piling. Approval of driving equipment shall conform with the requirements of these specifications. The Contractor shall excavate the ground at each test pile to the elevation of the bottom of the footing before the pile is driven.

In the absence of a wave equation analysis, test piles shall be driven to a penetration of 1/2 inch or less after 10 consecutive hammer blows unless the Engineer provides a hammer blow count established by wave equation analysis within a range of tip elevations or unless the driving criteria is established by the dynamic formula.

Test piles which do not attain the bearing value specified above at a depth of 1 foot above the estimated tip elevation shown on the plans shall be allowed to "set up" for 12 to 24 hours as directed by the Engineer before being redriven. A cold hammer shall not be used for redrive. The hammer shall be warmed up before driving by applying at least 20 blows to another pile. If the bearing value is not attained on redriving, the Engineer may direct the Contractor to drive a portion or all of the remaining test pile length and repeat the "set up" redrive procedure. Test piles driven to plan grade and not having the bearing required, shall be spliced and driven until the required bearing is obtained.

A record of driving of test piles will be prepared by the Contractor which includes the number of hammer blows per foot for the entire driven length, the as driven length of test pile, cutoff elevation, penetration in ground, and any other pertinent information requested by the Engineer. The Contractor shall provide the information listed in the "Pile Driving and Equipment Form" to the Engineer for inclusion in the record. If redrive is necessary the Engineer shall record the number of hammer blows per inch of pile movement for the first foot of redrive. The Contractor shall not order piling to be used in the permanent structure until test pile data has been reviewed and pile lengths are authorized by the Engineer.

940.64 Determinations of Required Pile Driving Resistance and Depth of Penetration.

Practical Refusal.

Unless otherwise specified practical refusal will be considered attained when ten blows of an adequate hammer, operating at the number of blows per minute for which the hammer is rated by the manufacturer, are required to produce a total penetration of 1/2 inch. Driving should then cease, provided that the pile has not hit an obstruction and has been driven to the depth at which the borings indicate refusal material or bedrock.

When piles are not either required or directed to be driven to bedrock or refusal, the Engineer shall determine the required driving resistance for safe bearing values and shall establish minimum tip elevations or acceptable bearing stratum depending on subsurface condition. The required driving resistance will be established as described in Section 940.61.

When determining the final driving resistance of the pile, the hammer shall be operated at a speed not less than ninety percent (90%) of the maximum blows per minute specified by the manufacturer. The final driving resistance shall be appropriately adjusted to the actural hammer energy delivered as specified by the manufacturer for the operating speed.

When directed by the Engineer, the Contractor shall make dynamic field measurements to demonstrate the percentage of the hammers rated energy is transferred to the pile head.

940.65 Procedure for Driving.

A. General.

No piles shall be driven except in the presence of the Engineer. Where practicable, piles shall be driven continuously to the required penetration and bearing capacity. When the continuous installation of a pile has been stopped for any reason, the pile advancement shall be started in a manner which will not damage the pile. Any pile which cannot be advanced or which is damaged in the process, shall be rejected and either cut-off and repaired or replaced at the discretion of the Engineer. Rejected piles shall be replaced or repaired at no cost to the Department. Unless specified otherwise by the Engineer, any pile restarted shall be advanced no less than three (3) inches before determining the final driving resistance.

The order of placing individual piles in pile groups shall be either starting from the center of the group and proceeding outwards in both directions or starting at the outside row and proceeding progressively across the group.

If any driven pile is raised more than 1/2 inch by the subsequent driving of adjacent piles, it shall be redriven to the required final resistance to penetration with no compensation for the additional driving.

Cast-in-place and steel pipe piles shall not be filled with concrete until all piles within a footing have been checked for uplift and redriven where necessary unless otherwise directed by the Engineer.

All piles shall be driven a minimum of ten (10) feet into original ground unless otherwise directed by the Engineer.

B. Accuracy of Driving.

The tops of piles at cut-off elevation shall be within 6 inches of plan locations. Furthermore, the as-driven center of gravity of any pile group at cut-off elevation shall be within 5% of the plan location of the center of gravity. No pile shall be nearer than 4 inches from any edge of the cap. Any increase in size of cap to meet this edge distance requirement shall be at the Contractor's expense.

Piles shall be installed so that the axial alignment of the top 10 feet of the pile is within 4% of the specified alignment. For piles that cannot be inspected internally after installation, an alignment check shall be made before installing the last 5 feet of pile or after installation is completed provided the exposed portion of the pile is not less than 5 feet in length. The Engineer may require that driving be stopped in order to check the pile alignment. If the location and/or alignment tolerances specified are exceeded, the extent of overloading shall be investigated and if, in the judgement of the Engineer, corrective measures are necessary, suitable measures shall be designed and constructed by the Contractor at no cost to the Department. Pulling laterally on piles to correct misalignment shall not be permitted.

C. Obstruction.

If conditions during driving indicate that the pile is hitting an obstruction and the obstruction is not in embankment that has been placed under the contract the following shall apply:

1. If the elevation of the top of the obstruction is less than 5 feet below the elevation of the bottom of the footing, the Contractor shall drive through the obstruction or shall use whatever means are necessary to remove or circumvent the obstruction without any additional compensation.

2. If the elevation at the top of the obstruction is 5 feet or more below the elevation of the bottom of the footing, the Contractor shall use a combination of water jet and hammer to drive through the obstruction without any additional compensation.

3. If the use of the combination water jet and hammer (2) above does not allow pile to be driven through the obstruction, upon approval by the Engineer, the Contractor shall exercise one of the following options; a. Drive all surrounding and adjacent piles to the hang-up pile or piles to determine the approximate size of the obstruction, b. Employ the services of a test boring or other such exploratory method.

4. After the approximate size of the obstruction is obtained, the Engineer will determine whether the obstruction is to be removed or if the footing will be redesigned leaving the obstruction in place.

5. If it is determined that the obstruction (3) above is to be removed, the Contractor shall be paid for the work of removing the obstruction under Subsection 9.03.

6. If the footing is redesigned any additional piles or excavation required shall be paid at contract unit prices. Any change in concrete or steel reinforcement shall be paid as specified under Subsection 995.80.

7. No allowance on any kind other than (5) and (6) above and as provided in Subsection 8.09 will be allowed for the above.

940.66 Splices.

A. General.

Full length piles shall always be used where practical.

B. Timber Piles.

Splicing of timber piles will not be permitted.

C. Steel Pipe Piles and Steel H Piles.

Where these piles have to be extended, the spliced connection shall be a continuous full penetration butt-weld. The butt-welding shall be made to develop the full strength of the pile, both in bearing and in bending. Welding shall conform to the applicable provisions of Subsection 960.61.

Butt-weld splicing of piles other than as shown on the plans will not be permitted without express written consent of the Engineer.

Welded splice connections for pipe piles shall be made with a welding or backup ring. Preheat requirements for the welding of pipe piles shall be as specified for ASTM-A-36 steel.

D. Precast-Prestressed Concrete Piles.

Splices shall develop one hundred percent (100%) of the pile strength both in direct stress and in bending. Splices for concrete piles shall be made by the cement-dowel method. Details of the cement-dowel splice shall be shown in the plans. Mechanical splices for concrete or steel piles may be approved by the Engineer if the splice can transfer the full pile strength in compression, tension and bending. Piles shall have only one (1) splice per pile. Splices in the lower 40 feet of the pile will not be permitted.

940.67 Defective Piles.

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse, producing: injurious splitting, splintering and brooming of the wood; deformation of steel; breakage and cracking in precast-prestressed concrete piles.

Manipulation of piles to force them into proper position will not be permitted when considered to be excessive by the Engineer. Piles damaged by reason of internal defects, by improper handling, driving, defective welds or piles driven out of proper location, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the piles in question.

1. The pile shall be withdrawn and replaced by a new and if necessary, a longer pile.
2. A second pile shall be driven adjacent to the defective or low pile.

Damaged steel piles may be spliced at some point such that the completed pile shall be satisfactory.

After the shells for cast-in-place piles and pipe for pipe piles have been driven, they shall be inspected and will be classified defective if any of the following are discovered:

1. The casing shows signs of buckling.
2. The diameter varies more than 15 percent from the original value.
3. The point of the casing deviates more than 10% of the length of the pile below plan cut-off elevation from the design alignment.
4. The casing deviates more than 6% of its length from a straight line connecting the mid-points of the ends of the casing. This requirement shall be taken as satisfied if some segment of the bottom of the casing is visible. If the bottom of the casing is out of sight, the shape and alignment of the casing shall be surveyed with a suitable instrument supplied by the Contractor and approved by the Engineer.
5. The inside of the casing shows any signs of water or soil.

The Contractor shall provide sufficient lights and other equipment necessary to inspect each shell throughout its length.

Precast-prestressed concrete piles which break within 10 feet of ground shall be, at the discretion of the Engineer, either replaced or cut-off and spliced at no cost to the Department. Piles which break below 10 feet from ground surface shall be rejected and replaced by the Contractor at no cost to the Department. The Engineer may elect to use dynamic measurements to aid in evaluating pile integrity.

940.68 Cutoffs

A. Timber Piles.

The tops of piles shall be sawed off to a true plane at the grades shown on the plans. All cuts and abrasions on treated piles shall be repaired in accordance with AWPA Standard M4.

Nail holes shall be filled by driving galvanized nails flush with the surface of the pile.

B. Steel or Cast-In-Place Piles.

After driving has been completed the steel or cast-in-place-piles shall be cut off at the directed grade. Cutting of piles shall not be done until it is certain that further operations will have no effect on the previously driven piles.

Temporary capping devices shall be provided for cast-in-place and steel pipe piles immediately upon cut-off to prevent soil and water from entering driven piles prior to placing concrete.

C. Precast-Prestressed Concrete Piles.

Precast-prestressed concrete piles shall be cut-off at the grades specified on the plans documents. Piles shall not be cut-off until it is certain that further pile driving operations will have no effect on the driven piles.

940.69 Placing and Protecting Concrete Filled Piles.

No concrete shall be placed in a shell or pipe until all piles within a footing have been satisfactorily driven, inspected and approved by the Engineer. No concrete shall be placed except in the presence of the Engineer.

Prior to placing concrete in each pile, one cubic foot of mortar, having a slump of not more than 3 inches, shall be deposited in the bottom of the pile.

Concrete shall then be deposited in the casing through a funnel having a neck not more than 1 ½ feet long and not more than 7 inches in diameter. The funnel shall be provided with supports at the neck to permit air to escape during the concrete placing operation.

Placing of concrete in each pile shall be continuous and in a manner which will assure complete filling of the casing. The slump of the concrete shall be from 3 to 5 inches.

Special care shall be exercised in filling the casing to prevent honeycomb and air pockets from forming. Internal vibrators and other means shall be used to the maximum depth practicable, as determined by the Engineer, to consolidate the concrete.

During cold weather the pile heads and surrounding ground shall be covered by straw or other suitable protection to prevent frost from damaging the concrete itself or heaving the ground.

During the hot weather pile heads shall be protected by suitable covering material.

COMPENSATION

940.80 Method of Measurement.

The length of piles to be paid for shall be the total length in place, measured from the tip of the pile to the plane of the plan cut-off elevation.

Timber pile cut-offs will be measured by the linear foot and the length to be paid for will be the difference between the length of piles approved by the Engineer on the schedule submitted by the Contractor and the length of piles in place, but will not include any lengths cut-off for correction of damaged ends or for piles rejected by the Engineer.

Precast-prestressed piles will be measured by the linear foot from the tip of the pile including any steel extension installed for protection (to the plan cut-off elevation) and any extensions required to reach the cut-off elevation.

940.81 Basis of Payment.

Timber piles will be paid for at the contract unit price per linear foot under the item for Untreated Treated Timber Piles, left in place, or under the item for Treated Timber Pile, left in place.

If timber piles furnished according to the approved schedule of length prove inadequate to sustain the required load, the Engineer may in writing make changes in the schedule previously approved by him and the piles ordered and driven according to the revised schedule will be paid for at the contract unit price per linear foot.

If as a result of the revised schedule or as a result of timber pile cutoff being used as piles, any of the timber piles which have been purchased by the Contractor in accordance with the approved schedule, cannot be used elsewhere on the project, such piles not used will be paid for under the provisions of Subsection 9.03, except that no profit or overhead will be allowed and subject to an allowance for their fair salvage value of the piles. In no case will payment for these piles exceed 50% of the bid price per linear foot of either treated timber piles or untreated timber piles.

Payment for cut-off allowance on treated and untreated timber piles will be made at 50% of the respective bid price per linear foot. The cut-off shall become the Contractor's property.

Timber test piles, whether used in the structure or driven outside the structure, will be paid for at the contract unit price for each pile driven under the item for Timber Test Pile. When the test pile is not used in the structure, the price shall also include full compensation for the removal of the test pile, or cutting off two feet below finished grade of ground and backfilling the hole with suitable material.

Steel piles will be paid for at the contract unit price per linear foot under the item for Steel Piles, complete in place.

Cast-in-place concrete and steel pipe piles will be paid for at the contract unit price per linear foot under the items Cast-in-Place Concrete Piles and Steel Pipe Piles, complete in place, including the concrete and steel reinforced cement.

Piles driven as Test Piles or for Load Tests, if incorporated in structures, will be paid at the contract unit price for the length in place under the item for the type of pile.

No payment will be made for the cut-off of precast-prestressed or steel piles.

Pile shoes will be paid per each on piles accepted for payment by the Engineer.

All costs for splicing piles shall be included in the contract unit price per linear foot for the respective pile item, which price shall also include full compensation for delays incurred by splicing of piles or by any other operations in connection with the work on piles.

Pile loading tests will be paid for at the contract unit price for each pile tested under the item for a specific load sequence.

The contract price shall also include full compensation for any interruptions to pile driving or other operations in the vicinity of the pile loading tests. The test at each pile shall be considered completed when all materials and equipment used in the test have been removed.

If a pile load test is applied to a steel pipe pile, cast-in-place concrete pile, or precast-prestressed concrete pile, then the contract price for a load test shall also include full compensation for cutting the pile to the grade necessary to properly incorporate the pile in the structure or, if it is not to be incorporated in the structure, for cutting the pile to the grade necessary to avoid its interference with the proposed construction.

The cost of performing Wave Equation Analysis shall be included in the contract unit price per linear foot of pile.

Payment for initial and restrike dynamic pile measurements will be at the contract unit price per pile tested. The price shall include costs for all sensory and wiring devices, monitoring equipment; the setting up and checking of equipment, monitoring personnel; costs associated with Contractor's down time during regular working hours while setting-up equipment and making dynamic measurements.

940.82 Payment Items.

940.	Untreated Timber Piles	Linear Foot
941.	Treated Timber Piles	Linear Foot
942.*	Steel Pile, HP —x—	Linear Foot
943.*	Steel Pipe Pile —inch OD	Linear Foot
945.	Cast-in-Place Concrete Piles	Linear Foot
946.	Precast-Prestressed Concrete Pile	Linear Foot
947.1	Timber Test Pile	Each
948.1	Short Duration Load Test	Each
948.2	Maintained Load Test	Each
948.3	Quick Load Test	Each
948.4	Dynamic Load Test Preparation	Each
948.41	Dynamic Load Test by Contractor	Each
948.5	Pile Shoes	Each
999.940	Untreated Timber Pile Cut-off	Linear Foot
999.941	Treated Timber Pile Cut-off	Linear Foot

*Designation by size and weight.

SECTION 950
SHEETING

DESCRIPTION

950.20 General.

This work shall consist of furnishing and placing lumber, wood or steel sheeting of the kinds and dimensions required, complying with these specifications, where indicated on the plans or where directed. All dimensions specified for lumber are nominal dimensions.

MATERIALS

950.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III. Materials:

Lumber Sheeting	M9.05.0
Wood Sheeting	M9.05.0
Steel Sheeting	M8.05.4

CONSTRUCTION METHODS

950.60 General.

Work shall not be started until all materials and equipment necessary for their construction are either on the site of the work or satisfactorily available for immediate use as required. Sufficient labor and equipment shall be employed to insure the completion of the excavation, placing of the concrete and backfilling in the shortest possible time.

Where no other direction is given, sheeting shall be driven to such depth that the footing may be lowered at least 2 feet below the elevation shown on the plans without any change in the sheeting as driven.

Sheeting that is to be paid as sheeting left in place shall be driven to a minimum depth of 5 feet below the proposed bottom of the concrete footings unless otherwise directed. After sufficient progress has been made on the construction the sheeting shall be cut off at the tops of the footings or as otherwise directed.

950.61 Placing of Sheeting.

The sheeting shall be securely and satisfactorily braced to withstand all pressures to which it may be subjected and be sufficiently tight to prevent any flow of water or material into the space in which concrete is deposited. The bottom edge of each piece of lumber and wood sheeting shall be so sharpened as to lead the toe of the sheeting away from the excavation. Jetting may be done only with the approval of the Engineer, but it will not be permitted when excess of water may endanger railroad tracks or other structures.

Where sheeting is to be used as a form for placing concrete the sheeting shall be driven entirely outside the neat lines shown on the plans for the concrete.

When, in the Engineer's judgment, the foundations must be altered to such an extent that changes must be made in the depths to which sheeting has been driven, or the area enclosed by the sheeting must be changed, the Contractor shall make the directed changes in accordance with the provisions of Subsection 9.03, Payment for Extra Work.

950.62 Cut-Off.

The sheeting shall be driven down or cut off to the elevation shown on the plans or directed by the Engineer. No sheeting may be left so as to create a possible hazard to navigation of a stream, safety of the public, obstruction to flow of water, or a hindrance to traffic of any kind.

950.63 Care Near Railroads.

When sheeting is driven adjacent to railroad tracks, the Contractor shall keep on the work site, quickly available for use, such equipment and operators needed to immediately burn or cut off any sheeting that cannot be driven into the clear before the arrival of trains.

950.64 Disposal of Cut-off and Waste Materials.

No cut-off shall be allowed to float away in a stream or left in such a manner as to obstruct the flow of water.

All cut-off will become the property of the Contractor and shall be removed by him from the site.

At the option of the Contractor, steel sheeting cut-offs may be used as sheet piling or parts of sheet piling. If welding is used, such welds shall be full butt-welds designed to develop the full strength of the sheet pile, both in bearing and bending, and shall conform with any of the prequalified joints shown in the specification for welded Highway and Railroad Bridges of the American Welding Society.

950.65 Defective Work.

The responsibility for the exact satisfactory construction and maintenance of sheeting complete in place shall rest with the Contractor and any work done which in the performance of incidental construction is not acceptable for the intended purpose shall be either repaired or removed and reconstructed by the Contractor at his expense.

COMPENSATION

950.80 Method of Measurement.

The items of Lumber Sheeting, Wood Sheeting, or Steel Sheeting will be a pay item only if indicated on the plans or in the Special Provisions to be left in place or when ordered left in place by the Engineer as a permanent part of the foundation. Otherwise the Contractor may remove the sheeting or abandon it at his option, provided that sheeting may be abandoned only to the extent permitted by the Engineer.

Lumber or Wood Sheeting, when indicated on the plans or in the Special Provisions to be left in place or when ordered by the Engineer to be left in place as a permanent part of the foundation, will be measured by the thousand feet board measure of lumber or wood sheeting. The quantity to be paid for will be the area of sheeting left in place multiplied by the nominal thickness.

Steel sheeting, when indicated on the plans or in the Special Provisions to be left in place or when ordered by the Engineer to be left in place as a permanent part of the foundation, will be measured by the pound. The weight of the quantity to be paid for shall be calculated on the basis of 22 pounds per square foot of wall in place. No additional compensation will be allowed if a heavier sheeting is used unless such heavier sheeting is specified in the Special Provisions, or shown on the plans.

950.81 Basis of Payment.

Steel sheeting, when indicated on the plans, in the Special Provisions, or when ordered by the Engineer, to be left in place as a permanent part of the foundation, will be paid for at the contract unit price per pound under the item for Steel Sheeting. The contract unit price per pound shall also include full compensation for anchors, when required, for the sheeting.

Lumber or Wood when indicated on the plans or in the Special Provisions to be left in place or when ordered by the Engineer in writing to be left in place as a permanent part of the foundation will be paid for at the contract unit price per thousand feet board measure for Lumber Sheeting or Wood Sheeting.

No direct payment will be made for any sheeting not indicated on the plans or in the Special Provisions or not ordered in writing by the Engineer to be left in place as a permanent part of the foundation. Such sheeting will be considered as incidental work necessary for the proper prosecution and protection of the work during construction operations and compensation therefor shall be included in the prices bid for the various items of work for which the sheeting was used. If the Contractor elects to leave such sheeting in place with the approval of the Engineer, no payment will be made for same as sheeting left in place.

For purposes of partial payment, except as noted below, the sheeting item will be considered 90 percent done when the sheeting has been completely driven and the area within the sheeting is ready for such work as may be required to be done therein. The sheeting item will be considered completed when the sheeting has been cut at the required elevation.

950.82 Payment Items.

950.	Lumber Sheeting	MBM
951.	Wood Sheeting	MBM
952.	Steel Sheeting	Pound

SECTION 955
TREATED TIMBER

DESCRIPTION

955.20 General.

Treated timber shall be used where indicated on the plans and where directed.

MATERIALS

955.40 General.

Material shall meet the requirement specified in the following Subsection of Division III. Materials:

Treated Timber	M9.05.1
Fastenings	M8.01.5
Tar Paper	M9.06.2
Preservatives	M9.05.5

CONSTRUCTION METHODS

955.60 General.

Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, pikes or hooks shall not be used.

The Contractor shall keep available at the site the preservatives and equipment for brush coating all treated timber that has been bored for fastenings or otherwise cut after treatment. The preservatives applied at the site shall be the same grade and concentrations used at the plant. They shall be applied hot and in two coats, the second application made after the first has been fully absorbed. Holes that would otherwise remain unfilled shall be treated with a pressure bolt-hole treater and then closed with a treated plug.

A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with timber. The nuts of all bolts shall be effectively locked after they have been finally tightened.

Fastenings shall conform to Subsection M8.01.5 for anchoring bridge bearings.

Stringers and other members supporting planking shall be capped with tar paper.

955.61 Inspection.

All materials will be inspected either at the place of manufacture or upon arrival at the site where it is to be used. All materials not conforming in every detail with the requirements of these specifications will be rejected and removed from the work by the Contractor.

COMPENSATION

955.80 Method of Measurement.

All treated timber used will be measured by the thousand feet board measure, in place.

The quantities will be measured according to the following dimensions:

For wheel guards, sleepers, blocking, bracing, isolated timbers and similar lumber, the nominal size of the timber and the actual length in place.

For platforms, decks and similar lumber, the nominal thickness of plank and the overall area, with no deduction for directed spaces between planks.

No allowance will be made for waste or cut-off.

955.81 Basis of Payment.

Treated timber will be paid for at the contract unit price per thousand feet board measure under the item for Treated Timber complete in place.

955.82 Payment Items.

955.	Treated Timber	MBM

SECTION 960
STRUCTURAL STEEL

DESCRIPTION

960.20 General.

This section shall apply to the furnishing, fabrication, erection and painting of all structural steel and metal work in the contract.

The work shall be done in accordance with the requirements of AASHTO Standard Specification for Highway Bridges and American Welding Society Specification for Welded Highway and Railway Bridges with the following additions:

MATERIALS

960.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III. Materials:

Structural Steel	M8.05.0
Steel Pins	M8.04.2
High Tensile Strength Bolts	M8.04.3
Bronze Self-Lubricating Bearing Plates	M8.11.0
Iron Casting	M8.03.0
Paints and Protective Coatings	M7.00.0
Steel Baffles & Drainage Troughs	M8.05.3
Bearing Pads Supports	
Moulded Fabric	M9.16.2
Rubber - Cotton Duck	M9.16.1
Sheet Lead	M9.16.0

The Contractor will be required to submit to the Department's Inspector, for approval, 3 certified copies of the mill test report for each kind of steel furnished. These certificates shall certify compliance with the specifications and shall give the chemical and physical analysis of the steel and shall contain marking numbers as used on steel as required in AASHTO M-160 (ASTM A6) so as to be able to reference certificates to steel covered by certificates. Any cost involved in furnishing the certificates shall be borne by the Contractor.

CONSTRUCTION METHODS

960.60 Shop Drawings.

After the Contract has been awarded, and before any shop work is commenced, the Contractor shall submit complete sets of prints of the shop drawings as specified in Subsection 5.02.

On projects which contain more than one bridge, each bridge will be considered separately in submitting shop drawings. Shop work can commence on each bridge as the shop drawings on that bridge are approved.

On projects which contain complicated steel structures such as viaduct, long span bridge, etc., the Contractor shall submit a schedule showing how he intends to divide the steel structure into sections. After this schedule is approved, shop work can commence on each section as the shop drawings for that section are approved.

Unless otherwise noted, dimensions indicated at expansion joints and similar construction are determined for a temperature of 50 °F. The proper adjustments for temperature must be made by the Contractor when the structure is placed at any other temperature.

If steel expansion joint assemblies are used, they must be properly fitted in the shop and shipped with a device for maintaining proper spacing and fit as shown on the plans. Bolts on shipping device must be loosened within one hour after concrete is placed, so that movement may take place. The device shall be removed after concrete has set on both sides of the assembly.

960.61 Design, Fabrication and Erection.

All structural steel and appurtenant material shall be designed, fabricated and erected in accordance with these specifications, the AASHTO Standard Specifications for Highway Bridges, and the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5).

A. Fabrication.

Approval of Metal Fabricators.

Before any steel or other metal members are ordered by the Contractor, the fabricator or fabricators shall be approved by the Engineer. Fabricators of structural steel shall be, as a minimum, certified in accordance with the American Institute of Steel Constructor's Quality Certification Program or an approved equal. Fabricators of miscellaneous welded steel and steel products, such as, expansion dams, sign structures, bridge rail, and lighting poles, shall meet the requirements of AISC Category I while fabricators of rolled beams, with cover plates, girders and more complex work shall meet the requirements of AISC Category III or an equivalent. A list of approved fabricators may be obtained upon request.

Fabricators wishing to be approved by the Depatment shall submit the following:

1. Description of facility including history, capacity and equipment.
2. Quality Control Manual.
3. Table of Organization.
4. Welding Procedure Specifications and Welding Procedure Qualification Test Records.
5. Welder and Welding Operator Qualification Test Records.
6. Resumes of supervisory personnel and resumes of all personnel involved in quality assurance, quality control and testing.
7. Copy of American Institute of Steel Construction Program Certificate or equivalent.[1]

[1]The flexibility of manufacturing processes and variations in plant size negate any attempt to standardize qualification requirements. Therefore, fabricator approval is done on a plant to plant basis. In general, the Department follows the United States Department of Defense quality control requirements that considers the interdependent relationships within the fabricators management and quality control systems. This allows for system and procedure adjustment by negotiation between the fabricator and the Department. Approval will be periodically reviewed to assure the maintenance of quality standards.

The Contractor shall submit a shop schedule to the Engineer. The schedule shall be provided sufficiently in advance for the Engineer to determine the level of quality verification inspection required and for inspector's attendance. No material shall be fabricated until the schedule is received and reviewed.

The fabricator shall provide facilities for the Department's inspectors in direct proximity to the work. These facilities shall include a secured office with a desk and chair for each inspector, a file cabinet provided with a lock, a plan rack and a table adequate to review plans and drawings. The office shall have a minimal floor area of 120 sq. ft. The office shall contain a telephone and a system of heating and cooling that will maintain a temperature of 72 °F.

The Contractor shall submit to the Department's inspector a certified mill test report for all steel furnished for the project. These test reports shall give the physical and chemical properties of the material and shall note the appropriate AASHTO and ASTM designation. If the Contractor proposes to use steel from a source other than a mill, the source must be approved by the Engineer. The Contractor shall provide the Engineer with a description of the proposed facility along with the method used by the facility to segregate, identify, and otherwise assure the Engineer that the supplied material is in conformance with specifications. All sources must supply the actual mill test report for the material to be used.

B. Inspection.

Quality control inspection and testing and verification inspection and testing are separate and distinct functions. Quality control inspection is the responsibility of the fabricator and shall be performed by sufficient qualified inspectors to guarantee product integrity. Quality control inspection shall be performed prior to and during assembly, as well as during and after welding. The manufacturer and fabricator shall maintain adequate inspection records. Such records shall be provided to the Engineer upon request.

Quality control inspectors at fabrication plants shall be certified by the American Welding Society in accordance with the provisions of the *Standard for Qualification and Certification of Welding Inspectors (AWS QCI)*. The Engineer, upon written request of the fabricator, may accept other certifications or experience and training consistent with AWS QCI, subject to review and testing by the Engineer. Assistant Inspectors may be used to perform specific inspections under direct supervision of a Quality Control Inspector when approved by the Engineer.

Quality Verification Inspectors will be employed by the Engineer and act on his behalf. The Inspector has authority to act for the Engineer on matters relating to quality including inspection and testing, within the scope of the Contract. Quality Verification Inspectors will be assigned at the discretion of the Engineer. The presence or absence of the Verification Inspector will not relieve the Contractor of quality control responsibility.

No material shall be shipped to a project until the Quality Control Inspector certifies that the material has met all provisions of the Contract. Such certificate shall be endorsed by the Verification Inspector who then shall place his acceptance stamp on the material. The Verification Inspector will affix his stamp only when the material is ready for shipment and properly loaded on trucks or rail cars. Material delivered to the project without such stamp affixed will be considered rejected and shall not be unloaded but immediately removed from the job site.

Non-Destructive Testing Personnel.

Personnel performing radiographic, magnetic particle and dye-penetrant tests shall be certified by a Level III technician who shall have attained certification by examination. Personnel performing radiographic, magnetic particle and dye-penetrant tests shall be qualified in accordance with the current edition of the American Society for Nondestructive Testing, Recommended Practice SNT-TC-1A. Only individuals qualified for NDT Level II, and certified as noted above, may perform non-destructive tests.

When ultrasonic testing is required, it shall be performed by technicians who shall be qualified by a written examination and performance test administered by the Engineer. The Engineer at his discretion may accept other properly documented certification.

Non-Destructive Testing.

All non-destructive testing shall be made by the Contractor in accordance with the procedures and standards set forth in the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5). The Department reserves the right to perform any testing at its own cost during fabrication and up to the final acceptance of the project. All welding must meet acceptable quality standards which are defined by the acceptance criteria for the particular test method of the governing welding code.

All non-destructive testing must be witnessed by the Department's Inspector. Certification that the magnetic particle inspection was completed satisfactorily in the presence of the Inspector shall be furnished to the Engineer. All radiographs shall be identified as to date, bridge number, girder, or beam number in addition to that required by the code. All costs for the above radiographs and magnetic particle tests, rewelding if required, and inspection of rewelding work, shall be at the Contractor's expense. Inspection of original radiographs and magnetic particle tests shall be at the Department's expense.

C. Process.

Structural steel shall be blast cleaned prior to fabrication. The blast cleaning shall conform to Steel Structures Painting Council Surface Preparation Specification "Near-White Blast Cleaning," SSPC-SP10.

Heat numbers shall be transferred (in the presence of Inspector) to any pieces which are to be major component parts of a main member (such as web, flange, cover plates, etc.) but heat numbers are not required to be transferred to component parts of secondary members or to minor component parts of a main member (such as stiffeners, clip angles, etc.).

Structural rolled beams that directly support the bridge deck concrete shall be cambered to the amount shown on the plans with a zero minus tolerance and with a plus tolerance of 1/2 inch for beam 50 feet and less, and a plus tolerance of 1/2 inch plus 1/8 inch for each 10 feet or fraction thereof in excess of 50 feet.

Plate girders that directly support the bridge deck concrete shall be cambered to the amount shown on the plans with a tolerance as specified in AWS Specifications for Welded Highway and Railway Bridges.

Total camber as specified on the plans shall be measured with the beams or girders in a no load position (beam or girder laying on its side).

The beams and girders shall be handled and stored in such a manner that they will have the required camber after erection.

When steel stringers or girders are to be spliced in the field, they shall be assembled in the fabricating shop in the no load position (stringer or girder laying on their side) in order that the assembly, including camber, alignment accuracy of holes and fit of stringer or girder ends may be done in accordance with the requirements of the type of splice. The requirements of AASHTO for shop assembly shall also apply.

All structural parts shall be provided with adequate drain holes at points where water could otherwise accumulate.

D. Erection.

Within sixty days of the date of the Notice to Proceed, the Contractor shall submit an erection procedure. The submitted method of erection is subject to review, comment, and approval by the Engineer. The method must be submitted with a detailed procedure which includes drawings and calculations sufficient to enable the Engineer to determine the adequacy of the proposed method.

The method and all submissions shall be prepared under the supervision of a professional engineer registered in Massachusetts. Such engineer must be familiar with these Specifications, those of the American Association of State Highway and Transportation Officials (AASHTO), the work, and be experienced in this technical field. All submitted sheets shall be stamped by the supervising engineer.

The stresses shall be investigated at each stage of erection with allowance for wind pressure determined by the following table:

Height of Members Above Ground-Ft.*	West of Longitude 71°–41′ Shrewsbury P.S.F.		East of Longitude 71°–41′ Shrewsbury P.S.F.	
	Beams & Girders	Trusses	Beams & Girders	Trusses
15	16.0	24.0	21.0	31.5
30	19.5	29.25	25.5	38.25
50	21.5	32.25	28.0	42.0
100	24.5	36.75	32.0	48.0
300	29.5	44.25	39.0	58.5

*For heights not given wind pressures shall be interpolated.

As a minimum the following information shall be included in the submittal:

1. Plan showing the location of all roadways, utilities, railroad tracks and other appurtenances in areas of erection.
2. The location of cranes, both horizontally and vertically, and their operating radii.
3. Lifting equipment information including rating data. Information shall include counter weights to be used and boom capability. (crane capacity shall be adequate for 125% of the total pick weight which shall include spreaders and other material except that in the area of railroads or other traffic, the capacity shall be adequate for 150% of the total pick weight.)
4. The type, size and arrangements of slings, shackles or other lifting and connecting devices including relative technical data.
5. The order of lifts, repositioning of equipment and weights, and location and method of attaching deadmen.
6. Methods and materials for temporary structures or the strengthening or bracing of a member (either temporarily or permanently) for erection purposes.

Curved girders and long span straight girders shall be stabilized with falsework, temporary braces, or holding cranes until a sufficient number of adjacent girders are erected with all diaphragms and crossframes connected to provide necessary lateral stability. All trusses shall be erected on falsework unless otherwise approved by the Engineer. The falsework shall provide for proper camber and alignment and shall be properly designed, constructed, and maintained for the loads which will be imposed upon it. When erecting trusses, the falsework shall be left in place until all connections are bolted and accepted by the Engineer unless otherwise provided in the approved erection procedure. Care shall be taken in the use of falsework and other temporary supports to insure that the temporary elevation of structural steel provided by the falsework is consistent with the deflections that will occur as the structure is completed.

In instances where falsework is required by the contract or proposed as part of the erection procedure, it shall be properly designed, constructed, and maintained for the loads that it will bear. Plans for falsework along with necessary engineering data shall be submitted to the Engineer for review, comment, and approval under the same guidelines as the erection procedure. In instances where changes in an existing structure are necessary to maintain traffic; plans, details, and calculations shall also be submitted to the Engineer.

The Contractor shall keep a full record of piles driven for false-work. If the Contractor does not make a pile loading test, the pile bearing formulas of Subsection 940.61 shall be used to determine the bearing values.

Erection drawings shall show bolting or welding procedures necessary to complete erection. Procedures shall include sequence and method of connecting main members and secondary members. For stringer and girder spans, the following minimum information shall be included in the notes, modified as necessary to conform to design and erection requirements for each structure:

1. Splices and field connections of main stress carrying members shall be made with a minimum of 50% of the holes filled with approved high strength bolts and erection pins before the external support system is released. At lease one-half of this percentage shall be bolts, tightened to specification requirements. The bolts and pins shall be installed uniformly throughout the connection except that erection pins shall be used in the extreme corners of all main connections.

2. Members to be assembled on the ground before erection shall be blocked to their proper "no load profile" and 100 percent of the approved high strength bolts shall be installed and tightened to specification requirements before erecting the member.

3. All diaphragms and crossframes shall be installed between stringerlines as the work progresses.

4. Unless otherwise noted, dimensions indicated at expansion joints and similar construction are determined for a temperature of 50 °F. Proper adjustments must be made when the structure is placed at any other temperature.

After erection of beams and girders has been completed, rockers shall be re-aligned so that they will stand vertical at 50 °F under full dead load.

960.62 Preparation of Bridge Seats.

Masonry bearing plates shall not be placed upon bridge seat bearing areas which are improperly finished, deformed or irregular. Bearing plates shall be set to grade and level in exact position and shall have full and even bearing upon the masonry after the following preparation.

Bearing plates shall be set to grade on sheet lead, a system of cotton duck impregnated with rubber or moulded pads with a full and even bearing. The bearing area of concrete three (3) inches outside of bearing plate shall be constructed at least one-quarter inch above the proposed finished grade, and shall then be dressed down sufficiently so that the lead, cotton duck or moulded pads will bring the area to the correct grade.

Where steel bearing plates are used for pre-stressed concrete beams, the bridge seats shall be prepared as described above.

960.63 Painting.

The surfaces of structural steel which are to be in contact with concrete shall be painted with a shop coat of paint meeting the requirements of M7.02.21 as noted hereinafter. All other structural steel shall receive three coats of paint except as noted.

No paint shall be applied to the shear connectors or to the flange surface of the beams to which shear reinforcement is to be welded.

Diaphragms, cross frames and bottom lateral bracing shall be zinc-coated (hot-dipped galvanized). The coating shall be in accordance with AASHTO M111. The galvanizing bath shall contain nickel (not less than 0.5% by weight). Members which have been hot dipped galvanized shall not be painted.

Upon completion of the welding, the welds shall be cleaned thoroughly in accordance with good practice and shall have a suitable surface to accept the primer; the steel shall have no visible rusting or detrimental rusting prior to painting; if any rusting or other detrimental material such as oil, grease, etc. has appeared upon the steel, the steel shall be re-blasted to SSPC-SP-10 cleaned surface and shall receive one shop coat of inorganic zinc rich primer (M7.02.21) having after application a minimum dry film thickness of 3 mils (0.003 inches — 76.2 microns); after erection, the surface shall be cleaned of any zinc residue products due to exposure, and shall receive a basic zinc chromate vinyl butyral wash coat (M7.04.10) having after application a minimum dry film thickness of 0.3 to 0.5 mils (0.0003 to 0.0005 inches — 7.62 to 12.7 microns); and within 24 hours of the application of the wash coat shall receive a finish coat of high build brown vinyl (M7.02.25)

having after application a minimum dry film thickness of 4 mils (0.004 inches — 101.6 microns). Both field coats shall be applied by the airless spray method. The field coats of paint shall be manufactured by the manufacturer of the prime coat.

The shop coat of paint shall have dried and the structural steel so painted shall not be delivered to the common carrier for shipment to the job site in less than 2 days after the application of the shop coat of paint, except by written permission of the Engineer.

Full protection shall be provided in the field for all surfaces that are not to be painted and for all private property.

Paint shall not be applied on shop contact surfaces. Field contact surfaces shall receive a shop coat of paint.

Structural steel shall not be painted until after shop welding is completed. Machine finished surfaces, except abutting joints and base plates shall be coated with a material suitable to the Engineer. Surfaces not in contact but inaccessible after assembly erection shall be painted in the shop with one coat of inorganic zinc rich primer (M7.02.21) having after application a minimum dry film thickness of 3 mils (0.003 inches — 76.2 microns) and followed with one coat of coal tar epoxy — polyamide paint (SSPC-P-16) having after application a minimum of 8 mils (0.008 inches — 203.2 microns).

Erection marks for field identification of members shall be painted on previously painted surfaces with a paint or ink compatible to the coatings system being used.

When the erection of steelwork is fully completed, all adhering rust, scale, concrete, laitance, dirt, grease, welding flux and slag, white rust or other foreign matter shall be removed. Immediately after cleaning of the steel has been done to the satisfaction of the Engineer and prior to the application of the first field coat of paint, all steel surfaces that require painting (including bolts, weld, etc.) and which are exposed or have become exposed to base metal and any surface from which the shop coat has become defective shall be thoroughly covered with one shop coat of organic zinc rich primer (M7.02.20) having after application a minimum dry film thickness of 3 mils (0.003 inches — 76.2 microns).

In order to avoid subsequent discoloring or staining due to dripping or running of concrete, finish coat of field painting of the steel shall not be done until all concrete nearby has been placed and all forms have been removed. Concrete, stone masonry, and other parts of the structure that are not to be painted shall be fully protected by covers during painting operations.

Paint shall not be applied when the air temperature is below 40 °F (4.4 °C) nor shall the paint be applied when the air temperature is greater than 125 °F (52 °C). Painting shall not be undertaken in rain, snow, fog or mist or when the temperature of the metal surface is below the dewpoint. Paint shall not be applied when the relative humidity exceeds 85%. When paint must be applied in damp or cold weather, the steel shall be painted under cover and shall remain under cover until dry or weather conditions permit its exposure in the open. Painting shall not be undertaken for any of the above or when, in the Engineer's judgement conditions are otherwise unsatisfactory for the work.

The contractor shall supply mechanical paint mixers on the job. Paints should be mixed in clean containers and agitated thoroughly before drawing off paint through a strainer into the painter's buckets and/or spray machines. Paint shall be kept thoroughly stirred in spray pots or containers during application and the zinc rich primers shall have continuous agitation.

Paints specified are formulated ready for application and if for any reason it is necessary to thin the paint, the method used to thin the paint shall not produce a dry — film thickness less than specified above. The method used to thin the paint and the thinner to be used shall be approved by the manufacturer of the paint and the Engineer.

All small cracks and cavities which have not been sealed in a watertight manner by the first field coat shall be filled with a coating conforming to M7.04.11.

The date (year and month) of painting and the maintenance bridge number shall be stencilled on the bridge as directed by the Engineer. The stencils shall be furnished by the Contractor at his expense.

When a multi-coat system of paint is specified, all coats of the system shall be manufactured by the same paint manufacturer.

COMPENSATION

960.80 Method of Measurement.

Payment will be based only on computed weights of steel complete in place in the structure. No additional allowance in weight will be made for the shop coat of paint or for any other coat of paint or other protective covering.

The weights of rolled shapes and of plates, regardless of the width of the plates shall be computed on the basis of their nominal weights and of their dimensions as shown on the approved shop drawings, deducting for copes and cuts, and for all open holes that are not to be filled with rivets, bolts or plug welded.

Steel for expansion assemblies at the roadway level of bridges and similar structures (whether or not attached to the structural steel of the deck) and bronze or other metal for expansion bearings, drainage troughs and baffles, shall be included in the weight to be paid for as structural steel. Where no separate items are in the contract for galvanized nose angles on piers, or curb plates or angles in bridge curbs, such steel will be paid for by the pound as structural steel, with no additional compensation for the galvanizing.

Computed weights shall not include the weight of welds.

The weights of the various metals shall be assumed as follows:

Steel (Structural, Cast, Galvanized)	490 lbs. per cu. ft.
Cast Iron	450 lbs. per cu. ft.
Bronze	542 lbs. per cu. ft.

The weight of heads of rivets shall be included in the computed weights, assuming the weights to be as follows:

Diameter of Rivet, Inches.	Weight Per 100 Heads, Pounds.
1/2	4
5/8	7
3/4	12
7/8	18
1	26
1⅛	36
1¼	48

Payment for rivet heads will be made by the pound. Where high tensile steel bolts are used in the permanent construction, the nuts and heads of these bolts shall be considered, for the purpose of payment, as rivet heads for rivets equal in diameter to the bolts, regardless of the material of which they are composed or the materials which they fasten.

All permanent washers will be paid for by the pound. The shank of a bolt will be considered as part of the material through which it passes and will be paid for as part of that material. No allowance or payment will be made for that part of a bolt shank that extends through and past the nut.

960.81 Basis of Payment.

The furnishing, fabricating, erecting and painting of all structural steel and all metal work for the structure not otherwise provided for, will be paid for at the contract unit price per pound under the item for Structural Steel, complete in place.

To avoid delay in computation of the weight for partial and final payment, the Contractor shall submit his computations for the steel shown on each of the approved shop drawings as soon as practicable after the sheet has been approved. The computation by the Contractor shall show the weight for each member, except that duplicate members may be grouped together.

960.82 Payment Items.

960.	Structural Steel	Pound
999.960	Structural Steel on Hand	Pound

SECTION 965
MEMBRANE WATERPROOFING AND PROTECTIVE COURSE FOR BRIDGE DECKS

DESCRIPTION

965.20 General.

Membrane waterproofing applied to the surface indicated on the plan and elsewhere as directed shall consist of one of the following systems:

1. Coal tar emulsion reinforced with two plies of coated glass fabric.
*2. Hot applied rubberized asphalt membrane.
3. Preformed sheet systems — either reinforced rubberized asphalt or reinforced tar and resin.

The protective course will be bituminous concrete. Type of mix shall be Dense Binder Course as specified in Table A of Section M3.11.03 and placed in accordance with Item 965.62 hereinafter.

*System 2 shall *not* be used on grades in excess of 3 percent.

MATERIALS

965.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Protective Seal Coat Emulsion (Coal Tar Emulsion)	M3.03.3
Coated Glass Fabric	M3.06.1
Bituminous Concrete	M3.11.00
Thermoplastic Asphalt Membrane	M3.04.2
Asphalt Primer	M3.02.1
Preformed Sheet Membrane	M9.08.0
Portland Cement	M4.01.0

CONSTRUCTION METHODS

965.60 Preparation of Surface.

All concrete surfaces which are to be waterproofed shall be screeded to the true cross section. Depressions shall be filled to a smooth flush surface with 1:2 mortar (1 part cement to two parts sand) or an approved rapid setting patching mortar. Other surfaces shall be trimmed free of rough spots, projections or other defects which might cause puncture of the membrane.

No waterproofing shall be done in wet, damp or foggy weather, nor when the ambient temperature is 40 °F or below, without permission of the Engineer.

The membrane waterproofing on bridge decks shall not be placed unless the Contractor is ready to follow within 24 hours with the first layer of bituminous concrete pavement, a longer period of time will be allowed only with the approval of the Engineer.

Immediately prior to the membrane application, the concrete surface shall be thoroughly swept and blown clean with an air compressor to remove any loose debris.

965.61 Application.

A. System 1 — Coal Tar Emulsion reinforced with two plies of Coated Glass Fabric.

Apply the first coat of coal tar emulsion on a dampened but puddle free concrete surface. Application shall be made by squeegees or suitable push broom. The emulsion shall be evenly spread to a uniform thickness. When this application is thoroughly dry a second application of emulsion shall be placed at the same rate of spread. Immediately following the second application the first ply of coated glass fabric shall be laid. After the second application of emulsion with fabric has thoroughly dried, the third and fourth applications of emulsion shall be spread.

No applications of emulsion shall be spread until the previous application has thoroughly dried.

Immediately after the fourth application of emulsion the second ply of coated glass fabric shall be laid at a right angle to the first ply. This shall be followed by the fifth application of emulsion. All applications of coal tar emulsion shall be uniformly spread at a minimum rate of 1/8 gallon per square yard.

The coated glass fabric shall be laid with edges lapped at least 3 inches. The first ply shall be laid transverse to the center line of the bridge and the second ply parallel with the center line.

Where granite curb or edging is to be placed the membrane shall extend under the curbing and turned up as shown on the plans.

Where membrane waterproofing is placed abutting steel expansion joints, scuppers, manholes or other metal projecting through the concrete, the membrane will be turned up about 1 ½ inches and sealed to the metal.

The bituminous overlayment shall be placed within 24 hours, in accordance with Item 965.62, but not before the membrane has completely cured.

B. System 2 — Thermoplastic Asphalt Membrane.

Surface preparation shall be the same as in Item 965.60 with the added requirement that if the concrete surface is damp it shall be dried by use of a propane gas torch or similar equipment. Immediately prior to the application of the primer and by use of an air compressor, the surface shall be blown clean of all debris, dust, etc.

Priming:

The primer shall be applied by a hand sprayer, or similar equipment. Application shall be at the rate recommended by the manufacturer of the thermoplastic membrane.

The primer shall be *thoroughly dry* before application of the thermoplastic membrane.

Membrane Application:

Melting of the thermoplastic membrane shall be done in a double jacketed indirect-fired heating kettle. Oil shall be used as the heat transfer medium. The kettle shall be equipped with a suitable agitator and temperature gauges for both the kettle and the oil-bath jacket.

Sufficient lead time shall be allowed for heating of the thermoplastic so that it will be in a fluid state at the time scheduled for application. Usually two to three hours are required for this phase of the operation.

A few packages of the thermoplastic shall be placed in the heating kettle and continuously agitated until thoroughly fluid. More material shall be added until the kettle is full and the material is fluid. As material is drawn off for application, additional packages shall be added.

Caution should be observed that the melting temperature does not exceed manufacturer's recommendation. This is usually between 350 °F–425 °F. When fluid, the material shall be drawn off in suitable containers and poured onto the primed and dried deck surface.

It shall be evenly spread with squeegees to a minimum thickness of 125 mils (1/8 ″). All horizontal surfaces shall be completely covered and vertical surfaces (curbing, edging, etc.) shall be covered up to a minimum of four inches.

Cracks greater than 1/16 ″ but less than 1/2 ″ shall covered with 6 ″ to 12 ″ wide strips of butyl or neoprene sheeting. The sheeting shall be embedded in the freshly spread hot membrane material. A second coat of membrane material shall be spread overlapping the strip edges at least 4 ″.

After application of the membrane is completed and the material has set, it shall be dusted thoroughly with dry portland cement. This will eliminate all tackiness.

To eliminate any possible damage to the membrane and in accordance with Subsection 965.62, the bituminous overlayment shall be applied as soon as possible. The only caution that must be observed is that the paving spreader travel in a straight course and not make any turns that could cause damage to the membrane.

C. System 3 — Preformed Sheet Membranes.

This system shall consist of the application of preformed reinforced rubberized asphalt or reinforced tar and resin sheet membranes.

Composition and dimensional requirements shall be as stipulated by the manufacturer of the sheet membrane.

Membrane application shall be in accordance with the manufacturer's instructions. The only exception, if required by the manufacturer, shall be the need for a separation or protection layer. As with Systems 1 and 2, the first course of the bituminous concrete overlayment shall serve as the protective course.

The bituminous overlayment shall be placed as soon as possible and as described in Subsection 965.62.

965.62 Bituminous Concrete Protective Course.

The first course of the bituminous concrete overlayment shall serve as the protective course. It shall be placed within 24 hours after the membrane has been installed.

The bituminous concrete protective course shall be spread upon the entire membrane to a finished depth as specified in accordance with the following requirements:

The precautions hereinbefore noted for Section 460, Bituminous Concrete Pavement, shall be strictly observed.

1. Spreading Mixture.

a. The use of rubber tired mechanical pavers and trucks on the membrane during the paving operations will be permitted provided workmanship is satisfactory to the Engineer. If work is judged unsatisfactory, the Engineer will require that subsequent placement be by hand.

b. Hand spreading of the mixture shall be accomplished by dumping the mixture from the trucks onto metal or wooden platforms which shall be of such a size that the mixture will not fall off when dumped thereon or work off during spreading. Each load of mixture shall be dumped outside of the area over which it will be spread and only as fast as can be handled by the shovelers. The mixture shall be deposited upon the membrane with shovels and spread with lutes, care being taken not to spread the mixture faster than it can be handled by the rakers.

2. Compacting.

After the mixture has been properly spread, it shall be rolled. Delays in the initial rolling of the freshly placed mixture will not be permitted. In all places inaccessible to a roller, the required compression shall be secured with hot tampers. Rolling shall be done with a roller conforming to the requirements as specified for

Class I-1 Bituminous Concrete in Section 460, except where power rollers are impracticable to use, approved hand rollers and tampers shall be used, as directed. Steel wheel rollers will not be allowed on bare membrane.

3. Joints.

The bituminous concrete shall be so placed that the number of joints required shall be reduced to a minimum. Where joints are necessary, they shall be constructed in the manner specified in Section 460. Edges of the bituminous concrete at the edge of parapets shall be protected by planks which shall be firmly secured and left in place until the course has been properly rolled and is thoroughly set.

No bituminous work shall be done during rainy weather or when weather conditions as to temperature or otherwise are, in the Engineer's judgment, unsuitable for obtaining satisfactory results.

COMPENSATION

965.80 Method of Measurement.

Membrane waterproofing for bridge decks will be measured by the square yard and the quantity to be paid for shall be the number of square yards of surface covered with no allowance for overlapping or for edges turned up or carried into recesses for seals, except that the area of the full 2-ply membrane turned down in back of the parapets and extended under and in back of curb of edging will be included for payment.

The protective course will be measured by the ton and the quantity to be paid for shall be the actual and verified tonnage, complete in place, and approved.

965.81 Basis of Payment.

The membrane waterproofing will be paid for at the contract unit price per square yard under the item for Membrane Waterproofing for Bridge Decks, complete in place.

The tonnage of protective course will be paid for at the contract unit price per ton, complete in place.

965.82 Payment Items.

965.	Membrane Waterproofing for Bridge Decks	Square Yard
462.	Class I Bituminous Concrete Dense Binder Course	Ton

SECTION 967
MEMBRANE WATERPROOFING AND PROTECTIVE COURSE

DESCRIPTION

967.20 General.

Membrane waterproofing applied to the surface indicated on the plan and elsewhere as directed shall consist of one of the following systems:

(1) Coal tar emulsion reinforced with two plies of coated glass fabric.

(2) Biodegradable corrugated kraft paper panels with flutes filled with bentonite and ends sealed.

The protective course, if required, will be cement concrete brick, cement concrete block or protection board as specified by manufacturer.

MATERIALS

967.40 General.

Materials shall meet the requirements specified in the following Subsection of Division III, Materials:

Protective Seal Coat Emulsion (Coal Tar Emulsion)	M3.03.3
Coated Glass Fabric	M3.06.1
Cement Concrete Brick	M4.05.0
Cement Concrete Block	M4.05.1
Portland Cement	M4.01.0
Bentonite Panels	M9.09.0

CONSTRUCTION METHODS

967.60 Preparation of Surface.

All concrete surfaces which are to be waterproofed shall be finished. Surfaces shall be trimmed free of rough spots, projections or other defects which might cause puncture of the membrane.

Immediately prior to the membrane application the concrete surface shall be thoroughly swept and blown clean with an air compressor to remove any loose debris.

967.61 Application.

A. System 1 — Coal Tar Emulsion reinforced with two plies of Coated Glass Fabric.

This system shall be applied in accordance with the requirements of Subsection 965.61.

B. System 2 — Bentonite Panels.

This system shall consist of applications of bentonite panels as indicated on the plans and elsewhere as an option to System 1 with the approval of the Engineer.

The placement and protection shall be in accordance with manufacturer's instructions.

967.62 Protective Course.

The protective course, if required, shall be placed within 24 hours after the membrane is installed in order to protect the membrane. A longer period of time will be allowed only with the approval of the Engineer. The protective course shall consist of either cement concrete brick, solid cement block, or protection board as recommended. The protective course shall be applied in a single layer of the thickness required.

A. Cement Concrete Brick.

Brick used as protective course shall be laid over the entire membrane in regular courses as shown on the plans except around drainage castings and other openings and obstructions, around such obstructions cement mortar shall be used for the protective course. When the brick protection is to be laid against a vertical wall or on a steep slope, the bricks shall be laid in cement mortar.

B. Cement Concrete Blocks.

Cement concrete blocks shall be machine made solid segments of a thickness corresponding to the required thickness of the protective course.

In a vertical wall or on a steep slope, the blocks shall be laid in cement mortar.

C. Protection Board for Bentonite Panels.

Protection Board will be used for Bentonite Panels when backfill contains sharp rocks larger than 2 ″. The hard surface fiber board 1/16 ″ of an inch thick, which is biodegradable and nailable shall be nailed over the panels to provide a continuous protective layer between the panels and the soil area. Boards shall be overlapped with the ends of joints staggered and cut to fit for complete protection.

COMPENSATION

967.80 Method of Measurement.

Membrane waterproofing will be measured by the square yard and the quantity to be paid for shall be the number of square yards of surface covered, with no allowance for overlapping or for edges turned up or carried into recesses for seals.

The protective course will be measured by the square yard and the quantity to be paid for shall be the number of square yards of membrane surface covered.

967.81 Basis of Payment.

The membrane waterproofing will be paid for at the contract unit price per square yard under the item for Membrane Waterproofing, complete in place.

The protective course will be paid for under the item for protective course.

967.82 Payment Items.

967.	Membrane Waterproofing	Square Yard
966.	Waterproofing Protective Course	Square Yard

SECTION 970
BITUMINOUS DAMP-PROOFING

DESCRIPTION

970.20 General.

Bituminous damp-proofing to be applied as shown on the plans shall consist of a cut-back asphalt, a protective seal coat emulsion or an asphalt emulsion. If material other than that specified herein is permitted to be used, the method of application shall conform to the published specifications of the manufacturer.

MATERIALS

970.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials.

Cut-Back Asphalt	M3.02.0
Emulsified Asphalt	M3.03.0
Protective Seal Coat Emulsion	M3.03.3

CONSTRUCTION METHODS

970.60 General.

Concrete surfaces shall be allowed to dry for a period of at least 5 days after the removal of forms before damp-proofing is applied.

Surfaces to be damp-proofed shall be made reasonably smooth and free from all projections and holes. All holes in concrete surfaces shall be satisfactorily filled with 1 part cement to 2 parts sand mortar before damp-proofing is applied. Concrete surfaces shall be properly cured before being damp-proofed. Surfaces shall be dry and immediately before the application of the damp-proofing shall be thoroughly cleaned of dust and all loose material. Damp-proofing shall not be done during wet weather, nor when the weather conditions as to temperature otherwise are unsatisfactory.

The material for damp-proofing shall be mopped or sprayed on the designated surfaces as directed and in amounts necessary to obtain a 2 coat coverage of not less than 5 gallons of asphaltic material per 100 square feet of area.

The initial coat of damp-proofing shall be allowed to dry thoroughly before a second coat is applied. The final coat shall be thoroughly dry before any fill is placed against it.

COMPENSATION

970.80 Method of Measurement.

Damp-proofing will be measured by the actual area of surface covered in square yards.

970.81 Basis of Payment.

Bituminous damp-proofing will be paid for at the contract unit price per square yard of surface under the item for Bituminous Damp-Proofing, complete in place.

970.82 Payment Item.

970. Bituminous Damp-Proofing	Square Yard

SECTION 975
METAL BRIDGE RAILINGS

DESCRIPTION

975.20 General.

Work under this item shall consist of furnishing and erecting metal bridge railing in accordance with the design and in close conformity with the lines and grades shown on the plan or as established by the Engineer.

MATERIALS

975.40 General.

Material shall meet the requirements specified in the following Subsections of Division III. Materials:

Bridge Railing, Aluminum	M8.13.0
Bridge Railing, Galvanized	M8.13.1
Bridge Railing, Steel	M8.13.1
Structural Paints:	
(a) Prime Coat	M7.02.21, M7.02.04
(b) Intermediate Coat	M7.04.10, M7.02.06
(c) Finish Coat	M7.02.25, M7.02.11
(d) Galvanizing	M7.10.0

CONSTRUCTION METHODS

975.60 Shop Drawings.

After the Contract is awarded, the Contractor shall furnish the Engineer with complete detail or shop drawings of the proposed work in accordance with the requirements of Subsection 5.02. No material for the bridge railings shall be fabricated before the approval of the detail or shop drawings by the Engineer.

975.61 Welding.

The members of the steel railing shall be jointed together as indicated on the plans by the arc welding process. Surfaces to be welded shall be cleaned of loose scale, rust, paint or other foreign matter by wire brushing, chipping or hammering. A thin coating of linseed oil need not be removed. Metal shall not be painted before being welded. In assembling and during welding, the component parts of the built-up members shall be held by sufficient clamps or other adequate means to keep parts straight and in close contact.

Welding shall conform to the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5).

Except as specifically called for on the plans or as directed by the Engineer, welding of aluminum bridge railing will not be permitted. When permitted welding aluminum shall be as specified in the Structural Welding Code—ANSI/AWS D1.2.

975.62 Setting Railing.

The three-rail aluminum and steel posts shall be plumb except when the grade is less than 1.50% and then they shall be set normal to the grade. One-rail aluminum and steel posts shall be set to normal grade. Longitudinal members shall follow the grade of the coping. In setting up the railing, care shall be taken to insure proper level and alignment in order to prevent springing or bending of the railing during erection. Where required on curves the rails shall be accurately formed to the required radius.

Steel base plates shall be set on a sheet of lead 3/32 of an inch thick. The sheet shall be 1 inch wider and 1 inch longer than the base, and shall be centered so that 1/2 inch extends beyond the base on all sides. After the plates have been finally set, the edges of the lead sheet shall be caulked under the plate to make a watertight joint. Excess lead that cannot be caulked under the plate shall be removed flush with the edges of the plate. If additional shimming of the plates is required, the shims shall be of the same material as base plates.

The bottom of the aluminum post plate shall be thoroughly coated with an aluminum impregnated caulking compound conforming to Federal Specification TT-C-00598A and shall be grey in color. Where shims are required for aluminum posts, such shims shall be made from fully annealed aluminum alloy sheets or plates.

Before the anchor bolt nuts are placed, the clearance between the bolts and the anchor bolt holes in the steel base plates shall be filled with thick red lead paste. The nuts shall then be brought tight against the plate.

All anchor bolts shall have a minimum of 1/2 inch of exposed thread after nuts have been properly tightened.

975.63 Painting.

All parts of the bridge railings (except expansion fittings and galvanized panels) shall be painted with one shop coat of paint. Aluminum bridge railing shall not be painted unless specified. Each field connection (welded, bolted or riveted) shall be spot coated with shop paint immediately after the connection has been approved. After the erection has been completed, the railing shall be painted with one coat of structural intermediate coat and one finish coat. If no other color is specified for the finish coat; structural chrome oxide green or high build brown vinyl finish paint shall be used. Painting shall conform to the applicable requirements of Subsection 960.63.

The Contractor may at his option and in lieu of painting, galvanize the steel bridge railing. Galvanizing shall conform to M8.13.1-1.

Galvanized areas that are damaged shall be thoroughly cleaned and given one coat of zinc rich paint conforming to M7.04.11.

975.64 Inspection.

Inspection may be done at the mill and fabricating plant by the Engineer or by a commercial inspection agency under a separate contract with the Department. The Contractor shall give sufficient notice to the Engineer of the beginning of the work at the mill and shop, so that arrangements may be made for the attendance of the Inspector at the plant. No material shall be rolled or fabricated before the Engineer has been notified as to the source of supply.

The Contractor will be required to submit copies of the Manufacturer's sworn statement for each kind of material furnished, as outlined under Subsection 6.01 prior to fabrication.

COMPENSATION

975.80 Method of Measurement.

Metal bridge railings will be measured by the linear foot along the line and grade of the railing for the distance from outside to outside of metal end posts above the base plates or outside to outside of top rail, whichever is greater. Curved portion of railings shall be measured along the centerline of the top rail.

975.81 Basis of Payment.

Metal bridge railings will be paid for at the contract unit price per linear foot under the item of railing required, complete in place.

975.82 Payment Items.

975.	Metal Bridge Railing (1 Rail)—Option	Linear Foot
975.1	Metal Bridge Railing (1 Rail), Aluminum (Type AL-1)	Linear Foot
975.2	Metal Bridge Railing (1 Rail), Painted (Type ST-1)	Linear Foot
975.3	Metal Bridge Railing (1 Rail), Galvanized (Type ST-1)	Linear Foot
976.	Metal Bridge Railing (3 Rail)—Option	Linear Foot

976.1	Metal Bridge Railing (3 Rail), Aluminum (Type AL-3)	Linear Foot
976.2	Metal Bridge Railing (3 Rail), Steel (Type ST-3)—Painted	Linear Foot
976.3	Metal Bridge Railing (3 Rail), Steel (Type ST-3)—Galvanized	Linear Foot

SECTION 983
REVETMENT

DESCRIPTION

983.20 General.

Revetment shall consist of slope protection of the required type at the location shown on the plans and in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

983.21 Classification.

A. Dumped Riprap.

This work shall consist of angular shaped stones dumped in place to form a well graded mass with a minimum of voids, in location where damage may be caused by water conditions and below water level as a foundation for slope paving.

B. Riprap.

This work shall consist of a protective covering of angular shaped stones laid on slopes in front of abutments, wingwalls, piers and elsewhere as required, to insure protection of structures and embankments.

C. Slope Paving.

Slope paving shall consist of angular shaped stones, having a reasonably flat face, carefully placed on slopes to insure their protection.

D. Special Slope Paving under Bridges.

This special slope paving is intended for use on slopes under bridges where not in contact with flowing water and shall consist of quarry stone, precast concrete blocks or cement concrete masonry laid on slopes in uniform courses under bridges.

E. Channel Paving and Grouted Channel Paving.

Channel Paving, of the type specified, shall be placed as protective covering along the slopes around culvert inlets or outlets, around foundations, bridge berms and dikes.

F. Modified Rockfill.

This work shall consist of slope protection of ditches and at ends of cross-culverts.

MATERIALS

983.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Dumped Riprap	M2.02.2
Modified Rockfill	M2.02.4
Riprap	M2.02.0
Slope Paving	M2.06.0
Special Slope Paving under Bridge (Quarry Stone)	M2.06.1
Special Slope Paving under Bridge (Precast Concrete Blocks)	M4.05.3
Channel Paving	M2.06.2
4000 psi, 1½", 565 Cement Concrete	M4.02.00
Reinforcing Steel	M8.01.0

Joint Filler	M3.05.3
Joint Sealer	M3.05.0
Crushed Stone for Drainage Foundatoin	M2.01.1
Mortar	M4.02.15

CONSTRUCTION METHODS

983.60 General.

Areas to be protected by revetment shall be free of brush, trees, stumps and other organic material and be dressed to a smooth surface. All soft or spongy material shall be removed to the depth shown on the plans or as directed by the Engineer and replaced with approved materials.

A toe trench as shown on the plans shall be dug and maintained until the revetment is placed.

Protection for structure foundations shall be provided as early as the foundation construction permits. The area to be protected shall be cleaned of waste materials and the surface to be protected prepared as shown on the plans.

Where shown on the plans a foundation shall be placed on the area before the stone is placed. The foundation will be specified as either gravel borrow or crushed stone and at least 12″ in thickness.

983.61 Dumped Riprap.

Stone for riprap shall be placed on the prepared slope or area in a manner which will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids and minimum thickness of 2 feet. Riprap protection shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap protection in layers or by dumping into chutes or by similar methods likely to cause segregation will not be permitted.

The larger stones shall be well distributed and the entire mass of stone shall conform approximately to the gradation specified in Subsection M2.02.2. All material going into riprap protection shall be so placed and distributed that there will be no large accumulations of either the larger or smaller sizes of stone.

It is the intent of these specifications to produce a fairly compact riprap protection in which all sizes of material are placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

Unless otherwise authorized by the Engineer, the riprap protection shall be placed in conjunction with the construction of the embankment with only sufficient lag in construction of the riprap protection as may be necessary to allow for proper construction of the portion of the embankment protected and to prevent mixture of embankment and riprap material.

In no case will the elevation of the embankment be greater than 5 feet above the elevation of the riprap material.

983.62 Riprap.

The stones shall be placed upon an approved bed of gravel, crushed stone or other acceptable material, to the lines and grades shown on the plans and as directed.

Each stone shall be carefully placed by hand or machine, on a prepared bed, normal to the slope and firmly bedded thereon.

The larger stones shall be placed closely together and the intervening spaces filled with smaller stones in such a manner that the entire surface will form a compact mass.

983.63 Slope Paving.

The stones shall be placed upon an approved bed of gravel, crushed stone or other acceptable material, to the lines and grades shown on the plans and as directed. The larger stones shall be placed closely together throughout the surface and the interstices carefully chinked with smaller stones. All stones shall be securely bedded, with the exposed surfaces approximately parallel to and within 6 inches of the slope shown on the plans. When the paving cannot be laid to the required line and grade below water, a suitable foundation of dumped riprap shall be constructed.

983.64 Special Slope Paving Under Bridges.

A. **General.** — This type of slope paving shall consist of either quarry stone, precast concrete blocks or cement concrete masonry and shall be firmly bedded on a 6-inch gravel foundation. The finished paving shall have a continuous surface of uniform appearance, approximately parallel to and within 3 inches of the slope shown on the plans.

B. Quarry Stone or Precast Concrete Blocks. — The paving shall be laid in uniform courses with broken joints not exceeding 2 inches in width. The joints shall then be filled with sand or fine gravelly material to within 2 inches of the paved surface. Cement mortar (M4.02.15) shall then be placed in the joints to the top of the paved surface.

C. Cement Concrete Masonry. — The paving shall be placed as specified in Section 901, the surface shall be finished as specified in Subsection 901.68C.

983.65 Channel Paving and Grouted Channel Paving.

All stones shall be placed upon an approved bed to the lines and grades shown on the plans and as directed. The larger stones shall be placed as closely together as possible throughout the surface. All stones shall be securely bedded and laid so that the exposed surfaces will be approximately parallel to and within 3 inches of the grade shown on the plans. The finished paving shall present a continuous uniform surface of stonework.

Grouting, when required, shall be done after the paving is completely in place. The paving stones shall be sprinkled with water immediately before placing the grout. The grout shall conform to Subsection M4.02.15.

983.66 Modified Rockfill.

Stone shall be placed on the prepared area in a manner which will produce a reasonably well graded mass with a minimum practical percentage of voids and a minimum thickness of one foot. The stone will be placed to its full thickness in one operation and in such a manner as to avoid displacing the underlying material.

It is the intent of these specifications to produce a fairly compact Rockfill protection in which all sizes of material are placed in their proper proportions.

Hand-placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

Unless otherwise authorized by the Engineer, the Modified Rockfill shall be placed in conjunction with the adjacent construction as shown on the plans.

COMPENSATION

983.80 Method of Measurement.

The quantity of Dumped Riprap, Riprap and Modified Rockfill shall be the weight of the stones.

Slope Paving, Special Slope Paving under Bridges, Channel Paving and Grouted Channel Paving will be measured in place by the square yard on the surface of the paved slope as constructed.

983.81 Basis of Payment.

No deduction from the excavation pay quantities will be made for stone taken from excavation and used in any type of revetment, provided that any additional filling material made necessary by such use shall be furnished as specified in Subsection 4.09.

Excavation below the original ground surface at the toe of slopes when required in the construction of revetment, unless otherwise shown on the plans, will be paid for under the Item for Class A Trench Excavation; but where the excavation is made along the slopes of an existing or proposed channel, such excavation will be paid for under the Item for Channel Excavation.

Excavation in cuts when required in the construction of revetment, will be paid for at the contract unit price per cubic yard under the Item of Earth Excavation or Bridge Excavation, whichever is applicable.

Gravel Borrow required in the construction of revetment will be paid for under the contract unit price per cubic yard for Item 151. Gravel Borrow, complete in place.

Crushed stone when required for foundation revetment will be paid for at the contract unit price per ton for Crushed Stone for Drainage Foundations.

The tonnage of Dumped Riprap, Riprap and Modified Rockfill will be paid for at the contract unit price per ton for the kind of stone required, complete in place.

Slope Paving, Special Slope Paving under Bridges, Channel Paving and Grouted Channel Paving will be paid at the contract unit price per square yard, complete in place.

983.82 Payment Items.

983.	Dumped Riprap	Ton
983.1	Riprap	Ton
984.	Stone and Stone Chips for Waterway Revetments, Groins, Jetties, Breakwaters and Mounds	Ton

985.	Slope Paving	Square Yard
986.	Modifed Rockfill	Ton
987.	Special Slope Paving under Bridge—Option	Square Yard
987.1	Special Slope Paving under Bridge—Quarry Stone	Square Yard
987.12	Special Slope Paving under Bridge—Quarry Stone (Grouted)	Square Yard
987.2	Special Slope Paving under Bridge—Precast Concrete Blocks	Square Yard
987.3	Special Slope Paving under Bridge—Cement Concrete Masonry	Square Yard
988.	Channel Paving	Square Yard
988.1	Grouted Channel Paving	Square Yard
120.	Earth Excavation	Cubic Yard
140.	Bridge Excavation	Cubic Yard
141.	Class A Trench Excavation	Cubic Yard
143.	Channel Excavation	Cubic Yard
151.	Gravel Borrow	Cubic Yard
156.	Crushed Stone for Drainage Foundation	Ton

SECTION 995
BRIDGE STRUCTURE

DESCRIPTION

995.20 General.

Work included in this section shall consist of constructing bridge structures in accordance with the designs and to the lines and grades shown on the plans, and in accordance with these specifications complete in place including the furnishing and installation of all materials that are part of the structures. The work also includes approach slabs, wing walls and retaining walls when specified.

The work under this section does not include the various classes of excavation, bituminous concrete pavement, any work on piles, backfill, revetments, temporary structure, removal of present superstructure, cofferdams, control of water, or other items noted in the contract.

MATERIALS

995.40 General.

The materials to be used shall be in accordance with the applicable sections of these specifications and/or the Special Provisions for each respective item included in the construction of the structure.

CONSTRUCTION METHODS

995.60 General.

The method of construction shall be in accordance with the applicable sections of these specifications and the Special Provisions for each respective item.

COMPENSATION

995.81 Basis of Payment.

The above work will be paid for at the contract lump sum price under the respective item of "Bridge Structures". Where more than one structure is included in the Contract the following provisions shall apply to each structure. Where reference is made to other sections in these specifications, the parts thereof which apply to payment are specifically excluded.

Except as stipulated in the following paragraphs, the payment shall be a lump sum for each bridge structure complete in place. In general, payment will include the full compensation for all concrete (including approach slabs, and all concrete sidewalks adjacent to the wingwalls), prestressed concrete beams and deck beams, steel reinforcement for structures, structural steel, shear connectors, bituminous damp-proofing, membrane waterproofing, protective course, curbing, edging, scuppers, drains, bridge railings, and incidental work such as flashings, waterstops, fillers, tile under sidewalk, brickwork at parapet walls, crushed stone for weep holes, fastenings, painting and other materials, equipment and labor that are indicated or implied as part of the construction for the bridge structure. Payment for each bridge structure includes all work indicated on the plans under one bridge number even though two or more structures may be included under one bridge number, due to a wide center reservation or some other physical feature. Walls, other than wingwalls or connecting walls between the structures, will not be included for payment under an item for Bridge Structure unless specifically included in the Special Provisions or indicated on the plans.

When the Engineer orders changes made in the plans that reduce or increase the quantity of concrete, such changes will be compensated for as follows:

For additional quantities of concrete ordered by the Engineer for footings and unreinforced gravity walls, the Contractor will be paid at the rate of 70 dollars per cubic yard for cement concrete masonry placed in excess of that indicated on the plan drawings.

If changes are made that require less concrete than that indicated on the plan drawings for footings and unreinforced gravity walls, the payment to the Contractor under the item for Bridge Structure will be reduced at the rate of 45 dollars per cubic yard for the difference in volume of concrete as indicated on the plan drawings and the actual volume of concrete used in construction as measured in place.

The cost of any other changes from the contract plans for any of a bridge structure included under the respective item shall also be on a negotiated lump sum price regardless of the quantity of the change. No work shall be done on any of such changes in concrete or other elements until the price has been agreed on in writing between the Contractor and the Engineer.

The negotiated cost (increase or decrease) of each change will be based on the provisions of Subsection 4.03.

Where more than one structure is included in the contract under separate items, the foregoing paragraphs apply to each structure separately, and only to the structure for which changes are ordered.

Placing concrete on the deck in excess of that shown on the plans, to compensate for camber of structural steel, will not be considered a change from the plans. Full compensation for the additional concrete is included in the lump sum bid price.

Basis for Partial Payments.

Within 10 days after award of the contract, the Contractor shall submit, in duplicate, for approval by the Engineer, a schedule of the quantities and unit prices for the major components of the respective items for Bridge Structure as listed in the Special Provisions. Each component part shall be considered as including all its concomitance so that the total cost listed for the components is the contract cost for the item. The approval of the schedule by the Engineer shall not be considered as a guarantee to the Contractor that the quantities shown on the schedule are the approximate quantities actually included in the structure as indicated on the plans. The schedule is only for the purpose of estimating partial payments, and it shall not affect the contract terms in any way.

The volume occupied by the tile under the sidewalk shall be considered as an equivalent volume of cement concrete. Fillers, flashings, brickwork at parapet walls, tar paper, fastenings, painting and other materials and work shall be included with the appropriate components.

The schedule shall list the item, the quantity and the unit of measurement, the Contractor's price per unit, the amount for the item, and the total that the Contractor bid for the lump sum.

Each schedule applies only to the respective bridge structure. Similar materials and constructions at other locations are not included in the schedule.

995.82 Payment Item.

995.	Bridge Structure Bridge No. ( )	Lump Sum
999.995	Increase in Concrete Quantity	Cubic Yard
999.996	Decrease in Concrete Quantity	Cubic Yard

DIVISION III
MATERIALS SPECIFICATIONS

SECTION M1 — Soils and Borrow Materials
SECTION M2 — Aggregates and Related Materials
SECTION M3 — Bituminous Materials
SECTION M4 — Cement and Cement Concrete Materials
SECTION M5 — Pipe, Culvert Sections and Conduit
SECTION M6 — Roadside Development Materials
SECTION M7 — Paints and Protective Coatings
SECTION M8 — Metals and Related Materials
SECTION M9 — Miscellaneous Materials

SECTION M
MATERIALS

Approval and Acceptance.

All materials must be approved prior to incorporation in the work. Approval of materials shall be in accordance with the applicable requirements of Subsection 5.03 and Section 6.00, Control of Materials. Materials may be approved at the source of manufacture or at the project site. Information regarding the origin, composition and/or manufacture of any material shall be furnished if requested by the Engineer.

Approval and acceptance of any material intended for use in the work of the Department is contingent upon the particular material conforming to a designated specification. Unless otherwise stipulated, all questions relating to materials will be resolved by the Research and Materials Section of the Department or its duly authorized representative.

Sampling and Testing.

Materials will be sampled and tested in accordance with the designated Standards. The applicable edition of the Standard shall be as stipulated in Subsection 1.33 References.

Sampling of materials will be performed by Department personnel, personnel authorized by the Department or personnel under Department supervision.

Certification.

Materials accepted on certification as stipulated in Subsection 6.01, Source of Supply and Quality, fall into two categories:

1. Those accepted on a particular certification and sampling frequency.
2. Those accepted on certification alone.

A listing of materials falling into one or the other of the above categories will be furnished upon request to the Research and Materials Section of the Department.

SECTION M1
SOILS AND BORROW MATERIALS

M1.00.0 General.

All Soils and borrow materials shall conform to the requirements of the specifications as designated hereinafter.

M1.01.0 Ordinary Borrow.

Ordinary Borrow shall consist of a material satisfactory to the Engineer and not specified as gravel borrow, sand borrow, special borrow material or other particular kind of borrow.

This material shall have the physical characteristics of soils designated as group A-1, A-2-4 or A-3 under AASHTO-M145. It shall have properties such that it may be readily spread and compacted for the formation of embankments.

M1.02.0 Special Borrow.

Special Borrow shall consist of one of the following:

a) A native in-situ soil that is classified under AASHTO-M145 as A-3, or that portion of A-1 with less than 12% passing the No. 200 sieve as determined by AASHTO-T11 and T27. Maximum size of stone for testing purposes shall be three (3) inches (nominal). For Muck Backfill only, 15% or less passing the No. 200 sieve will be allowable.

b)A crushed rock, either obtained from ledge excavation on the project or other approved sources, that meets the following requirements:

Percent of wear LA abrasion test	50% Maximum
Plasticity Index	6% Maximum

Gradation Requirements

Sieve Designation	Percent Passing
6 in.	100
2 in.	90-100
No. 4 mesh	20-65
No. 200 mesh	0-12

M1.03.0 Gravel Borrow.

Gravel Borrow shall consist of inert material that is hard, durable stone and coarse sand, free from loam and clay, surface coatings, and deleterious materials.

Gradation requirements for gravel shall be determined by AASHTO-T11 and T27 and shall conform to the following:

Sieve Designation	Percent Passing
1/2 in.	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10

Maximum size of stone in gravel shall be as follows:

M1.03.0 Type a	6 inches largest dimension
M1.03.0 Type b	3 inches largest dimension
M1.03.0 Type c	2 inches largest dimension

M1.03.1 Processed Gravel for Subbase.

This specification covers the quality and gradation for subbase material of crusher run gravel.

Gravel shall consist of inert material that is hard, durable stone and coarse sand, free from loam and clay, surface coatings and deleterious materials.

The coarse aggregate shall have a percentage of wear, by the Los Angeles Abrasion Test, of not more than 50.

The gradation shall meet the following requirements:

Sieve Designation	Percent Passing
3 in.	100
1½ in.	70-100
1/4 in.	50-85
No. 4	30-60
No. 200	0-10

The approved source of bank-run gravel material shall be processed by mechanical means. The equipment for producing crushed gravel shall be of adequate size and with sufficient adjustments to produce the desired materials. The processed material shall be stockpiled in such a manner to minimize segregation of particle sizes. All processed gravel shall come from approved stockpiles.

M1.04.0 Sand Borrow.

Sand Borrow shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from loam or clay, surface coatings and deleterious materials. The allowable amount of material passing a No. 200 sieve as determined by AASHTO-T11 shall not exceed 10% by weight.

The maximum particle size for Sand Borrow shall be as follows:

M1.04.0 Type a	1/4 in.
M1.04.0 Type b	3/8 in.

M1.04.1 Sand Borrow for Subdrains.

Sand for use in subdrain installations shall conform to the requirements of Section M1.04.0 with the following grading limitations, as determined by AASHTO-T11 and T27:

Sieve Designation	Percent by Weight Passing Through Minimum	Maximum
1/2 in.	100	
3/8 in.	85	100
No. 4	60	100
No. 16	35	80
No. 50	10	55
No. 100	2	10

M1.05.0 Loam Borrow.

Loam Borrow shall consist of a fertile, friable, natural topsoil typical of the locality, without admixture of subsoil, refuse or other foreign materials, and shall be obtained from a well-drained arable site. It shall be such a mixture of sand, silt and clay particles as to exhibit sandy and clayey properties in and about equal proportions. It shall be reasonably free of stumps, roots, heavy or stiff clay, stones larger than 1 inch in diameter, lumps, coarse sand, noxious weeds, sticks, brush or other litter.

Prior to stripping, the loam shall have demonstrated by the occurrence upon it of healthy crops, grass or other vegetative growth that is is reasonably well drained and that it does not contain toxic amounts of either acid or alkaline elements.

The loam shall contain not less than 4% nor more than 20% organic matter as determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230°F ±9°.

M1.06.0 Peat Borrow.

Peat Borrow shall consist of specified material obtained from the locality of the project or commercially from other sources to be used as detailed or as directed by the Engineer to fit adequately the intended purpose.

Peat Borrow shall conform to the following requirements:

1. Organic content	25% minimum
2. Acidity	pH 4.0-7.0
3. Water absorbing capacity	250% minimum
4. Soluble salt index	100% maximum

M1.06.1 Processed Planting Material.

Processed Planting Material shall consist of suitable organic soil containing a reasonable amount of fibrous material procured from within the project limits or elsewhere and mixed with a suitable type of subsoil, resulting in a homogeneous material free from hard lumps, brush or litter satisfactory as a substitute for natural loam and capable of supporting plant growth.

This material shall conform to the following requirements:

*[1]Soluble salt index	100% maximum
Acidity	pH 4.0-7.0
*[2]Organic content	10-20%

*[1]As determined with a type RD15 Solu Bridge electrical conductivity tester at a dilution ratio of 1 part oven-dried material in 5 parts of distilled water (by weight).

*[2]Organic content will be determined by the loss on ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230°F ±9°.

Sieve Designation	Percent by Weight Passing Through Minimum	Maximum
1/2	100	
*[3]No. 50	45	74
No. 200	20	40

*[3]This requirement shall be waived when the amount of fibrous material precludes an acceptable test procedure.

M1.07.0 Topsoil and Plantable Soil Borrow.

Topsoil and Plantable Soil Borrow shall consist of fertile, friable, natural topsoil, reasonably free of stumps, roots, stiff clay, stones larger than 1 inch diameter, noxious weeds, sticks, brush or other litter.

Prior to stripping the topsoil from the construction project, it shall have demonstrated by the occurence upon it of healthy crops, grass or other vegetative growth, that it is reasonably well drained and capable of supporting plant growth. Material classified as Topsoil can only be obtained *within* the project limits.

M1.08.0 Impervious Soil Borrow.

Impervious Soil shall have the physical characteristics of one of the following, under AASHTO-M145:

1. A-4, A-5, A-6, A-7 soils;
2. A-2 soils containing more than 20% by weight passing the No. 200 sieve;
3. Peats and other highly organic soils.

The Impervious Soil shall be reasonably free of stumps, brush, and stones larger than 3 in. diameter.

Material excavated near salt water to be used as impervious soil will be tested for salt content. The maximum soluble salt index shall be 100.

SECTION M2
AGGREGATES AND RELATED MATERIALS

M2.01.0 Crushed Stone.

Crushed stone shall consist of one or the other of the following material:

1. Durable crushed rock consisting of the angular fragments obtained by breaking and crushing solid or shattered natural rock, and free from a detrimental quantity of thin, flat, elongated* or other objectionable pieces.

A detrimental quantity will be considered as any amount in excess of 15% of the total weight.

2. Durable crushed gravel stone obtained by artificial crushing of gravel boulders or fieldstone with a minimum diameter before crushing of 8 in.

*Thin or elongated pieces are defined as follows: Thin stones shall be considered to be such stones whose average width exceeds four (4) times their average thickness. Elongated stones shall be considered to be such stones whose average length exceeds four (4) times their average width.

The crushed stone shall be reasonably free from clay, loam or deleterious material and not more than 1.0% of satisfactory material passing a No. 200 sieve will be allowed to adhere to the crushed stone. Where crushed stone is to be used for surfacing, this requirement shall be not more than 0.5% of satisfactory material passing a No. 200 sieve.

The crushed stone shall have a maximum percentage of wear as determined by the Los Angeles Abrasion Test (AASHTO-T-96) as follows:

1. For Class 1 Bit. Conc.	30%**
2. For Cement Concrete Aggregate	45%***
3. Crushed Stone for Subbase	45%
4. Special Borrow Ledge	45%

**Crushed stone for this use shall consist of crushed or shattered natural rock only. Crushed gravel stone will not be permitted.

***Except for 5000 psi or greater cement concrete and prestressed concrete which shall be 30%.

The crushed stone shall be uniformly blended according to the grading requirements for the respective stone sizes shown in the following Table.

M2.01.1 to M2.01.6 (See following Table for grading requirements).

Tabulation of Stone Sizes
Percent by Weight Passing Through

Square Opening Sieve	M2.01.1 and M2.01.2	M2.01.3	M2.01.4	M2.01.5	M2.01.6
	1½ in.	1¼ in.	3/4 in.	1/2 in.	1/4 in.
2½ in.					
2 in.	100				
1½ in.	95-100	100			
1¼ in.		85-100			
1 in.	35-70		100		
3/4 in.	0-25	10-40	90-100		
5/8 in.				100	
1/2 in.		0-8	10-50	85-100	100
3/8 in.			0-20	15-45	85-100
No. 4			0-5	0-15	20-50
No. 8				0-5	0-15
No. 16					0-5

M2.01.7 Dense-graded Crushed Stone for Sub-base.

This specification covers the quality and gradation requirements for a subbase material combining crusher-run coarse aggregates of crushed stone and fine aggregates of natural sand or stone screenings uniformly pre-mixed with a predetermined quantity of water.

Coarse aggregate shall consist of hard, durable particles of fragments of stone. Materials that break up when alternately frozen and thawed or wetted and dried shall not be used.

Coarse aggregate shall have a percentage of wear, by the Los Angeles test, of not more than 45.

Fine aggregate shall consist of natural or crushed sand.

The composite material shall be free from clay, loam or other plastic material, and shall conform to the following grading requirements:

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
2 in.	100
1½ in.	70-100
3/4 in.	50-85
No. 4	30-55
No. 50	8-24
No. 200	3-10

Sampling and testing shall be in accordance with the following standard AASHTO methods:

Sieve Analysis	T27
Passing No. 200 Sieve	T11

M2.02.0 Riprap.

Riprap shall be sound, durable rock which is angular in shape. Rounded stones, boulders, sandstone or similar soft stone or relatively thin slabs will not be acceptable. Each stone shall weigh not less than 50 pounds and at least 75% of the volume shall consist of stones weighing not less than 500 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones the entire mass will be compact.

M2.02.1 Rockfill.

Stone for rockfill shall be sound, angular in shape, free from structural defects and comparatively free of chemical decay. From 50% to 70% of the stones shall weigh not less than 500 pounds each and remainder shall weigh not less than 50 pounds each.

M2.02.2 Dumped Riprap.

Stone used for dumped riprap shall be hard, durable, angular in shape, resistant to weathering and shall meet the gradation requirement specified. Neither breadth nor thickness of a single stone should be less than one-third its length. Rounded stone or boulders will not be accepted unless authorized by special provisions.

Stone shall be free from overburden, spoil, shale, and organic material and shall meet the following gradation requirement specified:

Size of Stone	Maximum Percent of Total Weight Smaller Than Given Size
400 lb.	100
300 lb.	80
200 lb.	50
*25 lb.	10

*No more than 5% by weight shall pass a 2 in. sieve.

Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified. Stones smaller than the specified 10% size and spalls will not be permitted in an amount exceeding 10% by weight of each load.

Control of gradation will be by visual inspection. The Contractor shall provide at the locations specified a mass of rock of at least five tons meeting the gradation for the class specified. The sample at the construction site may be a part of the finished riprap covering. At the quarry, an additional sample shall be provided. These samples shall be used as a frequent reference for judging the gradation of the riprap supplied. Any difference of opinion between the Engineer and the Contractor shall be resolved by dumping and checking the gradation of two random truck loads of stone. Mechanical equipment, a sorting site and labor needed to assist in checking gradation shall be provided by the Contractor at no additional cost to the Department.

M2.02.3 Stone for Pipe Ends.

Stone for pipe ends shall be sound, durable rock which is angular in shape. Rounded stones, boulders, sandstone or similar stone or relatively thin slabs will not be acceptable. Each stone shall weigh not less than 50 pounds not more than 125 pounds and at least 75% of the volume shall consist of stones weighing not less than 75 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones the entire mass will be compact.

M2.02.4 Modified Rockfill

Modified rockfill shall consist of hard, durable angular shaped stones which are the product of the primary crushing of a stone crusher. Rounded stone, boulders, sandstone and similar soft stone or relatively thin slabs will not be acceptable.

Stone shall be free from overburden, spoil, shale, organic material and meet the following gradation requirements:

Size of Stone	Passing Percentages
8 in.	95-100
4 in.	0-25
2½ in.	0-5

M2.03.0 Granite Rubble Block.

Rubble pavement blocks shall be granite, basically light grey in color, free from seams and other structural imperfections or flaws which would impair its structural integrity, and of a smooth splitting appearance. Natural color variations characteristic of the deposit from which the paving blocks are obtained will be permitted.

Rubble pavement blocks shall be not less than 4 inches nor more than 12 inches in length, not less than 3½ inches nor more than 4½ inches in width and depth. Rubble blocks shall be rectangular in shape with one good face.

Opposite faces of rubble blocks shall be approximately parallel and adjoining faces shall be approximately at right angles to each other. Blocks shall be dressed so that they may be laid with 1 inch to 1½ inch joints.

M2.04.0 Aggregate for Sand Blasting.

Aggregate to be used for sand blasting shall be an approved material currently used in the industry. It shall be graded to produce the profile requirements of the material being cleaned and shall meet the applicable requirements of OSHA, EPA, and DEQE.

M2.05.0 Stone Screenings.

Stone Screenings shall be that product from a stone crusher that completely passes a No. 4 sieve and not less than 40% passes a No. 8 sieve.

M2.06.0 Slope Paving.

Stone for slope paving shall be sound, angular in shape and free from structural defects. Each stone shall have one reasonably flat face and a thickness perpendicular to the face of not less than 6 inches, which shall be the least dimension of the stone.

Approximately 60% of the stones shall vary from 2 to 3 cubic feet each in volume and the remainder of the stones shall each be from 1 to 2 cubic feet in volume.

M2.06.1 Special Slope Paving Under Bridge (Quarry Stone).

Quarry stone shall consist of granite or other similar durable stone. The exposed surface of the stones shall range from roughly square to rectangular shape, with split or quarry face finish and uniform in color. The stones shall be from 12 to 28 inches long, 10 to 14 inches wide and from 3 to 6 inches thick.

M2.06.2 Channel Paving.

Stones for Channel Paving and Grouted Channel Paving shall be sound, approved quality angular blocks, as nearly rectangular or cubical as practicable. Rounded stones or relatively thin slabs will not be acceptable. At least 75% of the volume shall consist of stones weighing at least 200 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones a compact mass will result.

SECTION M3
BITUMINOUS MATERIALS

M3.00.0 General.

All bituminous materials shall conform to the requirements of the specifications as designated hereinafter.

Bitumen delivered to a project or to a mix plant must be accompanied by a proper certificate signed by the producers' authorized representative. Shipments of material *not* accompanied by a certificate *will not* be accepted for use in the work until a representative sample has been tested and approved by the Research and Materials Section of the Department.

A. Unless otherwise stipulated, the sampling of bituminous materials shall be in accordance with AASHTO-T40.

The following procedure shall be followed in obtaining samples from pressure distributors or tankers used for the transport of bituminous materials:

1. Distributors and tankers shall be equipped with approved sampling valves. The sampling valves on tankers shall be installed in the rear bulkhead approximately 1/3 of the height from the bottom. The sampling valves on pressure distributors may be located in the side of the tank somewhere in the middle third of the tank depth.

2. At least one gallon of material shall be drained off through the sampling valve and discarded before the sample is taken.

3. Sample containers shall be new, clean and sealed with a tight fitting cap. Washing of sample containers with solvents or water will not be permitted.

B. The sampling of bituminous paving mix shall be in accordance with methods prescribed in the Department's Materials Manual.

M3.01.0 Asphalt Cement.

Materials of this type shall conform to AASHTO-M226, Table 2, with the additional requirement for Ductility at 60 °F.

Table 2
Specification Requirements for Asphalt Cement
Viscosity Graded at 140 °F (60 °C)

			Viscosity Grade					
	AC-5		AC-10		AC-20		AC-40	
Tests	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, 140 °F (60 °C), poises	500 ± 100		1000 ± 200		2000 ± 400		4000 ± 800	
Viscosity, 275 °F (135 °C), Cs	175		250		300		400	
Penetration, 77 °F (25 °C), 100g, 5 Sec.	140		80		60		40	
Flash Point, COC, °F	350		425		450		450	
Solubility in trichloroethylene %	99.0		99.0		99.0		99.0	
Tests on residue — Thin Film Oven Test								
Loss on Heating %		1.00		0.50		0.50*		0.50
Ductility, 60 °F (15.5 °C) 5 cm/min. cm	100		40		20			
Ductility, 77 °F (25 °C) 5 cm/min. cm	100		75		50		25	
Maximum viscosity, 140 °F (60 °C), poises		2000		4000		8000		16000

Ductility test temperature will be specified by the Research and Materials Engineer.

*Up to 1 % if approved by the Engineer.

M3.02.0 Cutback Asphalts.

These materials shall be blends of asphalt cements and suitable solvents. They shall be homogeneous, free from water and conform to the requirements of AASHTO-M81 for the rapid curing type and AASHTO-M82 for the medium curing type.

M3.02.1 Asphalt Primer.

This material shall be suitable for priming concrete and masonry surfaces prior to the application of waterproofing asphalt. It shall conform to the requirements of AASHTO-M116.

M3.03.0 Asphalt Emulsions.

These materials shall be homogeneous and shall show no separation after mixing within thirty days after delivery. They shall conform to the requirements of AASHTO-M140 with the following exception:

Viscosity determination will not be required for material sampled at point of delivery.

M3.03.1 Cationic Emulsified Asphalt.

This material shall be a homogeneous asphalt emulsion. It shall remain homogeneous for a minimum of three months. It shall conform to the requirements of AASHTO-M208.

M3.03.3 Protective Seal Coat Emulsion.

This material shall be a homogeneous emulsion consisting of coal tar pitch dispersed in water by means of a mineral colloid. Any separation or coagulation of its components shall be capable of being overcome by moderate stirring. It shall contain no asphaltic materials or chemical emulsifiers. When tested according to prescribed methods it shall meet the following requirements:

Department Designation: PSC-1	Minimum	Maximum
Percent Water (AASHTO-T55)		50
Percent Non-Volatile Matter (ASTM-D2939, Sec. 7)	48	
Percent Ash in Non-Volatile Matter (ASTM-D2939, Sec. 9)	20	45
Percent Solubility of Non-Volatile Matter in CS_2 (AASHTO-T44)	40	
Resistance to Water (ASTM-D466)	No blistering, Loss of Adhesion or Re-Emulsification	
Resistance to Petroleum Solvents (ASTM-D466 — with Solvents substituted for water)	No penetration and no loss of adhesion.	

M3.04.2 Thermoplastic Asphalt Membrane.

Only products* pre-approved by the Department will be accepted for use. Composition and physical properties shall conform to the manufacturer's specifications for the material. All accessory materials used in the application of the thermoplastic asphalt membrane will be considered a part of this specification and shall conform to the manufacturer's requirements.

*Refer to Departments pre-approved materials listing. Obtainable from Research and Materials Section.

M3.05.0 Hot Poured Joint Sealer.

This sealer shall be composed of a mixture of materials which will form a resilient and adhesive compound capable of effectively sealing joints in concrete and shall conform to the requirements of AASHTO-M173.

M3.05.1 Joint and Crack Sealer, Asphalt-Fiber.

This material shall consist of a blend of asphalt cement (AC-20) and polyester fibers. The asphalt-fiber blend shall consist of 6% fiber weight to weight of asphalt.

M3.05.3 Preformed Bituminous Joint Filler for Concrete.

This material shall be a non-extruding and resilient bituminous type preformed expansion joint filler. It shall conform to the requirements of AASHTO-M213.

M3.05.4 Hot Applied Bituminous Concrete Crack Sealer.

This specification covers a hot applied crack sealer suitable for use in cement concrete and asphaltic concrete pavements. It shall conform to the requirements of Federal Specification SS-S-1401.

M3.06.1 Coated Glass Fabric.

This material shall be a coated glass fabric composed of inorganic glass fibers smoothly woven into an open mesh cloth. The coating shall be uniform and compatible with asphalt base or tar base compounds. The finished material shall be free of visible external defects such as ragged or untrue edges, breaks, dents or cracks. It shall conform to the following requirements:

Coated Glass Fabric

Selvage

Unless otherwise specified, the selvage shall have a width of between 1/8 and 1/2 in. inclusive.

	Minimum	Maximum
Width of roll	36 in. ± 2 in.	48 in. ± 2 in.
Gross weight per roll	5 lb.	16 lb.
Average net weight per sq. yd.	1.5 oz.	
Coating on fabricated material per sq. yd.	0.2 oz.	

Uncoated Glass Fabric	**Minimum**	**Maximum**
Average dry weight per sq. yd.	1.4 oz.	
Composition of fabric	100% glass fibers	
Thread count per inch of width		
Warp	20 ± 1	24 ± 1
Filling	20 ± 1	24 ± 1

Where double strength fibers are used for the filling, the minimum requirement shall be 10 (−0 + 1) to 12 (−0 + 2).

Breaking Strength (ASTM Methods D146 and D1682)*

Warp	75 lb. minimum
Filling	75 lb. minimum

*To prevent the coated glass fabric from slipping out from between the jaws of the tension testing machine, insert a thin strip of soft gasket rubber between the fabric and each of the four jaws of the machine before clamping in position.

M3.09.0 Asphalt Pipe Coating.

This material shall conform to the requirements of AASHTO-M190.

M3.10.0 Asphalt Anti-Stripping Additive.

This specification provides for an additive to asphalt to assist in the coating of wet aggregate and to increase the resistance of the bituminous coating to stripping in the presence of water. The additive shall be chemically inert to asphalt (heat stable) and when blended with asphalt shall withstand storage at a temperature of 400 °F for extended periods without loss of effectiveness.

Composition: Anti-stripping compound shall be an organic chemical compound free from inorganic mineral salts or inorganic mineral soaps. It shall contain no ingredient harmful to the bituminous material or to the operator, and shall not appreciably alter the specified characteristics of the bituminous material.

Anti-stripping additive shall be incorporated and thoroughly dispersed in the bituminous material in an amount equal to the percent by weight established by the Department. This percent is based on the efficiency of the additive as determined by laboratory tests.

Test Requirements:

1. Heat Stability

Anti-stripping compound shall be tested for chemical inertness to asphalt (heat stability). The compound shall retain its effectiveness after heating in asphalt according to the prescribed method for 24 hours at 350 °F.

2. Resistance to Stripping

Treated bitumen shall be required to coat wet aggregate and to retain at least 90% of the coating after 24 hours static immersion. There shall be no loss in retained coating after immersion has been extended to one week.

3. Concentration of Additive

The percent of additive to be incorporated in the bituminous material shall be specified by the Department based on laboratory tests using Rhyolite as a test aggregate. No modification of the established additive concentration shall be made because of the use of hydrophobic aggregate. The Department reserves the right to establish a minimum percent of additive required.

M3.11.00 Class I Bituminous Concrete.

M3.11.01 General.

These mixtures shall be composed of mineral aggregate, mineral filler (if required), bituminous material, and reclaimed asphalt pavement (RAP). The use of RAP shall be at the Contractor's option unless otherwise provided by the special provisions of the contract.

Plants producing recycled mix shall be equipped so that they can properly proportion, blend and mix all components of a recycled mixture so that the end product is in conformance with the designated job-mix formula.

M3.11.02 Composition of the Mixture.

The mineral aggregate, filler (if required), bituminous material, asphalt modifier (if required) and RAP shall be proportioned and mixed to conform with the designated mixture as tabulated in Table A, hereinafter.

M3.11.03 Job-Mix Formula.

The composition limits in Table A are master ranges of tolerances of materials in general. In order to obtain standard texture, density and stability, the Contractor will furnish to the Engineer a specific job-mix formula for the particular uniform combination of materials and sources of supply to be used on each project. The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate and for batch plants, the number of seconds for dry mixing time and the number of seconds for wet mixing time. AASHTO-T195 (Ross Count) with a coating factor of 98% will be used when necessary to evaluate proper mixing time. The job-mix formula shall also specify a single source or uniform blend of particular sources for fine aggregate, a single source for each nominal size of coarse aggregate, a single source of supply for mineral filler and sources for asphalt. At the option of the Contractor and provided that the end product is in conformance with the designated job-mix formula, the use of RAP will be permitted for base, binder or dense binder courses, only.

The proportion of RAP to virgin aggregate shall be limited to a maximum of 40% for drum mix plants and 20% for modified batch plants. The actual amount used on each project shall be subject to the approval of the Engineer.

Two or more job-mix formulas may be approved for a particular plant; however, only material conforming to one job-mix formula will be permitted to be used on any given calendar day. The job-mix formula shall bind the Contractor to furnish paving mixtures not only within the master ranges, but also conforming to the exact formula thus set up for the project, within allowable tolerances as follows:

For "Table A" Mixes	
No. 4 and larger sieve	±7.0%
No. 8 and smaller sieves, except No. 200	±4.0%
Passing No. 200 sieve	±2.0%
Asphalt	±0.4%
For "Table B" Mixes	
No. 4 and larger sieves	±5.0%
No. 8 and smaller sieves, except No. 200	±3.0%
Passing No. 200 sieve	±1.0%
Asphalt	±0.3%

Table A
Percent by Weight Passing
Sieve Designation

Standard Sieves	Base Course	Binder Course	Dense Binder Course	Top Course	Modified Top Course	Dense Mix	Surf. Treat.
2 in.	100						
1 in.	55-80	100	100		100		
3/4 in.		80-100	80-100		95-100		
5/8 in.				100			
1/2 in.	40-65	55-75	65-80	95-100	75-90	100	
3/8 in.				80-100	60-75	80-100	100
No. 4	20-45	28-50	48-65	50-76	40-60	55-80	80-100
No. 8	15-33	20-38	37-51	37-54	32-44	48-63	64-85
No. 16				26-40	24-34	36-49	46-68
No. 30	8-17	8-22	17-30	17-29	16-26	24-38	26-50
No. 50	4-12	5-15	10-22	10-21	8-18	14-27	13-31
No. 100*				5-16	4-13	6-18	7-17
No. 200	0-4	0-5	0-6	2-7	2-7	4-8	3-8
Bitumen	4-5	4.5-5.5	5-6	5.5-7.0	5.5-6.5	7-8	7-8

*Percentages shown in table above for aggregate sizes are stated as proportional percentages of total aggregate for the mix.

Unless authorized by the Engineer, no Job-Mix Formula will be approved which specifies:

More than 45% passing No. 8 for Top Course and Dense Binder Course.

More than 38% passing No. 8 for Modified Top Course.

More than 55% passing No. 8 for Dense Mix.

Less than 4% passing No. 200 for Top Course.

Less than 6% bitumen for Top Course.

Should a change of sources of materials be made, a new job mix formula shall be established by the Contractor before the new material is used. When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new job-mix formula.

The aggregate will be accepted in stockpile at the plant site. The bituminous material will be accepted on certification.

If the Contractor elects to furnish bituminous concrete from more than one plant, the job-mix formula must be adhered to by all plants.

Table B
Specifications for Open-Graded Friction Course (OGFC)
and Open-Graded Friction Course — Modified (OGFC-M)

Sieve Designation	OGFC	OGFC-M
5/8 in.		100
1/2 in.	100	95-100
3/8 in.	90-100	70-80
No. 4	30-50	30-45
No. 8	5-15	15-25
No. 200	1-3	2-4
% Bitumen (AC-20)	6.0-7.0	4.5-6.5

All relevant provisions of M3.11.00 shall apply to OGFC and OGFC-M with exceptions as hereinafter noted:

a) Mixing temperatures for OGFC shall be between 225 ° and 250 °F. This will require close control over aggregate drying and asphalt storage temperatures so that the resulting mix temperatures will fall within the limits stipulated herein.

b) Mixing temperatures for OGFC-M shall be between 270 ° and 310 °F.

c) Placing temperature for OGFC shall be between 225 ° and 250 °F. As placing temperature is a critical factor in this type of mix, hauling time to the project should be limited so as to avoid mix temperature from dropping below the required minimum. All mixes should be covered during transportation.

d) Placing temperature for OGFC-M shall be between 270 ° and 310 °F.

e) Tack coat — *Asphalt Emulsion*, RS-1 when needed, applied at the rate of 0.05 gallons per square yard.

f) Silicone shall be added to the asphalt in the amount of 1 oz. to each 5000 gallons of asphalt.

g) Anti-stripping additive shall be added if indicated by laboratory tests and only as directed by the Engineer.

h) Mix meeting the requirements of this specification shall be placed to a compacted thickness of 3/4 to 1 inch for OGFC and 1 to 1¼ inch for OGFC-M.

Weather Limitations

No mix shall be placed on wet or damp surfaces. When surface and ambient temperatures are 60 °F and rising, the Contractor shall use mix prepared and placed in accordance with the specified requirements of the mix herein before designated as OGFC. When surface and ambient temperatures are less than 60 °F and falling, the Contractor shall use mix prepared and placed in accordance with the stipulated requirements of the mix designated herein before as OGFC-M.

No mix conforming to the requirements of these specifications shall be placed when ambient temperatures are 40 °F and falling.

Irrespective of any temperature requirements, no mix conforming to the requirements of these specifications shall be placed after October 31 or before May 1 of any year.

M3.11.04 Mineral Aggregate.

A. Coarse Aggregate.

The coarse mineral aggregate shall be clean, crushed rock consisting of the angular fragments obtained by breaking and crushing shattered natural rock, free from a detrimental quantity of thin or elongated pieces, free from dirt or other objectional materials, and shall have a percentage of wear, as determined by the Los Angeles Abrasion Test (AASHTO-T96), of not more than 30. It shall be surface dry and shall have a moisture content of not more than 1/2% after drying. The use of crushed gravel stone will not be permitted.

B. Fine Aggregate.

The fine aggregate shall consist of one of the following:

a) 100% Natural Sand

b) 100% Stone Sand

c) A blend of sand and stone screenings the proportions of which shall be approved by the Engineer

d) A blend of natural sand and stone sand.

Natural sand shall consist of inert, hard, durable grains of quartz or other hard, durable rock, free from topsoil or clay, surface coatings, organic matter or other deleterious materials. When the primary source of material, passing the No. 200 sieve, is obtained from natural sand, these fines must be approved prior to use.

Stone sand shall be a processed material prepared from stone screenings to produce a consistently graded material conforming to specification requirements.

The stone screenings shall be the product of a secondary crusher and shall be free from dirt, clay, organic matter, excess fines or other deleterious material.

The fine aggregate as delivered to the mixer shall meet the following requirements:

	Percent Passing	
Sieve Designation	Minimum	Maximum
3/8 in.	95	100
No. 8	70	95
No. 50	20	40
No. 200	2	16

In the fine aggregate sieve analysis (passing No. 8), the amount between two successive sieves (No. 16, 30, 50 and 100) shall not exceed 33% of the fine aggregate total.

Plants that experience a large variation in the quality and gradation of their primary fine aggregate sources and have difficulty in consistently providing fine aggregate that conforms to the requirements of this specification, shall be equipped with an approved fine aggregate system for processing fine aggregate that *will* meet the requirements of this specification.

C. Reclaimed Asphalt Pavement (RAP)

Reclaimed Asphalt Pavement (RAP) shall consist of the material obtained from highways or streets by crushing, milling or planing existing pavements. This material shall be transported to the mix plant yard and processed through an approved crusher so that the resulting material will contain no particles larger than 1½ inch. The material shall be stockpiled on a free draining base and kept separate from the other aggregates. The material contained in the stockpiles shall have a reasonably uniform gradation from fine to coarse and shall not be contaminated by foreign materials.

M3.11.05 Mineral Filler.

Mineral filler shall consist of approved Portland Cement, limestone dust, hydrated lime, stone float or stone dust. Stone dust shall be produced from crushed ledge stone and shall be the product of a secondary crusher so processed as to deliver a product of uniform grading. Mineral filler shall completely pass a No. 50 sieve and at least 65% shall pass a No. 200 sieve.

M3.11.06 Bituminous Materials.

A. The asphalt cement for the mixture shall be the grade designated by the Engineer and shall conform to the requirements of M3.01.0. When required an approved anti-stripping additive conforming to M3.10.0, shall be added to the asphalt cement.

B. Bituminous material for the tack coat on the existing surface, where required and specified, shall be emulsified asphalt, grade RS-1 conforming to M3.03.0.

C. For any bituminous mixture containing RAP, the Contractor shall submit in addition to the Job-Mix formula, the amount and type of asphalt modifier to be added to the mixture to restore the asphalt properties of the RAP to a level that is reasonably consistent with the requirements of current specifications for new asphalt. The restored asphalt when recovered by the Abson Method from the recycled mixture shall have a minimum penetration at 77 °F of 50 and a maximum absolute viscosity at 140 °F of 8000 poises.

Only asphalt cements, grades AC-5, AC-10, AC-20 or a blend thereof will be used as modifiers and shall meet the requirements of M3.01.0.

M3.11.07 Plant Requirements.

Bituminous concrete conforming to these specifications shall be produced either in a batch plant or a drum mix plant. Mix plants shall comply with the following:

Requirements for Batch Plants

A. Plant Scales

1. Scales for measuring materials into the mixtures shall be springless dial or digital type and shall be of standard make and design. Scale graduations and markings shall be plainly visible and dials must be so located as to be easily readable from the operator's normal workstation by direct sight, through repeating dials or digital displays. Parallax effects shall be reduced to the practical minimum with clearance between indicator index and scale graduations not exceeding 0.06 inches (1.5mm). Dials shall be equipped with a full complement of adjustable index weighed into the batch.

2. Digital scales will be either electronic/mechanical (load cell and lever system) or fully electronic (all load cell). Digital indicators shall be of standard make and design. Scale graduations and capacity shall be plainly visible on the faceplate of the indicator, if panel mounted. If the unit is of desktop or wall-mount variety, a data sticker shall be located on the side of the unit. Indicators must be located as to be easily readable from the operator's normal workstation by direct sight.

3. Bitumen scales shall be accurate to 0.05%, have minimum graduations not greater than 0.025%, and must be readable and sensitive to 0.0125% or less. Scales for any weigh box or hopper shall be accurate to 0.5%, have minimum graduations not greater than 0.5% and must be readable and sensitive to 0.25% or less. The preceding percentages for both bitumen and aggregate scales are to be based on the maximum total batch weight of the mixtures.

B. Truck Scales

Shall be located on the plant property and shall be within a reasonable walking distance for the plant inspector. Scales shall be accurate to within ±0.5%.

C. Testing of Scales.

a) All plant scales, including truck scales, shall be tested at the expense of the producer by a competent scale technician as follows:

1. Annually prior to use in Department work.
2. At intervals of not more than 90 calendar days.
3. At any time ordered by the Engineer.

b) Where appropriate and at the direction of the Engineer, an approved cradle or platform for each scale and at least ten (10) standard fifty (50) pound test weights shall be provided for testing scales whenever directed by the Engineer. The use of a set of test weights for two (2) or more plants will be permitted only when they can be made readily available with no more than an hour's notice.

D. Automated Batching.

1. Automatic Proportioning.

All Batch Type mixing plants furnishing bituminous concrete mixtures for contracts which are financed fully or partially with Federal Funds, or 100% State Contracts requiring in excess of 15,000 tons shall be equipped with approved automatic proportioning devices. Such devices shall include equipment for accurately proportioning batches containing the various components of the mixture by weight in the proper sequence and for controlling the sequence and timing of mixture operations. Interlocks shall be provided which will hold or delay the automatic batch cycling whenever the batched quantity of any component is not within the specified weight tolerance, when any aggregate bin becomes empty or when there is a malfunction in any portion of the control system. The weight setting and time controls shall be so equipped that they may be locked when directed by the Engineer.

2. Automatic Recordation.

Recordation equipment shall be provided in all plants producing bituminous concrete under the provisions requiring automatic proportioning. Each recorder shall include an automatic printer system. The printer shall be so positioned that the scale dial or the digital display and the printer can be readily observed at one location by the plant inspector and the plant operator. Use of repeating dials or digital displays or an additional printer to achieve this condition will be permitted. The printer will print, in digital form, on a delivery ticket the following data:

a) Date mixed.
b) Time of batching.
c) Tare weight of aggregate weigh box.
d) Tare weight of bitumen weigh bucket.
e) Accumulative or *net weights* as batched for each bin with a batch total for all net ingredients.
f) Weight of bitumen.
g) Total weight of mix in truck (pay weight).

This printed ticket will be used in lieu of truck scale weights.

3. Equipment Failure.

If at any time the automatic proportioning or recording system becomes inoperative, the plant will be allowed to batch materials manually for a period not in excess of 2 working days. Manual batching for longer periods will require written permission of the Engineer.

4. Batching Controls.

a) The batching controls shall meet the following delivery tolerances with respect to the various components weighed in each batch:

Tare weight of aggregate weigh box	±0.5% of total batch weight
Tare weight of bitumen weigh bucket	±0.1% of total batch weight
Individual aggregate components	±1.0% of total batch weight
Combined aggregate components	±1.5% of total batch weight
Mineral filler	±0.5% of total batch weight
Asphalt	±0.1% of total batch weight

Truck loads consisting of more than one batch will be deemed acceptable if the average of the deviations of any of the components of the several batches which comprise the load do not exceed the specified tolerance.

b) The total weight of the batch shall not vary more than plus or minus 2% from the theoretical design weight.

c) If directed by the Engineer, provision shall be made for locking controls against tampering.

E. Testing Facilities

A weatherproof building or room shall be furnished at the site of the producing plant suitable for the housing and use of equipment necessary to carry on the various tests required and for recording and processing test

results. This building shall be for the exclusive use of the Engineer or his representative for testing and recording purposes. The building or room shall have a least dimension minimum of 7 feet. Windows and doors shall be adequately screened. Satisfactory lighting and heating shall be provided for a 24 hour day and the facility shall be supplied with water. The room shall have adequate ventilation and be air conditioned. A table, chairs, desk, work bench, file cabinet, electronic calculator and a minimum of two-five pound fire extinguishers shall be provided.

Provision shall be made for the safe performance of extraction test determinations by providing an adequate exhaust fan and/or hood system and a suitable means of disposing of used solvent and other waste. All to be in conformance with current OHSA, EPA, and DEQE standards.

If the Engineer permits, the testing facility may be part of another building in which case it shall be entirely partitioned off from the remainder of such building.

Testing equipment conforming to current AASHTO standards and meeting the approval of the Engineer shall be furnished as follows and installed in the building for use in testing the materials (and mixtures) supplied by the Plant for the work:

1 Approved Rotary Extractor or approved Vacuum Extractor (minimum 3000 gm capacity).

1 Coarse Aggregate Sieve Shaker, power driven with a minimum clear sieve area of 324 square inches. The shaker shall be attached to a firm anchorage.

1 Each of the following square opening screens for coarse aggregate shaker: 2 in., 1½ in., 1 in., 3/4 in., 1/2 in., 3/8 in., No. 4 and No. 8.

1 Fine Aggregate Sieve Shaker, Power driven and independent of coarse aggregate shaker, for eight (8) inch minimum diameter sieves.

1 Each of the following standard eight (8) inch minimum diameter square opening sieves: 3/4 in., 5/8 in., 1/2 in., 3/8 in., No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200 with pan and cover.

1 Sample Splitter with a minimum capacity of one (1) cubic foot. It shall be of the clam shell type and the chute width shall be adjustable from a minimum of 1/2 in. up to 2 in.

1 Solution Balance, 20 kilogram capacity, weighing directly to 1 gram, with two weighing beams and a taring beam: tare capacity to be 2 kilograms; weight beams to read 1000 grams by 100 gram divisions and 100 gram by 1 gram divisions. Additional matching weights (one — 1 kg, two — 2 kg, and one — 5 kg, and one — 10 kg) shall be provided to fulfill the capacity of 20 kilograms. The platform to be 11 in. diameter. An electronic, direct reading, top loading, 20 kilogram minimum capacity, balance with a precision of 0.1 gram may be substituted for the solution balance.

1 Approved scale with a minimum capacity of 2000 grams and a sensitivity of 0.50 grams. Or an electronic, top-loading, balance, with a capacity of 2000 grams minimum, and reading to 0.1 gm.

Approved Dial Thermometers, range of 50 °F to 500 °F.

Approved Hot Plates.

Approval of a plant will be contingent upon approval of the aforementioned requirements for Plant Laboratory, including the building and appurtenances, furnishings, facilities including heat, light, power and water, the testing equipment and any other incidentals.

F. Sampling Facilities.

Adequate and convenient sampling facilities shall be provided which allow the Inspector to obtain representative samples from the full width and depth of the discharge area of each aggregate bin. The sampling tray shall be structurally supported during the sampling operation. Access to the sampling facilities shall be provided requiring no more difficulty than that to climb a ladder leading to a secure platform with railings.

G. Preparation of Mixtures.

1. Preparation of Asphalt Cement.

The temperature of the bituminous materials when placed in the mixer shall be not less than 275 °F nor more than 375 °F.

2. Preparation of Mineral Aggregate.

All aggregates shall be thoroughly dried and heated before entering the mixer. The temperature of the aggregates shall be controlled so that the temperature of the completed mixture shall be within the range specified under section G3 (Preparation of Bituminous Concrete Mixtures).

3. Preparation of Bituminous Concrete Mixture.

The mineral aggregate, prepared as prescribed above, shall be combined and conveyed into the mixer in the proportionate amounts of each aggregate required to meet the job-mix formula. The required quantity of asphalt cement shall be measured by weight, or approved metering device.

The mixture shall be made by first charging the mixer with the required amount of mineral aggregate and mineral filler. After these materials have been thoroughly mixed, the asphalt cement shall be added and the mixing continued for a period of time sufficient to produce a homogeneous mixture.

The ingredients shall be heated and combined in such a manner as to produce a mixture which shall be at a temperature, when discharged, of not less than 275 °F, nor more than 325 °F.

4. The temperature of mixture containing RAP as discharged from the modified batch plant shall be within the range of 265 °F to 300 °F. Moisture content of the mixture at discharge shall be no greater than 1.0% by weight. All aggregate particles shall be completely and uniformly coated. The recycled mixture shall not contain any visible chunks of unprocessed RAP. The recycled mixture shall be capable of being spread and compacted to a density that is not less than 95% of the density obtained from laboratory compaction of a mixture composed of the same materials in like proportions.

Requirements for Drum Mix Plants

The basic components of the drum mix plant are:

Aggregate cold-feed bins
Conveyer and aggregate weighing systems
Drum mixer
Asphalt storage metering system
Hot-mix conveyer
Storage and surge silos
Central Control Panel

A. Aggregate Cold Feed Bins.

The number and capacity of the cold-feed aggregate bins shall be sufficient to keep the plant in continuous operation. There shall be one cold-feed bin for each stockpile of material to be used. Stockpiles shall be established on clean free draining surfaces and shall be so constructed as to minimize segregation. The bins shall be designed to prevent overflow of material from one bin to another. The fine aggregate bin compartments shall be equipped with a vibrator or other anti-bridging device which is automatically actuated when bridging of the material occurs and which automatically shuts off when continuous material flow is restored.

An interlocking automatic cold-feed shut-off shall be provided so that all production is stopped if flow from any one bin is interrupted for more than five seconds.

B. Mineral Filler Bin.

The requirements for a mineral filler bin shall be optional. Mineral filler bin shall be fed from a separate bin provided with a device that controls the feed at adjustable rates accurately and uniformly. The bin shall be equipped with an interlocking device to shut off all production if the flow of mineral filler is stopped. It shall also be equipped with an automatic anti-bridging device.

C. Aggregate Feeder Control.

The plant shall have a mechanical system for feeding the aggregate from each cold bin accurately and uniformly in its proper proportion onto a common collecting belt. The system shall be so designed that production is automatically stopped if the flow of material from any one of the bins is interrupted for more than five seconds.

Each aggregate and mineral filler bin shall have an adjustable feed rate control.

The accuracy of the aggregate feeder control system shall be such that the total variations for all materials being drawn per interval of time shall not exceed 1.5% of the total weight of bituminous mixture per interval of time. Where the separate addition of mineral filler is required, the variation shall not exceed 0.5% on the same basis as stated above for aggregates.

For purposes of accurate weight and gradation checks, and calibration of the aggregate proportioning system, suitable means shall be provided for conveniently obtaining representative samples of the full flow of material from each cold feed and the total cold feed. A sampling device for diverting the full flow of the combined aggregate into a suitable container shall be provided.

Prior to entering the drum mixer the combined aggregate on the common feeder belt shall pass through a 2 in. scalping screen.

D. Aggregate Weighing Systems.

All aggregates including mineral filler, if required, shall be weighed by a continuous weighing device either as it is proportioned by the individual feeders or after all materials have been deposited on the common belt.

The weighing device for weighing the total material accumulated on the common belt shall be located so that the weight reading is obtained after the material has passed through the two (2) in. scalping screen.

Belt scales shall meet the requirements of the National Bureau of Standards Handbook 44. When tested, the weighing system shall have an accuracy of 0.5%.

All weighing devices shall be installed in accordance with the manufacturer's recommendations.

The weighing devices shall be capable of displaying at the control panel, the aggregate weight flow, in tons per hour, and shall continuously accumulate the weights of material during the day's production.

E. Aggregate Moisture Compensator.

Moisture content of the aggregate shall be determined manually or electronically and a moisture compensation device shall be capable of electronically changing the wet aggregate weight to dry aggregate weight.

F. Reclaimed Asphalt Pavement (RAP).

The plant shall be equipped with a separate bin suitably located for introduction into the drum mixer. The RAP bin shall be equipped with an interlocking device for automatically stopping production if the RAP bin becomes empty or flow is stopped for any reason.

A weighing device shall be located on the RAP conveyer for continuous weighing of the RAP. Also a moisture compensator shall be included in the RAP delivery system to compensate for the moisture in the RAP.

G. Drum Mixer.

The drum mixing unit shall be approved by the Engineer and shall be a revolving type that continuously agitates and mixes the aggregate and bituminous material. It shall have an automatic burner control and be capable of producing a uniform mix within the job specifications.

An automatic temperature recording device that continuously records the mix temperature shall be located in the area of discharge and the data transmitted to the control panel.

H. Bituminous Metering System.

The bituminous material shall be introduced into the drum mixer by a metering system that is capable of accurately and continuously measuring the quantity and temperature of the material being introduced. The temperature recording device shall be located so as to record the temperature of the bituminous material prior to entry into the mixer.

The metering system shall be capable of introducing the proper amount of material into the mix, accurate to $\pm 0.1\%$ based on the total weight of the mix.

The bituminous metering system shall be interlocking with both the aggregate and RAP weight control system so that any change in the aggregate or RAP rate of flow will automatically trigger a change in the bituminous material rate of flow so as to maintain the correct proportions. Also, any interruption in the flow of bituminous material to the mixer shall stop all production. Means shall be provided for conveniently and safely diverting the flow of bituminous material into a suitable container for checking the accuracy of the metering system. A temperature compensating device shall be installed in the metering system to correct the quantity of bituminous material to 60 °F.

The Bituminous material flow shall be continuously displayed at the central control panel in tons per hour or as the corresponding percentage of the total mix.

I. Hot Mix Conveyer.

The mix will discharge onto a hot mix conveyer that carries the mix to a surge silo. The temperature of the mix when discharged onto the conveyer shall be not less than 275 °F nor more than 325 °F. Means shall be provided for conveniently and safely obtaining a representative sample of the mix as it is discharged from the mixer or from the hot mix conveyer.

The hot-mix conveyer shall be designed so as to prevent any segregation and excessive temperature variation of the mix as it is transported and dumped into the surge-silo.

J. Surge and Storage Silos.

The plant shall be equipped with sufficient surge and storage silos to accommodate the temporary storage of different mixes and to minimize any production interruptions.

Surge-Storage Silos shall be approved in accordance with the following requirements:

a) All bins shall be designed and equipped so that there will be no segregation of the mix at the time of loading, during storage or at time of discharge. The Engineer reserves the right to reject any material when there is any indication that the material is not in conformance with specifications.

b) The holding bins, together with all equipment and methods pertaining to their use, shall be subject to approval by the Engineer. The use of coatings on the internal surfaces of the bins shall not be permitted. The use of additives to the bituminous concrete mixes will be permitted only with the approval of the Engineer.

c) Unless otherwise permitted by the Engineer, the mixtures shall not be stored in surge and storage bins longer than the following:

Type of Bin	Maximum Holding Time
Unheated and not insulated	2 hours
Unheated, but insulated (may have heated gate)	15 hours
Insulated and heated	24 hours

d) Surge silos for the temporary storage of mix during a day's production shall always be maintained above the one-quarter full level.

K. Proportioning Controls.

All proportioning controls for aggregate, mineral filler, bitumen and RAP shall be electronically interlocked so that any interruption of more than five seconds in the flow of one component will automatically stop all production. The central control panel shall be equipped with a master control which will increase or decrease the production rate without having to reset the individual controls for each change in production rate.

a) Each aggregate and mineral filler feeder shall have an adjustable rate control. The controls shall maintain the accuracy of the aggregate feeders to $\pm 1.5\%$ of the total weight of the bituminous mix per interval of time and the mineral filler feeder to 0.5% of the weight of the bituminous mix per interval of time.

The flow rates of the aggregate and mineral filler shall be continuously displayed at the central control panel in tons per hour and continuously accumulated for each day's production.

b) Provisions shall be made for a moisture compensating device that will electronically correct combined wet aggregate weight to dry aggregate weight.

c) The bitumen control shall be capable of presetting the bitumen content directly as a percentage of the total weight of the mix in increments of 0.1%. The bituminous metering system shall be coupled with the aggregate and RAP feeder systems to automatically maintain the required proportions as the aggregate and RAP flow vary.

The bituminous flow rate shall be continuously displayed at the central control panel in tons per hour and continuously accumulated.

d) At the start of each production season all plant controls necessary to the production of specification mix shall be calibrated. The method of calibration shall be in accordance with the plant manufacturer's instructions and shall be subject to approval by the Engineer.

Calibration points for the delivery of each type of mix used by the Department shall be determined.

e)The central control panel shall be equipped with an automatic digital recording device, that on a continuing specified interval and on demand, records the weight of aggregate from each bin or the accumulated weight of all aggregates on the common belt, mineral filler and RAP, if used, and bitumen. All print-outs shall show time and date and shall be clearly legible. Copies shall be provided to the Engineer.

L. All plant controls shall be capable of being locked to prevent tampering. After calibration, no changes will be made to the equipment or operating procedures without the approval of the Engineer.

M. Testing of Scales.

All plant scales, including truck platform scales shall be subject to the same testing requirements as found under M3.11.07C "Testing of Scales."

N. The plant shall be designed and operated to meet all current Federal and State air quality requirements.

O. Portable Drum Mix Plants.

Whenever a plant is moved from one location to another, it shall be recalibrated in accordance with Section K, "Proportioning Controls", Subsection "d" of this specification.

P. Testing Facilities.

Testing facilities shall conform to Subsection M7.11.07, Plant Requirements. F. Testing Facilities.

M3.11.08 Inspection.

The Engineer or his authorized representative shall have access at any time to all parts of the plant for:

1. Inspections of the conditions and operations of the plant.
2. Confirmation of the adequacy of the equipment in use.
3. Verification of the character and proportions of the mixture.
4. Determination of temperatures being maintained in the preparation of the mixtures.
5. Inspection of incidental related procedures.

M3.11.09 Composition and Compaction Acceptance Tests.

Where plant inspection is maintained, the material will not be considered acceptable for use unless the specified tests from samples obtained at the production plant indicate conformance to the approved job mix formula.

The applicable tolerances defining reasonably close conformity with the specifications (as outlined in Subsection 5.03) shall be the amount of bitumen, the percentage by weight passing No. 8 and No. 200 sieves as specified under M3.11.03, Table "A".

For determination of pavement density the Nuclear Density Gauge Method ASTM D2950 and/or Bulk Specific Gravity Method AASHTO-T166 shall be used. Where AASHTO-T166 is used, samples for the full depth of the course being laid shall be taken from the mixture incorporated in the work after finishing operations have been completed and the pavement has cooled. The Contractor shall have suitable coring equipment available in order that the required number of samples (6 in. cores) may be taken. At least one such sample shall be taken from each project containing 3000 or more tons of mixture. In projects containing more than 3000 tons of mixture, at least one sample shall be taken for each 3000 tons; except that any additional number of samples shall be taken as may be deemed necessary by the Engineer.

These samples will be taken by the Contractor in the presence of the Engineer on the day following the placement of the course, weather permitting.

M3.12.0 Bituminous Concrete Curb, Types 1, 2, or 3.

The Bituminous Concrete for curbing shall be Class I conforming to the applicable requirements for Dense Mix (See Table A, M3.11.03).

SECTION M4

CEMENT AND CEMENT CONCRETE MATERIALS

M4.00.00 General.

All cement, cement concrete and related materials shall be sampled and tested in accordance with the applicable AASHTO, ASTM or other designated methods. Cement as defined in this specification shall mean cementitious material as specified in the following sections.

M4.01.0 Portland Cement

Portland Cement shall conform to the requirements of AASHTO M85.

M4.01.1 Blended Hydraulic Cements

Blended hydraulic cements shall conform to the requirements of AASHTO M240.

M4.01.2 Fly Ash.

Fly ash shall conform to AASHTO M-295.

M4.02.00 Cement Concrete

Cement concrete shall be composed of specified proportions by weight of cement, aggregates, water and approved additives to form a homogeneous composition.

Cement concrete shall be designated by class according to strength, cement factor, coarse aggregate size, entrained air content, slump, and by weight for light-weight concrete. The classes of concrete to be used shall be designated on the plans or in the specifications for the particular work. The Contractor will furnish to the Engineer, for approval, a specific job mix formula for the particular uniform combination of materials and sources of supply to be used on each project complete with test results from trial batches. A new job mix formula shall be supplied anytime any source of material has been changed.

Classifications of Concrete Mixes

Class 28-Day Compressive Strength	Minimum Cement Content** (Pounds Per Cubic Yard For Coarse Aggregate)		
	1½ in.	3/4 in.	3/8 in.
2500 psi	425	470	520
3000 psi	470	520	565
3500 psi	520	565	610
4000 psi	565	610	660
5000 psi	660	705	760
% Entrained Air (±1.0%)	5.0	6.0	7.0

All concrete shall contain a water reducing admixture.

**Fly ash may be substituted for cement up to a maximum of 15% by weight.

Concrete which will be subjected to conditions of severe exposure will be minimum Class 4000 psi with air-entrained content of 7.0 ±1.0% when so specified.

The use of an approved additive other than air entraining (AASHTO-M154) or water reducer (AASHTO-M194, Type A) shall require written approval of the Enginer and additives shall not affect a change in the minimum cement content. The minimum cement content can be changed only with the prior written approval of the Engineer.

M4.02.01 Cement

Cement for concrete shall be the kind and type designated on the plans or in the specifications for the particular work. If no type is specified either Type I, IA, IP, IP-A or Type II, IIA shall be furnished except that cement for exposed bridge deck concrete or concrete exposed to sea water shall be Type II or IIA.

When high early strength concrete is required it shall be obtained by using Type III or by adding an accelerator meeting AASHTO M194.

Cement shall not exhibit a flash set or cause an abnormal initial rise of temperature when mixed with water. It shall maintain its full plasticity and fluidity during the period required for placing the concrete.

The temperature of the cement at the time of mixing shall not exceed 150°F.

When tested at the mill, no cement shall be shipped to the work until it has passed the 7 day test, unless otherwise directed. At least 12 days from the time of sampling shall be allowed to the completion of the required 7 day test.

Each shipment, regardless of quantity, shall be accompanied by a certified Mill Test Report, three copies of which shall be furnished to the Engineer before the cement may be incorporated in the work.

Cement of a uniform color shall be used in all exposed concrete of any structure.

M4.02.02 Aggregates

A. Fine Aggregates

Sand shall be composed essentially of clean, hard, strong, durable and impermeable particles, resistant to wear and frost, inert to cement and water, reasonably free from structurally weak grains, organic matter, loam, clay, silt, salts, mica or other fine materials that may affect bonding of the cement paste. Sand shall be taken from a natural deposit. The sand particles shall be relatively spherical in shape, and shall have gritty surfaces.

Sand for cement concrete shall be properly washed to satisfactorily remove deleterious materials and surface coatings, and shall be stockpiled after washing for a period as long as necessary to drain off all excess water.

The sand shall conform to the following requirements:

	AASHTO Test Method	Maximum Percent by Weight
Clay Lumps and Friable Particles	T-112	3.0
Coal and Lignite	T-113	0.5
Materials Passing No. 200 Sieve	T-11	3.0
Organic Impurities	T-21	*Pass
Soundness (Na_2SO_4) — 5 Cycles	T-104	10

*Sand when tested for mortar making properties as specified above shall produce a compressive strength, at any period of time, equal to or greater than that developed by mortar of the same proportions and consistency made of the same cement and sand after the sand has been treated in a 3% solution of sodium hydroxide in accordance with AASHTO-T71.

Sand not conforming to the requirement specified above for organic impurities, shall be rejected unless the 28 day strength tests show the color is due to impurities not detrimental to the strength of the concrete.

The sieve analysis of the sand shall show it to be well graded and conforming to the following:

Sieve Designation	Minimum	Maximum
3/8 in.	100	
No. 4	95	100
No. 16	55	80
No. 50	10	25
No. 100	2	8
No. 200	0	3

The fineness modulus of fine aggregate shall be not less than 2.5 and not greater than 3.0. For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from any one source. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the representative sample will be rejected.

Samples for tests of fine aggregate will be taken under the direction of the Engineer from approved storage piles at the site of the batch plant or from approved storage piles at the producing pit.

The fineness modulus of fine aggregate shall be determined by adding the cumulative percentages, by weight, of materials retained on U.S. Standard Sieves numbered 4, 8, 16, 30, 50, 100 and dividing by 100.

Fine aggregate failing to pass the minimum requirements for material passing the No. 50 and/or No. 100 sieves may be used, provided an approved inorganic fine material is added to correct the deficiency in grading.

Sand for cement mortar shall conform to the requirements specified above except that the compressive strength shall not be less than 85 % of that developed by mortar of the same proportions and consistency made of the same cement and sand after the sand has been treated in a 3 % solution of sodium hydroxide in accordance with AASHTO-T71. The sieve analysis shall conform to the following requirements:

Sieve Designation	Minimum	Maximum
No. 8	100	
No. 50	15	40
No. 100	2	10
No. 200		3

B. Coarse Aggregates

Physical Characteristics.

Coarse aggregate for cement concrete shall consist of crushed rock or screened gravel, and shall be composed essentially of clean, hard, strong, and impermeable particles, resistant to wear and frost, and free from deleterious amounts of organic matter, loam, clay, salts, mica, and soft, thin, elongated, laminated or disintegrated stone, and it shall be inert to water and cement. Where finishing of the concrete is to be done by hammering or any other method that breaks the surface of the concrete, only crushed rock shall be used for coarse aggregate.

The aggregates shall conform to the following requirements:

	AASHTO Test Method	Maximum Percent by Weight
Clay Lumps & Friable Particles	T-112	2.0
Chert (Less than 2.40 Sp. Gr. SSD)*		3.0
Sum of Clay Lumps, Friable Particles and Chert (Less than 2.40 Sp. Gr. SSD)*		3.0
Material Finer than No. 200 Sieve	T-11	1.0
Coal and Lignite	T-113	0.5
Percent of Wear (Los Angeles Abrasion Test)	T-96	45 except 30 for all concrete 5000 psi and above
Sodium Sulphate Solution Soundness (5 Cycles)	T-104	10

*These limitations apply only to aggregates in which chert appears as an impurity.

Gravel stone shall be thoroughly washed to remove impurities if surfaces are coated with dust.

A deleterious amount of thin and elongated stones will be considered any amount in excess of 15% of the total weight. Thin stones shall be considered to be such stones whose average widths exceeds four (4) times their average thickness. Elongated stones shall be considered to be such stone whose average length exceeds four (4) times their average width.

C. Sieve Analysis.

When tested by U.S. Standard laboratory sieves, coarse aggregate for cement concrete shall be blended from stone sizes to meet the graduation requirements for each designation listed below. The limits shown in the table define master ranges of variation for general application and are minimum and maximum in each case. To insure uniformity of material used on any one job or project, the range of variations may be reduced to 1/2 of the range upon determination of the character and source of the materials that the Contractor proposes to furnish.

Percent by Weight Passing (AASHTO T-27)

Designation and Nominal Size	1½ in.		3/4 in.		3/8 in.	
Sieve Size	Min.	Max.	Min.	Max.	Min.	Max.
1½ in.	90	100				
3/4 in.	35	60	90	100		
1/2 in.					90	100
3/8 in.	10	25	20	50	30	70
No. 4	0	5	0	10	0	15
No. 8			0	5	0	5

Stone retained on the largest sieve shall be within an oversize tolerance of 1/4 in.

1½ in. aggregate shall be proportioned in two or more sizes, separately weighed in the mix. The combined grading as proportioned in the mix shall meet the grading requirements for 1½ in. coarse aggregate, as determined by actual test.

Three-quarter-inch aggregate may be proportioned in two sizes or processed to the specified gradation.

For use in mass concrete the Engineer may allow the use in 1½ in. aggregate of not more than 30% of coarse aggregate passing 2¼ in. and retained on 1½ in. sieve, provided such aggregate is separately proportioned as an additional size.

M4.02.03 Lightweight Aggregates.

Lightweight aggregates for Structural Concrete shall meet AASHTO M-195.

M4.02.04 Water.

Water for use in cement concrete shall be clean, clear and free from deleterious amount of oil, acid, alkali, salts and organic matter.

The water shall exhibit no deleterious effect upon the strength, setting, or soundness of the cement. It shall conform to the following requirements:

1. pH — 3.0-11.7
2. Total Solids.
   a) Organics — .01% Maximum
   b) Inorganics — .10% Maximum
   c) Sulphate — .05% Maximum

Testing of the water shall be in accordance with AASHTO-T26.

M4.02.05 Cement Concrete Additives.

Air-entraining admixtures, Water-reducer, Retarders, etc., shall conform to the following Specifications:

A. Air-entraining admixtures, AASHTO-M154

B. Retarders, AASHTO-M194

C. Water Reducers, AASHTO-M194

M4.02.06 Proportioning.

Concrete shall be proportioned with the specified minimum cement content for each class and shall be mixed to the required consistency as determined by standard slump test AASHTO-T119.

A. Proportioning by Weight.

Cement and aggregates shall be proportioned by weight in an approved manner. Scales shall be calibrated and sealed by the proper authority within the preceding year, or following any reassembly, or as the Engineer may direct.

B. Scope of Control for Proportioning.

The responsibility of the Department is confined to the inspection of the following four factors controlling the mix:

1. Minimum Cement Content and Minimum Strength.

The cement proportion is subject to adjustment and approval by the Engineer in order to insure compliance with minimum strength requirements. Standard field test specimens (AASHTO T-23) shall be taken on the job and the Contractor shall be required to add additional cement as directed by the Engineer if test specimens strength fail to meet the requirements of ASTM C94, Section 17.

No claims shall be allowed for extra cement or extra concrete due to variations in materials, proportioning, dimensions, shrinkage, waste and similar causes. The Contractor is advised to anticipate a normal loss in yield of 1 or 2% due to the foregoing causes.

The volume of plastic concrete in a given batch shall be determined from the total weight of the batch divided by the actual weight per cubic foot of the concrete. The total weight of the batch shall be calculated as the sum of the weights of all materials including water. The weight per cubic foot shall be determined in accordance with the Method of Test for Weight per Cubic Foot Yield and Air Content (Gravimetric) of Concrete (AASHTO-T121).

2. Consistency.

The Contractor shall uniformly regulate the consistency of the mix to the slump directed by the Engineer. The Engineer may reject all batches not conforming to this requirement and the Contractor shall receive no additional compensation.

The general requirements in regard to consistency are as follows:

Mass Concrete	1 to 3 in. slump
Reinforced Concrete	2 to 4 in. slump
	according to placement conditions
Very Constricted Placement Conditions	3 to 5 in. slump
Exposed Bridge Deck Concrete	2½ in. slump
Tremie Concrete	6 in. slump

When the specified slump is 3 in. or less, the tolerance shall be plus or minus 1/2 in. When the specified slump is greater than 3 in., the tolerance shall be plus or minus 1 in. The Engineer will specify the lowest slump with which it is practicable to properly place and consolidate the mix within the forms.

3. Workability.

The Engineer may vary the proportion of fine aggregate in order to regulate the workability or density of the mix, making an equivalent change in the course aggregate to keep the yield constant.

4. Air Content.

The air content of the concrete by volume shall be as shown in the table above when tested in accordance with AASHTO-T152. A tolerance of plus or minus 1% in the above percentages will be allowed.

C. Automatic Proportioning Plants.

All plants shall be equipped with an approved automatic weighing, cycling and monitoring system installed as part of the batching equipment. Each plant shall include equipment for accurate proportioning batches containing the various components by weight or by volume for admixtures and water in the proper sequence and for controlling the sequence and timing of mixing operation. The automatic proportioning system shall be capable of consistently delivering each constituent within the tolerances indicated in M4.02.07. Interlocks shall be provided which will hold or delay the automatic batch cycling whenever the batched quantity of any component is not within the specific weight tolerance, when any aggregate bin becomes empty or when there is a malfunction in any portion of the control system. The weight setting and time controls shall be so equipped that they may be locked when directed by the Engineer.

The weighing equipment shall be so arranged that the batch plant operator can conveniently observe all scales from his operation station.

The Controls shall be set so that:

1. The batcher inlet gates cannot be opened while the discharge gates are open.
2. The batcher discharge gates cannot be opened:
   a) Until the full batch weights are registered on the scales;
   b) While the weigh hopper is being filled;
   c) If batch weights are over or under the delivery tolerances specified on M4.02.07.
3. A new batch cannot be weighed until the hopper is entirely empty of the previous batch and all scales have returned to zero.

Discharge chutes shall be so arranged that they are not suspended from any part of the weighing system and so that no materials will lodge therein or be lost on discharge.

Each weighing unit shall include a springless dial which shall indicate the scale load at all stages of the weighing operation from zero to full capacity.

If at any time the automatic proportioning system becomes inoperative, the plant will be allowed to batch materials manually for a period not in excess of 2 working days. Manual batching for longer periods will require written permission of the Engineer. All plant scales shall be tested at the expense of the producer by a competent scale technician as follows:

1. Annually prior to use in Department work.
2. At any time ordered by the Engineer.

D. Admixture Dispensing Systems.

Plants shall be equipped with a separate dispensing system necessary to incorporate each of the required admixtures into the concrete. At least two admixture dispensing systems shall be required for plants supplying structural concrete.

E. Recording the Batching.

All concrete batching plants equipped with automatic proportion systems shall have digital recording instruments approved by the Engineer which shall be so located as to be readily accessible and readable to the operator from his normal work station. The recording instruments shall be designed to record the quantities of each aggregate component, cement, fly ash (when used), water and the presence of admixture for each batch of concrete produced. All records of batches shall show the batch number, the day, the month, year, and time of day to the nearest minute for each batch and they shall be imprinted on the record so that each batch may be permanently identified. The Department shall be provided with a clear and legible copy of all batch records.

Cement, fly ash, and aggregate component weight quantities shall be recorded separately. Water may be recorded by weight or volume.

Weights and/or volumes shall be recorded as indicated on the batching scale or meter within an accuracy of ± 1 scale or meter gradation. The minimum recorder resolution shall be equivalent to or less than minimum gradation on the scale or meter, unless otherwise approved by the Engineer. When the automation system is capable of producing other than standard size batches (full, half or quarter cubic yard increments), the recordation requirements shall be in accordance with written directives from the Engineer.

Each plant site shall be equipped with an approved instrument capable of automatically applying a time-date stamp to each delivery ticket as the delivery vehicle departs from the plant site.

M4.02.07 Measuring Materials.

A. Cement shall be measured by weight or in bags of 94 lbs. each. When fly ash is specified in the mix design, it may be weighed cumulatively with cement. Cement should be weighed before fly ash. When cement is measured by weight, it shall be weighed on a scale separate from those used for other materials, and in a hopper entirely free and independent of the hoppers used for weighing the aggregates. All beam type scales for weighing cement shall be equipped with a tare beam. When cement is measured in bags, no fraction of a bag shall be used unless weighed. The cement as weighed, shall be within a 1% of required weight.

B. Aggregates shall be measured by weight. Batch weights shall be based on dry materials and shall be the required weights of dry materials plus the total weight of moisture (both absorbed and surface) contained in the aggregate. The individual aggregates as weighed, shall be within $\pm 1\%$ of required weight.

C. Mixing water shall consist of water added to batch, ice added to batch, water occurring as surface water on the aggregates, and water introduced in the form of admixtures. Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and shall be capable of being set to deliver the required amount and cut off the flow automatically when this amount has been discharged. Under all operating conditions the device shall have an accuracy within 1% of the quantity of water required for the batch. The device shall be so arranged that measurements will not be affected by variable pressures

in the water supply line. Measuring tanks shall be of adequate capacity to furnish the maximum mixing water required and shall be equipped with outside taps and valves to provide for checking their calibration unless other means are provided for readily and accurately determining the amount of water in the tank. All wash water must be removed from truck mixers or agitators. All water measuring systems shall be capable of discharging total quantity of measured water into the mixer drum in a time not greater than one third of the specified mixing time.

D. Dry admixtures shall be measured by weight, and paste or liquid admixtures by weight or volume, within a limit of accuracy of 3%. When admixtures are used in small quantities in proportion to the cement, as in the case of air-entraining admixtures, mechanical dispensing equipment shall be used.

M4.02.08 Plant and Equipment.

The plant and equipment shall be subject to approval by the Engineer to insure satisfactory prosecution of the work without delay.

A. Batching Plant.

1. Bins with adequate separate compartments for fine aggregates and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall be designed to discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. Weighing hoppers shall be constructed so as to eliminate accumulation of tare materials and to discharge fully.

2. Fly ash shall be stored at the batch plant in a separate storage or holding bin and it shall be protected from rain and moisture.

3. Scales for weighing aggregates and cement shall be of either the springless-dial type or the load cell type and shall indicate the load at all stages of the weighing operation from zero to full capacity. They shall conform to the applicable sections of the current edition of the National Bureau of Standards Handbook 44, Specifications, Tolerances and other Measuring Devices, except as may be otherwise specified. They shall be accurate within one half of 1% under operating conditions. Ten 50 pound weights shall be available at the plant at all times for checking accuracy. All exposed fulcrums, clevises, and similar working parts of scales shall be kept clean. When beam-type scales are used, provisions shall be made for indicating to the operator that the required load in the weighing hopper is being approached; the device shall indicate within the last 200 pounds of load and within 50 pounds overload. All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

4. The materials, including admixtures, shall be proportioned by automatic proportioning devices, approved by the Engineer. The automatic proportioning equipment shall be installed in an area enclosed for protection against dust and inclement weather.

B. Testing Facilities.

A weatherproof building or room shall be furnished at the site of the producing plant suitable for the housing and use of equipment necessary to carry on the various tests required and for recording and processing test results. This building shall be for the exclusive use of the Engineer or his representative for testing and recording purposes. The building or room shall have at least dimension minimum of 7 feet. Windows and doors shall be adequately screened and satisfactory lighting and heating shall be provided for a 24 hour day and be supplied with water. The room shall have adequate ventilation and be air conditioned in the warm months to provide a minimum of 75 °F. A table, chairs, desk, work bench, file cabinet, electronic calculator, and a minimum of two-five pound fire extinguishers shall be provided.

If the Engineer permits, the testing facility may be part of another building in which case it shall be entirely partitioned off from the remainder of such building.

Testing equipment conforming to current AASHTO standards and meeting the approval of the Engineer shall be furnished as follows and installed in the building for use in testing the materials (and mixtures) supplied by the Plant for the work:

1 Fine Aggregate Sieve Shaker, power driven, for eight (8) inch minimum diameter sieves.

1 Each of the following standard eight (8) inch minimum diameter square opening sieves: No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, and No. 200, with pan and cover.

1 Sample Splitter with a minimum capacity of one (1) cubic foot. It shall be of the clam shell type and the chute width shall be adjustable from a minimum of 1/2 in. up to 2 in.

1 Solution Balance, 20 kilogram capacity, weighing directly to 1 gram, with two weighing beams and a taring beam; tare capacity to be 2 kilograms; weight beams to read 1000 grams by 100 gram divisions and 100 gram by 1 gram divisions. Additional matching weights (one — 1 kg., two — 2 kg., one — 5 kg., and

one — 10 kg.) shall be provided to fulfill the capacity of 20 kilograms. The platform to be 11 in. diameter. An electronic, direct reading, top loading, 20 kilogram minimum capacity, balance with a precision of 0.1 gram may be substituted for the solution balance.

1 Approved Scale with a minimum capacity of 2000 grams and with a sensitivity of 0.50 grams. An electronic, top-loading, balance, with a capacity of 2000 grams minimum, and reading to 0.1 gm. may be used in place of the scale.

1 Approved Dial Thermometer, range of 50 °F to 500 °F.

1 Approved Hot Plate.

Approval of a plant will be contingent upon approval of the aforementioned requirements for Plant Laboratory, including the building and appurtenances, furnishings, facilities including heat, light, power and water, the testing equipment and any other incidentals.

M4.02.09 Mixers and Agitators.

A. Mixers may be stationary mixers or truck mixers. Agitators may be truck mixers or truck agitators. Each mixer and agitator shall have attached thereto, in a prominent place by the manufacturer, a metal plate or plates on which is plainly marked the various uses for which the equipment is designed, the volume of the drum, the capacity of the drum or container in terms of the volume of mixed concrete and the speed of rotation of the mixing drum or blades. Stationary mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. Truck mixers shall be equipped with counters by which the number of revolutions of the drum or blades may readily be verified. The counters shall be read at the time of starting and ending of mixing at mixing speeds.

B. The truck mixer when loaded with concrete shall not contain more than 63% of the gross volume of the drum. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

C. The stationary mixer, when loaded at the manufacturer's guaranteed mixing capacity, and the concrete mixed for the time prescribed, shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and discharging the concrete with satisfactory uniformity.

D. The agitator, when loaded not to exceed 80% of gross drum volume, shall be capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

M4.02.10 Mixing and Delivery.

A. Ready-mixed concrete shall be mixed and delivered to the point designated by the Engineer by means of one of the following combinations of operations.

1. Mixed completely in a stationary mixer and the mixed concrete transported to the point of delivery in a truck agitator or in a truck mixer operating at agitator speed or in nonagitating equipment when approved by the Engineer.

2. Mixed completely in a truck-mixer at the point of delivery under the supervision of the Resident Engineer or his designated assistant, one of whom shall certify on a delivery slip that he observed the complete mixing of the concrete.

B. Truck mixers and truck agitators shall be operated within a capacity not to exceed 63 or 80% respectively of the gross volume of the drum and at a speed of rotation for mixing or agitating as designated by the manufacturer of the equipment. A truck mixer or truck agitator used for transporting concrete that has been completely mixed in a stationary mixer shall be operated within the limits of capacity and speed of rotation designated by the manufacturer for agitating, except that the agitator capacity in no event exceed 80% of the gross drum volume.

C. When a stationary mixer is used for the complete mixing of the concrete, the mixing time for mixers having a capacity of 10 cubic yards or less shall be not less than 60 seconds. For mixers of more than 10 cubic yards capacity, the mixing time shall be determined by the Engineer. The time is valid provided mixer efficiency tests prove the concrete is satisfactory for uniformity and strength. Mixing time shall be measured from the time all cement and aggregates are in the drum. The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates, and all water shall be in the drum by the end of the first one-fourth of the specified mixing time.

D. When a truck mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 nor more than 100 revolutions of the drum or blades at the rate of rotation designated by the manufacturer of the equipment on the metal plate on the mixer as mixing speed. Additional mixing, if any, shall be

at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determination of number of revolutions of mixing.

E. When a truck mixer or truck agitator is used for transporting central-mixed concrete, or when all ingredients including water have been added to the truck mixer at the batching plant, the drum shall be constantly rotated at the agitating speed designated by the manufacturer of the equipment, both during transport and while on the project prior to discharge, except during the period required for mixing.

F. When a truck mixer or truck agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within 90 minutes after the addition of the cement to the aggregates. Each batch of concrete delivered at the job site shall be accompanied by a time slip issued at the batching plant, bearing the time of charging of the mixer drum with cement and aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete or when the temperature of the concrete is 85 °F or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed 1 hour. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within 30 minutes after the cement has been added to the aggregate.

When it is determined that more than 90 minutes will be required to batch and completely discharge the load, an alternate method of delivery and mixing will be permitted. The truck mixer will be charged at the batching plant with reasonably dry aggregates and cement but no mixing water. The required amount of mixing water shall be carefully introduced into the truck mixer at the job site and the batch of concrete mixed as outlined above. Under such conditions one hour shall be allowed for the discharge of the load, computed from the time the mixing water has been added to the batch and the mixing begun.

The concrete when discharged from truck mixers and truck agitators, shall be of the consistency and workability required for the job. The rate of discharge of the plastic concrete from the mixer drum shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

If additional mixing water is required to maintain the specified slump and is added with permission of the Engineer, a minimum of 20 revolutions of the truck mixer drum at mixing speed shall be required before discharge of any concrete.

All wash water shall be removed from truck mixers and truck agitators prior to charging with a fresh load.

G. When approved by the Engineer, central-mixed concrete which is designed for the purpose may be transported in suitable nonagitating equipment.

I. When nonagitating equipment is used for transportation of concrete:

a) Bodies of equipment shall be smooth, water-tight, metal containers equipped with gates that will permit control of the discharge of the concrete. Covers meeting the approval of the Engineer shall be provided for protection against the weather.

b) The concrete shall be delivered to the site of the work in a thoroughly mixed and uniform mass and discharged with a satisfactory degree of uniformity. Slump tests of representative samples taken during the discharge shall not differ by more than 2 in. Discharge shall be completed within 30 min. after introduction of the mixing water to the cement and aggregates.

II. Concrete delivered in outdoor temperatures lower than 40 °F shall arrive at the work having a temperature not less than 60 °F nor greater than 90 °F.

M4.02.11 Storage and Handling of Materials.

All materials shall be stored and handled in an approved manner.

A. Cement.

Cement shall be fully protected against moisture and any cement damaged by exposure shall not be used.

Cement shall be emptied directly from the shipping packages into the skip of the mixer, except when bulk cement is used. The cement discharge chute at the aggremeter shall be so arranged that there will be no possibility of loss of cement in passing through it.

B. Aggregates.

Aggregates in stockpiles shall be placed on firm well-drained ground. The piles shall be of such shape and size that materials may be handled and stored without becoming dirty or mixed with deleterious substances. Aggregates from different sources or of different grading shall be kept in separate stockpiles.

Coarse aggregate will be handled and stored to produce minimum segregation of sizes. Fine aggregate will be handled in such a way as to prevent the loss of fines. Aggregate shall be induced into the aggremeter in an approved manner complying with required gradation.

Storage and handling of aggregates shall be done in a manner to ensure a uniform moisture content satisfactory for proper control of the consistency of the mix. Frozen aggregates shall not be used.

Aggregates shall be taken continuously from one source in filling the compartments of the batcher bin, and no change of source of any of the aggregates shall be permitted without the consent of the Engineer.

The Department reserves the right to prohibit the use of aggregates from any plant, pit quarry or deposit where the character of the material method of operation or rate of production is inadequate.

When aggregate is proportioned in the batching plants and transported by trucks to the paving mixer, the compartments in the trucks shall be of sufficient size to prevent spilling from one compartment to another either in transit or when emptying the load into the skip of mixer.

M4.02.12 Cold Weather Concrete.

Concrete mixed or placed when the air temperature is below 40 °F will be considered cold weather concrete and will require special treatment. In general the special treatment is indicated below.

When concrete operations are permitted when the air in the shade and away from artificial heat is 40 °F or lower temperature, the mixing water and/or aggregates may be heated (prior to cement being added) by approved methods so that the temperature of the aggregates and water mixture is not less than 70 °F nor more than 140 °F. The temperature of the concrete shall not be less than 60 °F nor more than 90 °F at the time of placing it in the forms. The heating shall be done in a manner to preclude the occurrence of overheated areas which might result in damage to the materials. Any material containing frost or lumps of hardened material shall not be used.

M4.02.13 Test Specimens

A. Samples of concrete shall be obtained in accordance with the Standard Method of Sampling Fresh Concrete (AASHTO-T141) in the case of individual samples secured to determine uniformity of consistency for approval of the mixer or agitator. In securing individual samples to determine uniformity of consistency, AASHTO-T141 shall be followed but the requirements shall be so modified as to permit obtaining and testing of each of three samples: one at approximately the beginning, one at approximately the midpoint and one at approximately the end of discharge.

B. For the purpose of making tests to determine the flexural or compressive strength of concrete, the Engineer reserves the right to cast such test beams or cylinders as he deems necessary.

The Contractor shall furnish concrete and such assistance as the Engineer may require.

The specimens shall be protected and cured on the project by the Contractor, without additional compensation under the direction of the Engineer, and as required in Section 9 of AASHTO-T23 for the first 24 hours. After 24 hours specimens taken to insure compliance with minimum strength requirement shall be removed from the mold and imbedded in moist sand or cured by other methods approved by Department's Research and Materials Section for five days with temperatures ranging from 60 °F to 80 °F, by the Contractor, without additional compensation, under the direction of the Engineer.

When the sequence of the construction operation is dependent upon the development of strength in concrete previously placed the specimens taken for this purpose shall be further cured after 24 hours as required in Section 9 of AASHTO-T23 by the Contractor, without additional compensation, under the direction of the Engineer.

C. Consistency tests shall be made when designated by the Engineer. Determination of air content shall be made as designated by the Engineer if air-entraining cement or an air-entraining admixture is used. If the measured consistency or air-content falls outside the limits specified, a check test shall be made. In the event of a second failure, the Engineer may refuse to permit the use of the load of concrete represented.

D. Methods of testing ready-mixed concrete shall be in accordance with the following methods of the American Association of State Highway and Transportation Officials:

1. Sampling Fresh Concrete (AASHTO-T141).
2. Weight Per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete (AASHTO-T121).
3. Flexural Strength of Concrete (Using Simple Beam with Third Point Loading) (AASHTO-T97).
4. Compressive Strength of Molded Concrete Cylinders (AASHTO-T22).
5. Making and Curing Concrete Compression and Flexure Test Specimens in the Field (AASHTO-T23).
6. Slump Test for Portland Cement Concrete (AASHTO-T119).
7. Air Content of Freshly Mixed Concrete by the Pressure Method (AASHTO-T152).
8. Air Content of Freshly Mixed Concrete by the Volumetric Method (AASHTO-T196).

M4.02.14 Precast Units

Precast concrete units shall be manufactured of air-entrained 4000 psi, 3/4 in., 610 lbs. cement concrete, true to line, plane and dimensions, in accordance with the following special requirements:

A. Plant Requirements.

The units shall be manufactured in an approved area or enclosed building under the Engineer's control and inspection with guaranteed provision to meet the requirements for curing and protecting the concrete as specified.

B. Forms.

As specified below metal or wood forms of tight, rigid construction, true to shape, and with smooth finish shall be used. Concrete forms may be used if approved by the Engineer. The forms shall be oiled in any approved manner. Re-use of old, worn, or misshapen forms, will not be allowed.

Bounds	Wooden or wooden faced; Metal or metal faced
Catch Basins & Manholes	Metal or metal-faced
Cribbing	Metal or metal-faced
Curb	Wooden or wooden-faced
Curb corners	Wooden or wooden-faced
Edging	Wooden or wooden-faced
Railings	Wooden or wooden-faced
Posts	Wooden or wooden-faced; Metal or metal-faced
Box Culverts	Metal
Light Foundations	Metal
Median Barrier	Metal
Retaining Walls	Metal
Noise Barrier Panels	Metal
Pull Boxes	Metal
Handholes	Metal

C. Vibration.

Vibrators shall be provided and used as specified in 901.65C and as directed by the Engineer. Prolonged vibration shall be avoided in order to prevent surface finish susceptible to crazing. Units showing surface checking or crazing will be rejected.

D. Protection and Curing.

The units shall be cured either by steam or water for a sufficient length of time for the concrete to obtain the minimum compressive strength.

1. Steam Curing.

Two to four hours after the concrete has been placed and attained the initial set, the first application of steam shall be made. Forms shall be removed after the units have been steam cured for 24 hours.

The steam shall be at 100% relative humidity to provide moisture for proper hydration of cement. The steam shall be directly applied onto the concrete. During application of steam the ambient temperature shall increase at the rate not to exceed 40 °F per hour until a minimum temperature of 130 °F is reached.

When discontinuing the steam application, the ambient temperature shall be decreased at the rate of 40 °F per hour until a temperature of 20 °F above the atmospheric temperature has been attained. The concrete shall not be exposed to temperatures below freezing for a minimum of 6 days after casting.

2. Water Curing.

The units may be water cured with water, saturated material or other acceptable or approved methods that will keep the units moist for a period of 5 days. Under no condition will the use of curing compounds be permitted.

Concrete delivered in outside temperature lower than 40 °F shall arrive at work having a temperature not less than 60 °F nor greater than 90 °F. Water and aggregates shall be heated if necessary but the water shall not be heated above 140 °F. The use of direct heating torch in mixer shall not be approved.

3. Protective Coating.

A protective coating approved by the Engineer shall be used on Curb, Curb Corners, Edging, Railings and Posts.

After the concrete is at least 14 days old and thoroughly dry, the surface shall be cleaned to remove all oil, grime and loose particles which would prevent the protective compound from penetrating the concrete. Immediately before the application of the compound an air blast shall be directed over the surface to be treated so that all dust will be removed and then treated as follows:

The rate and number of applications for each unit shall be in accordance with the manufacturer's recommendations.

After curing a minimum of 14 days, the outside surface of the tapered or cone section of pre-cast cement concrete catch basins shall be dried, cleaned and given a protective coating of Koppers Bitumastic Super Service Black, or equal.

E. Finish and Color.

Edging curb corners, precast fence rails and similar units shall be rub finished in the following manner:

After the concrete has properly hardened, the exposed surfaces shall be rubbed with a No. 16 carborundum stone or an abrasive of approved equal in a manner to fully remove cement enamel finish and expose a durable sand grain finish satisfactory to the Engineer. No cement shall be used in the rubbing process.

The color and finish of these units shall be uniform and shall conform to those of adjacent work in their final position.

F. Testing and Sampling.

Representative test specimens of the concrete shall be taken by the Engineer. No precast units will be shipped to a project until the test specimens cured as required in M4.02.13 show a compressive strength of 4000 pounds.

G. Inspection.

All precast units shall be subject to inspection at the point of manufacture and on the project and any units showing defects or damage before the completion of the project shall be removed and replaced at the expense of the Contractor.

H. Quality Control

The contractor shall provide quality control in the form of personnel, equipment and laboratory and office space.

1. Personnel:

There shall be sufficient personnel trained and licensed to perform the tests listed under M4.02.13, Part D.

2. Equipment:

Air Content Meter Type A or B AASHTO-T152
Air Content Meter Volumetric Method AASHTO-T196
Slump Cone AASHTO-T119
Cylinder Molds AASHTO-M205
Concrete Testing Machine AASHTO-T22
Screening Sieve: AASHTO-T27, T11
Curing Box AASHTO-T23
And other necessary items such as ovens, scales, hot plates, pans, etc. to perform tests.
Portable Temperature Recorders

3. Laboratory:

A room of sufficient size to house all equipment and to adequately perform all these tests. The room shall have either a separate moisture storage room or curing box for concrete cylinders and it shall be thermostatically controlled to maintain 70 °F. The laboratory room shall be heated and air conditioned to maintain 70 °F. It shall include a desk and file cabinet for proper record keeping, and have good lighting and ventilation. This room shall be kept for testing and quality control and not used for any other purpose.

No exception from these requirements will be allowed without the expressed written permission of the Engineer.

M4.02.15 Cement Mortar.

Mortar shall be composed of one (1) part Portland cement and two (2) parts of sand by volume with sufficient water to form a workable mixture. Cement, sand and water shall conform to M4.01.0, M4.02.02B and M4.02.04 respectively.

M4.03.00 Prestressed Concrete Beams.

This work consists of fabricating pretensioned bonded prestressed concrete deck beams and beams in accordance with the plans and these specifications.

The Contractor shall order all materials and services for this work immediately after execution of the Contract.

The work under this Section shall conform to the relevant requirements of the current AASHTO Specifications for Highway Bridges and shall be supplemented by the relevant provisions of the current AASHTO Standards and Inspection Manual for Prestressed Concrete.

The angle at the ends of the beam shall be determined from the skew angle of the bridge which is shown on the construction plans. This angle will also determine the placing of the sleeves for the transverse cables.

All exterior deck beams shall be cast to show the year in the center of the beam in the center of the coping unless otherwise specified in the Special Provisions or shown on the plans. The numerals shall be 5 in. high of a style and type furnished by the Engineer.

The Contractor shall properly identify each beam giving the bridge number and the type of beam (Type A, B or C).

M4.03.01 Drawings

Detailed working or shop drawings will be required in accordance with the pertinent provisions of Subsection 5.02. The shop drawings shall show the number and type of beams; location and spacing of strands and tensioning load to be applied per strand; span length from centerline to centerline of anchor rods; total length of beams; skew angle; and locations, type and size of sleeves and inserts; location; type and size of handling hooks, steel reinforcement and all other information required for proper fabrication and handling of the beams.

When prestressed concrete beams are used to support screed rails for mechanical finishing of bridge decks, the Contractor shall submit for approval his method of incorporating this support into the prestressed concrete beam before fabrication of the beam has begun.

M4.03.02 Responsibility

The Contractor shall be responsible for any failure to cast the beams to the correct dimensions or for any other omissions or inaccuracies in his work. If the Engineer determines that proper corrections cannot be made, the beams will be rejected and replaced with new beams at the Contractor's expense.

Satisfactory proof shall be given to the Department that the fabricator of the prestressed concrete beams is capable of and has the organization and plant for performing the work involved in fabricating the beams.

MATERIALS

M4.03.03 Concrete.

Concrete for the bonded prestressed concrete beams shall be made in accordance with the pertinent provisions of M4.02.00 supplemented by the following:

Prestressed concrete beams shall be made in a plant with approved facilities and equipment for prestressing and ready for immediate production. Special plant supervision and control will be required to meet the precision standards for quality and workmanship.

The beams shall be cast with Type I or II Portland cement, or Type III high-early strength cement may be used at the Contractor's option and expense. The air content of the concrete by volume shall be 5½% with a tolerance of plus or minus 1%.

M4.03.04 Aggregates.

The aggregate shall be fully drained, free from excess entrapped water in voids, to a uniform moisture content of plus or minus 1% in the fine aggregate and 1/2% in the coarse aggregate. The standard organic color test of the sand shall be minus plate 2.

The aggregate shall meet requirements of M4.02.02. Crushed stone or gravel with a maximum Los Angeles abrasion of 30% shall be used.

M4.03.05 Steel.

Steel reinforcement shall conform to the pertinent provisions of Section M8. Handling hooks shall be fabricated from steel conforming to AASHTO-M183.

Structural steel for the prestressed concrete beams shall conform to AASHTO-M183 the pertinent requirements of Section M8 and shall include attached anchor plates. Other steel not actually attached to the beams such as sole plates, bed plates, bronze expansion bearings, anchor bolts, pipe supports, nuts and washers are not included under "Prestressed Concrete Beams".

M4.03.06 Pretensioning Strands.

Pretensioning Strands shall conform to AASHTO-M203, which specification covers seven-wire, uncoated, stress relieved steel strand intended for use in pretensioned, bonded, prestressed concrete construction.

Strand diameter for deck beams shall be 3/8 in. unless otherwise specified on the plans.

The 1/2 in. strand shall be the maximum size permitted in pretensioning.

The approval of the Engineer will be required if the Contractor desires to use strands of larger diameter.

CONSTRUCTION METHODS

M4.03.07 Forms.

The side forms shall be of metal of approved design and construction to meet rigid conformance to line, dimension, design, workmanship, and finish. Any defects or damage of more than minor nature due to form work, stripping or handling shall be cause for rejections. Forms shall be so designed that they will not restrict the longitudinal movement of the casting when the prestressing force is transferred to the casting.

Tubes for forming the voids in the concrete deck beams shall be fabricated of material sufficiently strong and resistant to water to carry the wet concrete, which is to be packed around the tubes, without collapsing. The tubes shall be capped at both ends to exclude concrete from entering the tubes. The tubes shall be securely anchored so that no movement will occur during placing and consolidation of the concrete.

M4.03.08 Placing Tension Strands.

Prestressing strands shall be accurately placed in position and tensioned before the concrete is placed. Care shall be exercised to keep the strands clean of form oil and other substances harmful to the bond.

Each strand shall be tensioned to 0.70 of the rated ultimate strength (Manufacturer's) and the tension held until the concrete has attained the minimum required strength for prestressing.

The strands shall be tensioned in the casting bed by holding the tension with end anchorages until the concrete is cast and hardened, and then releasing the tension gradually by an approved method. Each strand shall be finally burned or cut off at a depth of 1/2 in. into the end of the beam and the recessed area around the strand shall be filled with cement mortar, as designated in Subsection M4.02.15.

When two or more strands are tensioned simultaneously, means as approved by the Engineer shall be provided to obtain equal tension in each strand as may be practicable.

Jacks for tensioning shall be of approved design and shall be equipped with gauges for determining the tensioning load. The accuracy of the gauge shall be checked when and as directed by placing a recently calibrated dynamometer in the line. A further check of the tension shall be made by measuring the actual elongation against the elongation figured from the modulus of elasticity of the element. Suitable allowance shall be made in the tensioning for anchorage efficiency as determined by test.

M4.03.09 Draped Pretensioned Strands.

Draped pretensioned strands may be tensioned partially by jacking at the end of the bed and partially by uplifting or depressing strands or they may be tensioned entirely by jacking with the strands being held in their draped positions by means of rollers or pins or other approved methods during the jacking operation.

Whatever means is used, low friction devices must be used at all points of change in slope of strand trajectory at the time of tensioning.

The tension for draped strands applied by jacking is done in essentially the same manner and must conform to the same requirements as the tensioning for straight strand, unless otherwise noted.

If draped strands are tensioned in their draped position, they should be supported by lubricated rollers with bronze bushings or roller bearings at all hold-up points and low friction free turning rollers at all hold-down points.

A recommended procedure for tensioning draped strands in the deflected trajectory by single strand jacking is as follows:

1. Applying initial tensioning load to strand.
2. Mark the strand for elongation measurement.
3. Apply the full tension load as determined by the jack gauge, not by elongation.
4. Measure elongation and determine the remaining elongation required for full tension based on computed elongation.
5. Jack the strand from the other end to remaining required elongation and note the load measured by the jack gauge. The actual gauge reading will probably be in excess of the theoretical gauge reading but should not exceed it by more than 5%.

Single strand tensioning of strands in the draped position by jacking the strands from only one end is permissible provided the required strand elongation is obtained without the jack gauge pressures exceeding the theoretical by more than 5%.

When strands are deflected after partial tensioning, the strands must be raised or depressed exactly the correct distances and they should be deflected simultaneously at all points or in an approved specific sequence. Disregard of these requirements could result in incorrect strand tension and put stress distribution along the strand.

The lengths of the strands to be used in calculating elongations should be the actual length of the strand along its trajectory between the fixed anchorage and the reference point at the jacking end of the strand.

It is imperative that the actual dimensions of the bed layout and locations of hold-up and hold-down points agree with the dimensions shown on the approved working drawings.

Up-lift and hold-down devices must be attached in such a manner as to maintain the specified center-to-center spacing of strands in both the vertical and the horizontal directions.

Provisions should be made for a minimum of 1 in. of concrete cover on all metal parts of the hold-down devices remaining within the beams. Use of approved fiber sleeves for the hold-down bolts is satisfactory.

M4.03.10 Mix Design.

The concrete mix shall be designed to produce a minimum 28 day strength of 6000 psi. The job-mix design shall be submitted by the fabricator and approved by the Engineer. No job-mix design will be approved with a cement content less than 7 ½ bags. The use of additives will be at the option of the fabricator with approval of the Engineer.

M4.03.11 Slump.

The Engineer shall specify the consistency of the mix to have a minimum slump so as to place the stiffest mix practical without excessive vibration, free from segregation and voids. The Contractor shall control the slump, as directed, uniformly within a tolerance specified in M4.02.06.

M4.03.12 Mixing, Placing and Curing Concrete.

The concrete shall be proportioned as specified in M4.02.06 and mixed in accordance with M4.02.10.

No delay or shutdown of over 30 minutes duration in continuous filling of individual forms will be allowed.

The forms shall be cleaned and properly oiled, and the mix shall be carefully placed without excess vibration to avoid segregation or displacement of reinforcing or forms. The surface shall be cured during the initial setting period to avoid shrinkage cracking. The beams shall be cast true to line and dimensions, free from checking, cracking, voids and surface honeycomb without requiring additional rubbing or patching.

The top surface of pretensioned deck beams and butted box beams shall be screeded to a smooth surface except where concrete is to be placed over the top surface. In this case the surface shall be rough. Recesses shall be provided where the handling hooks enter the concrete surface of the beams. The recesses shall be 2 in. greater in diameter of the bar or strand, and one inch deep. For purpose of definition the following is provided:

Rough = Raked to a full 1/4 in. amplitude in any direction (intended for concrete to concrete secondary casting.)

Smooth = A float finish with maximum amplitude of 1/8 in. at ridges (intended for application of membrane waterproofing.)

Sleeves and galvanized steel or cast inserts shall be placed in the beams as shown on the plans. They shall be carefully located and securely fastened to the forms to prevent displacement. Sleeves or inserts not properly placed may be cause for rejection of the beams.

Curing.

The beams shall be cured at a minimum temperature of 70 °F and minimum humidity of 95% for the minimum curing period necessary to produce 4000 psi cylinder strength for prestressing. A longer period of curing shall be required if curing test specimens fail to meet a minimum compressive strength of 4000 psi. Steam curing may be permitted under the Engineer's direction and approval as specified in M4.02.14D.

M4.03.13 Test Requirements.

Standard comparison test specimens of concrete shall meet a minimum strength requirement of 6000 psi as follows:

Concrete made with:

Type I or II Cement	28 Days
Type III Cement	7 Days

Three representative test cylinders shall be made for each day's pour and they shall be cured under standard job conditions (AASHTO-T23). Failure of any test specimen to meet 90% of minimum strength, or failure of average to meet the full minimum strength requirement, shall be cause for rejection of all beams poured that day.

M4.03.14 Transferring Tension to Concrete.

In pretensioning, after the concrete has developed the required strength the tension in the strands shall be transferred to the concrete gradually. This may be done by a system of jacking or by burning or cutting the strands. If the latter method is used, the strands shall be cut by burning, and the number of strands cut at a time shall be such that the stress in the remaining strands will not reach the ultimate-strength of the strands after due allowance has been made for the friction in the bed. They shall be cut or burned between each pair of beams in the casting bed so that all of the tension in these strands is transferred to the concrete before other strands are cut or burned.

A symmetrical pattern shall be followed in releasing the tension by this method. In order for release of the strands to occur gradually they should not be quickly cut, but should be heated until the metal gradually loses its strength.

Draped pretensioned strands should be detensioned in accordance with the following:

A. Unless the weight of the precast concrete member is as much as twice the total of the forces required to hold the strands in the low position within the member, or unless the members are weighted or restrained in an approved manner to resist the uplifting forces on the member at the hold-down points, the following sequence should be followed for detensioning:

1. Release the tensions in the draped strands at the ends of the members by heating each strand until it fails. The draped strands should be heated to failure at each up-lifted point in accordance with an approved sequence as shown on the working drawings.
2. All hold-down devices for the draped strands should be released and the hold-down bolts within the members removed.
3. If any straight pretensioned strands are located within the members, they should be detensioned after the draped strands have been detensioned. Straight strands shall be detensioned by releasing the tension in these strands gradually and uniformly.

B. When the weight of the precast concrete member is more than twice as great as the total of the forces required to hold the deflected strand in the low position within the member, the following sequence may be used, at the fabricator's option, for detensioning the prestressed strands:

1. Hold-down devices for the deflected strands may be released and the hold-down bolts within the members removed.
2. Deflected strands and straight strands may be detensioned by releasing the tension in the strands gradually and uniformly.

When the weight of the member is less than twice as great as the total of the hold-down forces, weights or approved vertical restraint may be applied to the member in order to counteract the uplifting forces at the hold-down points when hold-down devices are released.

The weight or vertical restraint added to the member should be placed directly over the hold-down points for the deflected strands. When the total of the weight of the member plus the added weights or restraint is more than twice as great as the hold-down forces, the strand-detensioning method of releasing hold-down devices before strand tension may be followed.

It is very important that the procedures for transfer of prestressing forces to members with deflected pretensioned strands are followed. Disregarding the procedures for tranferring the forces to the members will probably result in unacceptable members.

M4.03.15 Quality Control.

Quality Control requirements shall be in accordance with M4.02.14H.

M4.04.0 Mortar for Prestressed Concrete Deck Beams.

The mortar shall conform to the following specification:

General.

The purpose of this specification is to describe a 2-component, polymer-modified, cementitous, fast setting, free flow mortar for filling keyways between adjacent box beams.

Materials.

The polymer-modified cementitous system shall consist of a factory pre-proportioned, 2-component system whose components conform to the following requirements:

a) Component A shall be a liquid polymer emulsion of an acrylic copolymer base and additives. This acrylic copolymer shall have the following properties:

pH	4.5-6.5
Minimum film forming temperature	Approx. 68 °F
Tear Strength	Approx. 990-1420 psi
Elongation at break	500-900%
Particle size range	Less than 0.1 micron

b) Component B shall be a blend of a selected Portland Cement, specially graded aggregates, organic accelerator, and admixtures for controlling setting time, water reducers for workability and a corrosion inhibiter.

c) The component ratio A:B shall be 1:7.2 by weight. The system shall not contain chlorides, nitrates, added gypsum, added lime, or high alumna cements. The system shall be non-combustible, either before or after cure.

Typical Properties of Mixed Components:

a) Application Time (Working Time)	15 min. after components have been mixed.
b) Finishing Time	20-60 min. after combining components.
c) Color	Concrete Gray
d) Flow Test	100-200%

Typical Properties of Cured System:

a) Abrasion Resistance	6 times greater than Control
b) Bond Strength (Pulloff method)	100% concrete substrate failure.
c) Modulus of Elasticity	4.5×10^6
d) Surface Scaling (Deicing salt freeze/thaw)	No deterioration after 120 cycles
e) Compressive Strength (4 hours 50% RH)	100 psi min.
f) Compressive Strength 28 days 50% RH)	5300 psi min.
g) Flexural Strength (28 days 50% RH)	1200 psi min.

h) System shall conform to EPA/USPHS Standards for surface contact with potable water.

i) The system shall not produce a vapor barrier.

j) The system shall be thoroughly compatible with concrete.

M4.05.0 Cement Concrete Brick.

Cement concrete brick shall be machine made solid segments conforming to the requirements of ASTM-C139, except that the minimum average compressive strength for five (5) representative bricks shall be 3000 psi. The minimum compressive strength for one individual brick shall be 2500 psi. Dimensional requirements shall be the same as for Clay Brick M4.05.2.

M4.05.1 Cement Concrete Blocks.

Cement concrete blocks shall be machine made solid segments, conforming to the requirements for Concrete Masonry Units for Construction of Catch Basins and Manholes. ASTM-C139, supplemented by the following requirements:

The blocks shall be 6 in. in width for basins and manholes of 9 feet or less in depth, 8 inches in width below a depth of 9 feet when used in structures having a depth greater than 9 feet.

The permissable dimensional variation for nominal size shall be in accordance with ASTM-C139. The inside and outside surfaces of the blocks shall be carved to the necessary radius and so designed that the interior surfaces of the structures shall be cylindrical, except the top batter courses which shall be designed to reduce uniformly the inside section of the structure to the required top size and shape. The blocks used in the top courses shall be designed to produce a surface 8 in. in width upon which to seat the frame, and the curb inlet when one is used. Blocks shall be so designed that only full length units are required to lay any one course.

Blocks shall be sampled and tested in accordance with ASTM-C140. The minimum average compressive strength for 5 representative blocks shall be 3000 psi. The minimum compressive strength for one individual block shall be 2500 psi.

M4.05.2 Clay Brick.

Clay brick shall conform to the requirements of ASSHTO-M91 with the following exceptions:

The size of brick furnished shall be 7¾ in. long × 3¾ in. wide × 2¼ in. deep.

All dimensions shall be nominal.

The average of the absorption of 5 representative samples shall not exceed 15% and the individual absorption of any one sample shall not exceed 17½%. The average compressive strength of 5 representative samples shall not be less than 3000 pounds per square inch and the compressive strenth of any one sample shall not be less than 2500 pounds per square inch.

M4.05.3 Precast Concrete Block for Slope Paving.

Precast blocks shall be solid segments, conforming to requirements for Concrete Masonry Units for Construction of Catch Basins and Manholes, ASTM-C139, supplemented by the following requirements:

The thickness shall be 4 in. The width shall be 12 in., and the length 16 in. Blocks shall be sampled and tested in accordance with ASTM-C140. Dimensional tolerances shall be in accordance with ASTM-C139.

M4.05.4 Sidewalk Brick.

Sidewalk brick shall conform to the requirements of ASTM C902 except that the absorption shall be 5% maximum when subjected to 5 hours of submersion in boiling water.

M4.05.5 Epoxy-Resin Base Bonding System for Concrete.

This specification covers two-component, epoxy-resin bonding systems for application to Portland cement concrete. The material shall meet ASTM C881. The Type, Grade and Class shall be specified for each individual application.

Types:

Type I For use in bonding hardened concrete and to other materials to hardened concrete.

Type II For use in bonding fresh mixed concrete to hardened concrete.

Type III For use in bonding skid-resistant materials to hardened concrete, and as a binder in epoxy mortars or epoxy concretes.

Grades:

Grade 1	Low viscosity
Grade 2	Medium viscosity
Grade 3	Non-sagging consistency

Classes:

Class A	For use below 40°F
Class B	For use between 40° and 60°F
Class C	For use above 60°F

M4.07.0 Latex Modified Mortar and Concrete Overlayments.

DESCRIPTION

This work shall consist of furnishing and constructing a one course protective wearing surface of latex Portland cement mortar or concrete on the prepared surface of concrete bridge decks.

MATERIALS

The materials used in producing latex modified mortar or concrete shall meet the applicable requirements of Section M4 of the Standard Specifications for Highways and Bridges and as described herein.

A. Portland cement shall be non-air entraining cement of recent manufacture, free of lumps and conform to the requirements of AASHTO M-85, Type I or Type II.

B. Aggregates shall meet the requirements of M4.02.02A. Maximum nominal size of coarse aggregate shall not be larger than 3/4 in. and in no case greater than one half the thickness of section to be placed.

C. Water shall meet the requirements of M4.02.4.

D. Latex Emulsion Admixture-Formulated latex admixture shall be a non-hazardous, film forming polymeric emulsion in water to which all stabilizers have been added at the point of manufacture and shall be homogeneous and uniform in composition. The latex shall be a styrene butadiene latex emulsion that has been approved for use in latex modified concretes/mortars by the FHWA using procedures covered by FHWA-RD-78-35. The latex supplier shall provide certification that each lot of material meets the requirements of the certification program in FHWA-RD-78-35.

Note: Air-entraining admixtures will *not* be used.

Mix Design:

	Latex Modified Mortar	Latex Modified Concrete
Average Thickness	1 in.	1¼ in. +
Cement, Sacks/cu. yd.	8.0	7.0
Latex Emulsion Admixture, gal/sack	3.5	3.5
*Water, gal/sack	2.5	2.5
Air content, % of plastic mix According to AASHTO-T152	0-9	0-6½
**Slump, in.	4-6 in.	4-6 in.
***Weight ratio of cement: fine coarse aggregates (dry basis agg. spg. = 2.65	1:3.25	1:2.5:2.0
Strength (28 days) psi	3750 min.	3500 min.

*The net water added shall be adjusted to control the slump within the prescribed limits and to produce a water-cement ratio of 0.35-0.40.

**The slump shall be measured 4 to 5 minutes after discharge from the mixer. During this waiting period, it shall be deposited on the deck and not be disturbed. Care shall be exercised that traffic vibrations do not affect the measurement.

***The dry weight ratios are approximate and should produce accurate yield and good workability but due to gradation changes and/or variable specific gravity may be adjusted within limits by the Engineer. A maximum adjustment of ±20% may be made in aggregate weights.

EQUIPMENT

All equipment for the deck preparation, mixing, placing and finishing of latex modified mortar or concrete shall be approved by the Engineer prior to start of any work.

A. Surface preparation equipment shall be of the following types:

1. Blast cleaning equipment capable of removing hardened curing compound, laitance dust layer or any other contaminates detrimental to achieving bond and also capable of removing rust from reinforcing bars and removing small chips of concrete partially loosened by a scarifying or chipping operation.

2. Sawing equipment capable of sawing concrete to the specified depth.

3. Power-operated mechanical scarifier capable of removing not less than 1/4 in. from old surface.

4. Power driven hand tools for removal of unsound concrete subject to the following restrictions:

a) Pneumatic hammers heavier than nominal 30 pound class shall not be used, unless approved by the Engineer. No hammers heavier than 60 pounds shall be used in any case.

b. Triple-headed tampers fitted with star drills shall not be less than 2 in. D in the tamper sockets.

B. Proportioning and mixing equipment shall be self-contained, mobile, continuous mixing subject to the following:

1. The mixer shall be self-propelled and be capable of carrying sufficient unmixed dry bulk cement, aggregates, latex modifier, and water to produce on the site not less than 6 cubic yards of concrete.

2. The mixer shall be capable of positive measurement of cement being introduced into mix. A recording meter visible at all times and equipped with a ticket printout shall indicate this quantity.

3. Mixers shall be calibrated to accurately proportion the specified mix at 100 cubic yard intervals. Certification of the calibration by approved testing authority will be accepted as evidence of this accuracy if the yield is shown to be true within a tolerance of 1.0% according to the following test:

With the cement meter set on zero and all controls set for the desired mix, activate the mixer, discharging mixed material into a one quarter cubic yard container — 36 in. × 36 in. × 9 in. and when the container is level-struck full, making provision for settling the material into all corners, the cement meter must show a discharge of 1¾ bags of cement for modified concrete, (7 bags/cu. yd. mix).

4. The mixer shall provide positive control of the flow of water and polymeric emulsion into the mixing chamber. Water flow shall be indicated by flow meter and be readily adjustable to provide minor variations in aggregate moisture.

5. The mixer shall be capable of being calibrated to automatically proportion and blend all components of the indicated composition on a continuous or intermittent basis as required by the finishing operation. It shall discharge mixed material through a conventional chute directly in front of the finishing machine.

6. The mixer shall be capable of spraying water over the entire placement width as it moves ahead to insure that the surface to be overlaid is damp prior to receiving the modified material.

C. Mixing and Delivery Control: Cement and aggregates shall be proportioned, measured and batched by a volumetric weight equivalent method. In operation, the entire measuring and batching mechanism must produce the specified proportions of each ingredient. Tolerance in proportioning the various ingredients shall be as follows:

Cement, weight percent	0 to +4
Aggregates, weight percent	±4
Water, weight or volume percent	±1
Latex, weight or volume percent	±2

The tolerances are based on a volume/weight relationship established during the calibration or the measuring devices.

During mixing, the drive shaft speed as indicated by the tachometer shall be maintained at operation speed ±50 rpms. The auger mixer angle shall be set in the range determined by the manufacturer. The interval between the continuous placing of succeeding batches shall not exceed 30 minutes.

D. Placing and Finishing Equipment shall include hand tools for placement and brushing-in freshly mixed latex modified material and for distributing it to approximately the correct level for striking off with the screed.

An approved finishing machine complying with the following requirements shall be used for finishing the work:

The finishing machine shall be self-propelled and capable of forward and reverse movement under positive control. Provisions shall be made for raising all screeds to clear the screeded surface for traveling in reverse.

A rotating cylinder type self-propelled finishing machine with one or more rotating rollers, augers, and vibratory pans may be used.

Any modifications shall be subject to approval by the Engineer.

Travel rails for the machine shall be 2 in. × 2 in. perforated steel bar stock, 2 in. pipe rail or approved equal.

One or more suitable portable lightweight or wheeled work bridges shall be required and used behind the finishing operation for touch-up work, surface texturing and curing cover pavement.

CONSTRUCTION METHODS

A. Preparing the surface.

1. For new construction:

Newly constructed concrete bridge decks shall be cured a minimum of 14 days before placement of the latex modified concrete wearing surface.

Within 24 hours prior to applying the latex modified concrete overlayment, the concrete surface to be covered shall be thoroughly blast cleaned. This operation shall remove all hardened curing compound and/or laitance layer and shall expose the concrete aggregate. The edge of previously placed lanes shall be similarly treated to promote bond. The surface shall be thoroughly cleared of all debris created by this operation and then pressure flushed with clean water. Immediately prior to placement of the latex cement composition, the clean surface shall be thoroughly wetted for a period of not less than one hour. Any standing water shall be blown clear before the placement is made.

2. For Repair or Deck Restoration:

Prior to applying the latex modified concrete overlayment, the concrete surface to be covered shall be machine scarified to the depth shown on the plans. In areas where scarifying cannot reach, in areas of deep spalling and where steel reinforcement is exposed, deteriorated concrete will be removed to sound material by chipping and by use of hand tools.

Forty-eight hours of good curing shall have elapsed prior to scarifying or chipping on adjacent concrete within 6 feet of latex modified concrete.

Area from which unsound concrete and epoxy patches have been removed shall be kept free of slurry produced by wet sawing or wet scarifying by planning the work so that this slurry will drain away from the complete areas of preparation. All such slurry shall be removed from prepared areas before resurfacing. Before placement begins, and within 24 hours, the entire surface shall be thoroughly cleaned by blasting. The edge of previously placed lanes of overlayment shall be blasted to remove the trowel cut surfacing and promote bond. If necessary, to remove rust, oil and other foreign materials detrimental to achieving bond, detergent cleaning followed by sandblasting and air blast cleaning will be required. Immediately prior to placement of

latex modified concrete, the clean, surface shall be thoroughly wetted for a period of not less than one hour. Any standing water in depressions, holes or areas of concrete removal shall be blown out with compressed air.

All corroded reinforcing bars shall be thoroughly cleaned by blasting. Those bars that have lost 1/4 or more of their original diameter shall be supplemented by new bars spliced in place. In splicing new bars they shall be lapped sufficiently to develop the full strength of the bar and, if necessary additional chipping will be required to provide for this lap. Dual bars of equivalent or greater section may be used. Where the bond between existing concrete and reinforcing steel has been destroyed, or where more than half the diameter of the steel is exposed, the concrete adjacent to the bar shall be removed to a depth that will permit modified concrete to bond to the entire periphery of the bar exposed. A minimum of 3/4 in. clearance shall be required except where lower bar mats makes this impractical. Care shall be exercised to prevent cutting, stretching or damaging any exposed reinforcing steel. Any exposed old copper waterstop shall be removed to the limits designated by the Engineer.

B. Proportioning and Mixing of Latex Modified Concrete:

The operations of proportioning and mixing latex cement materials shall comply with the following requirements:

Mixers shall be clean and the ingredients accurately proportioned.

Latex Modified Concrete shall be mixed at the site in accordance with the specified requirements for the equipment used. The latex modified concrete as discharged from the mixer shall be uniform in composition and consistency. Mixing capability shall be such that finishing operations can proceed at a steady pace with final finishing completed before the formation of the plastic surface film.

C. Placing and Finishing.

Existing expansion joints and dams shall be raised prior to placing overlayment.

A bulkhead shall be installed to the required grade and profile prior to placing latex cement material. Joint filler and STYROFOAM* or equal brand plastic foam may be used but casting full across the joint and later sawing will not be allowed.

Travel rails shall be placed and fastened in position to insure finishing at the new surface to the required profile. Anchorage for supporting rails shall provide horizontal and vertical stability.

All surfaces shall be completely cleaned as approved by the Engineer prior to placing mixtures.

The latex cement mix shall be brushed onto the wetted, prepared surface. Care shall be exercised to insure that all vertical as well as horizontal surfaces receive a thorough, even coating and that the rate of progress is limited so that the brushed material does not become dry before it is covered with additional material as required for the final grade. Material used for brushing which has had the mortar used up, shall be disposed of.

The mixture shall be placed and struck-off to approximately 1/4 in. above final grade. It shall then be consolidated and finished at final grade with the vibrating devices. Spud vibration will be required at edges and adjacent to joint bulkheads. Hand finishing with a float may be required along the edge of the pour. Edge tooling is required at joints, except next to metal expansion dams, curbs, and previously placed lanes.

When a tight uniform surface has been achieved it shall be textured to provide a relatively skid resistant surface. Texturing shall be done by use of wire rake before the plastic film forms on the surface. The wire rake shall have flexible tines approximately 1/2 in. on center and will be subject to the approval of the Engineer.

Screed rails and/or construction bulkheads shall be separated from the newly placed material by passing a pointing trowel along their inside face. Metal expansion dams shall not be separated from the overlayment. Care shall be exercised to insure that this trowel cut is made for the entire depth and length of rails after the mixture has stiffened sufficiently.

The surface shall be promptly covered with a single layer of clean, wet burlap as soon as the surface will support it without deformation.

Immediately following covering with wet burlap, a layer or polyethylene film (minimum 4 mil) shall be placed on the wet burlap and the surface cured for 24 hours. The curing material shall then be removed for an additional 72 hours air cure. Wet burlap-polyethylene sheets may be substituted for the polyethylene film with the approval of the Engineer, but shall not replace the initial wet burlap.

Limitation of Operations:

No vehicular traffic shall be permitted on the latex cement composition until at least 5 days after placement.

No latex cement composition shall be placed at temperatures lower then 45 °F. They may be placed at 45 °F and rising.

*Trademark of the Dow Chemical Company.

At temperatures below 55 °F, the Engineer will require a longer curing period and compliance with applicable sections of the Standard Specifications for curing bridge deck concrete during cold weather.

At temperatures above 85 °F the Engineer may require placements to be made at night or early morning hours, if in his opinion a satisfactory placement is not being achieved.

A construction dam or bulkhead shall be installed in case of major delay in the placement operation exceeding one hour in duration. During minor delays of one hour or less the end of the placement may be protected from drying with several layers of wet burlap.

Adequate precautions shall be taken to protect freshly placed material from sudden or unexpected rain. All placing operations shall stop when it starts to rain. The Engineer may order removal of any material damaged by rainfall.

Application of Live Loads:

Truck mixers and other heavy equipment shall not be permitted on the latex modified concrete overlay, nor the traveling public until authorized by the Engineer. Such authorization may only be given after the prescribed curing period has taken place, after the last concrete has been placed, and provided the concrete in the deck has attained a minimum strength of 3500 psi. Specimens shall be cured in the same manner as the deck.

SECTION M5
PIPE, CULVERT SECTIONS AND CONDUIT

M5.00.0 Pipe, Culvert Sections and Conduit.

These shall consist of individual sections of the kinds and sizes shown on the plans and as directed. They shall conform to the requirements of the applicable following subsections.

All pipes shall be subject to inspection at the point of manufacture as well as the site of the work. The purpose of the inspection shall be to cull and reject pipes which, independent of the physical tests, fail to conform to the specification in the particulars of dimension, workmanship, finish, blisters, cracks or fractures.

M5.01.0 Clay Pipe.

Clay Pipe for use in the construction of culverts, drains, and sewers shall conform to the requirements of AASHTO-M65 for Extra Strength Clay Pipe, except that the minimum average strength per linear foot by the three-edge bearing method for 12 in. and less diameter pipe shall be 2400 pounds.

M5.02.0 Cement Concrete Pipe

Cement Concrete Pipe shall conform to the requirements of AASHTO M86 Class 2. The hydrostatic test will only be required for concrete pipe to be used in sewer construction. Unless otherwise provided, all cement concrete pipe shall be of the bell and spigot type.

M5.02.1 Reinforced Concrete Pipe.

Reinforced concrete pipe shall conform to the requirements of AASHTO-M170 for Standard Strength Reinforced Concrete Culvert Pipe for Class III Pipe, unless otherwise designated on the plans, except that the steel area for 24 in. pipe shall be 0.10 square inch per foot and circular reinforcement only shall be used in circular pipes. All pipe 24 in. in diameter or smaller shall be of the bell-and-spigot type. Pipes larger than 24 in. in diameter shall be tongue and groove or bell and spigot.

M5.02.2 Reinforced Concrete Pipe Flared Ends.

Flared End Sections shall be fabricated to comply with the current construction standard for this item. The method of fabrication and materials used shall conform to the requirements of AASHTO-M170, Class III, except that the three edge bearing tests shall not be required. The flare shall be of the same thickness and materials as the barrel and have steel reinforcement equaling or exceeding the amount shown on the table for AASHTO-M170, Class III, except that a double row of steel will not be required.

M5.03.0 Asphalt Coated Corrugated Metal Pipe

This pipe shall consist of metallic coated (galvanized or aluminized) corrugated metal pipe and coupling completely coated inside and out with an asphalt cement, and unless otherwise shown on the plans, and/or called for in the Proposal, the thickness of the metal may be any one of those allowed for the size of pipe in the AASHTO Designation below:

A. Metallic Coated (galvanized or aluminized) Corrugated Metal Pipe.

The pipe shall conform to AASHTO-M36. Pipe 8 in. or less in diameter shall be constructed of sheets not lighter than 0.052 in. in thickness.

B. Asphalt Coating for the pipe shall conform to AASHTO-M190. Type C Coating. The Asphalt Coating for coupling bands shall conform to Type A Coating.

C. If Strutting of the Pipe is required it will be done as follows:

1. The pipe shall be elongated by the manufacturer, after fabrication, by reducing the horizontal diameter three percent and increasing the vertical diameter three percent, and held in the elongated shape by means of rods, all in accordance with this specification.

2. The rods shall be 5/8 in. diameter threaded seven inches at both ends with washers and nuts. The length of the rods shall be the diameter of the pipe plus eight inches. The rods shall be placed on the horizontal axis of the pipe on two foot spacing and located at the halfway point between the circumferential riveting.

3. A soft wood block 2 in. × 4 in. and 12 in. long shall be placed over the rods at each end to provide contact against the outside of the pipe. The long dimension of the blocks shall be parallel with the horizontal axis of the pipe in order to prevent distortion of the pipe when the nuts are tightened.

4. The three percent elongation shall be obtained by tightening on the rods uniformly from end to end of the pipe, obtaining approximately one quarter of the required elongation each time through the length of the pipe.

5. The rods shall be left in the pipe until the fill is completed and well compacted, unless for some unusual condition their removal is ordered by the Engineer.

6. The rods shall be removed by the Contractor by cutting from the inside adjacent to the pipe. The three percent of ellipse shall be subject to manufacturing tolerances.

D. When elongation of the pipe is specified, but strutting is not required, the elongation may be accomplished by the fabricator prior to delivery in the following manner:

The pipe shall be elongated by the manufacturer, after fabrication, by reducing the horizontal diameter five percent and increasing the vertical diameter five percent by mechanical pressure sufficient to produce a permanent distortion in the pipe. The elongation shall be maintained by drilling of holes in the ends of sections of pipe and placing horizontal wires. After the pipe sections have been placed and coupling bands installed and prior to placing of backfill the wires shall be removed.

M5.03.1 Perforated Asphalt Coated Corrugated Metal Pipe.

This pipe shall consist of perforated metallic coated (galvanized or aluminized) corrugated metal pipe and couplings, completely coated inside and out with an asphalt cement.

A. Perforated Corrugated Metal Pipe.

The pipe shall conform to AASHTO-M36, with the following modification:

1. End Finish. Reinforcing the ends of the pipe will not be required.

B. Asphalt Coating for Pipe and coupling bands shall conform to AASHTO-M190 Type A. coating with the following modifications. The entire pipe shall be coated to a minimum thickness of 0.03 of an inch.

M5.03.2 Perforated Corrugated Metal Pipe.

This pipe shall conform to the requirements of AASHTO-M36, Type III.

M5.03.3 Asphalt Coated Corrugated Aluminum Pipe.

This pipe shall consist of corrugated aluminum alloy pipe and couplings completely coated inside and out with an asphalt cement

A. Aluminum Corrugated Metal Pipe.

The fabrication of pipe, coupling, and thickness of sheets used shall conform with the relevant requirements of AASHTO-M196.

B. Asphalt Coating.

Asphalt Coating for the pipe shall conform to AASHTO-M190, Type C. Coating. The asphalt coating for coupling bands shall conform to Type A Coating.

M5.03.4 Perforated Asphalt Coated Corrugated Aluminum Pipe.

This pipe shall consist of perforated corrugated aluminum alloy pipe and couplings, completely coated inside and out with an asphalt cement.

The fabrication of pipe, couplings, and thickness of sheet used therefore shall conform with the relevant requirements of AASHTO-M197. The asphalt coating for the pipe shall conform to M5.03.1, Section B.

M5.03.5 Perforated Corrugated Aluminum Pipe.

This pipe shall conform to the requirements of AASHTO-M197.

M5.03.6 Metal End Sections.

Metal End Sections shall be fabricated to conform with the current construction standard for this item. The method of fabrication and materials used shall conform to the applicable requirements of AASHTO-M36.

After fabrication of end sections, the entire unit shall be coated with 2 coats of material conforming to Subsection M7.04.01.

M5.03.7 Plastic (PVC) Pipe

Plastic (PVC) Pipe shall meet ASTM D 1785 Standard Specification for Poly Vinyl Chloride (PVC) and Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe, Schedule 40, 80, and 120. The pipe shall be PVC, Type I Schedule 80. Fittings, such as adapters, couplings, etc. shall be the same material as the pipe. Joints shall be made in accordance with ASTM D 2855 Recommended Practice for Making Solvent-cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings. Cements shall meet ASTM D 2564.

M5.03.8 Polymeric Precoated Corrugated Metal Pipe.

Polymeric precoated corrugated metal pipe shall conform to the requirements of AASHTO M246, Type B with the thinner polymeric coating a minimum of 3 mils.

M5.03.9 Slot-Perforated Corrugated Plastic Pipe.

This pipe or tubing shall consist of slot-perforated corrugated polyethylene tubing, couplings and fittings. Materials, dimensions, physical properties and fabrication shall be in conformance with AASHTO-M252.

M5.03.10 Corrugated Plastic Pipe

This pipe or tubing shall consist of corrugated polyethylene tubing, couplings and fittings. Materials, dimensions, physical properties and fabrication shall be in conformance with AASHTO M294.

M5.04.0 Asphalt Coated Corrugated Metal Pipe Arches.

Asphalt coated corrugated metal pipe arches shall consist of corrugated metal pipes which have been reformed to multi-centered pipe having arch shaped tops with a slight outwardly curved integral bottom. The pipe shall be fabricated from standard length culvert sheet and factory riveted to form a continuous length pipe arch.

Asphalt coated corrugated metal pipe arches, including coupling bands, shall conform to the requirement of AASHTO-M36 or AASHTO-M196 for corrugated metal pipe meeting the requirements for base metal, rivets, sampling, testing, brands, corrugations, end finish, weight, bands and workmanship.

FABRICATION

A. Dimensions.

Dimensions, tolerances, and areas shall be in accordance with AASHTO M-36 unless otherwise noted on the plans and/or called for in the proposal.

The lapped longitudinal seams shall be factory riveted and shall be placed in the top arch and be staggered so as to alternate on each side of the center of the top of the arch by approximately 15% of the periphery.

B. Asphalt Coating.

The insert of the pipe arch shall be coated with asphalt conforming to AASHTO-M190. Type C Coating, so as to form a smooth pavement to widths of 40% of the circumference of the pipe arch. These widths are determined by 40% of the circumference of equivalent diameters. It shall be applied in such a manner that the corrugations are completely filled and that, excepting where the upper edges intersect the corrugations, the pavement has a minimum thickness of 1/8 in. above the crests of the corrugations. The remainder of the inside of the pipe arch and the entire outside shall be uniformly coated with asphalt cement to a minimum thickness of 0.05 in. The thickness shall be measured on the crests of the corrugations. All coupling bands shall be coated to same requirements as the pipe arch except the pavement shall be omitted.

C. Bituminous Materials.

The asphalt cement used for coating shall conform to the requirements in M5.03.0, Section B.

M5.04.1 Half Circle ACCM Pipe.

This pipe shall conform to M5.03.0 except that the bottom of the pipe will not be paved.

M5.04.2 Structural Plate for Pipe and Pipe Arches.

All materials, including base metal analysis, galvanizing, bolts, nuts, corrugations, gauge determination and acceptance of plates, forming and punching holes, bearing shapes, fabrication and incidental items shall conform to AASHTO-M167 and the following:

A. The gauge of plates shall be as specified on the Plans.

B. Bituminous Coating for Metal Surfaces. The bituminous coating shall be a coal tar blend conforming to the requirements of M7.04.01.

M5.04.3 Asphalt Coated Smooth Steel Liner Helically Corrugated Shell Metal Pipe.

This pipe shall conform to AASHTO M36,8.1.1, Type 1A pipe. The coating shall conform to AASHTO Designation M190, Type A.

M5.05.1 Cast Iron for Water Systems.

Cast iron pipe shall be centrifugally spun, bell-and-spigot type conforming to the requirements of ASA Standard A21.6 (AWWA-C106 or A21.8 (AWWA-C108) for Cast Iron Pipe Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids and shall be of the class called for on the plans or in the Special Provisions. When no class is specified on the plans or in the Special Provisions, Class 150 pipe shall be used. Cast iron fittings shall conform with ASA Standard A21.10 or AWWA Standard C100, Class D. When cement lining is called for the pipe and fittings shall be cement lined in accordance with the requirements of ASA Specification A21.4 (AWWA-C104) for Cement Mortar Lining. When bituminous coating is specified it shall conform to the requirements stipulated in Standards A21.6 or A21.8.

A. Hydrants.

Hydrants shall conform to the requirements of AWWA Standard C502 and/or to the type used by the particular municipality involved as specified in the Special Provisions.

B. Gate Valves.

Gate valves shall conform to the requirements of AWWA Standard C500 and/or to the type used by the particular municipality involved as specified in the Special Provisions.

M5.05.3 Ductile Iron Pipe and Fittings

Ductile Iron Pipe shall conform to the requirements of ANSI A21.50 (AWWA C150) American Standard for Ductile Iron Pipe Centrifugally cast in metal molds or sand-lined molds for water or other liquids and shall be of the class called for on the plans or in the Special Provisions.

Ductile iron fittings shall conform with ANSI A21.10 (AWWA C 110, latest revision) American Standard.

When cement lining is called for the pipe and fittings shall be cement lined in accordance with the requirements of ANSI A21.4 (AWWA C104 latest revision) for Cement Mortar Lining for Ductile Iron Pipe and Fittings.

When bituminous coating is specified it shall conform to the requirement of ANSI A21.6 (AWWA C106, latest revision).

A. Hydrants.

Hydrants shall conform to the requirements of AWWA Standard C502, and/or to the type used by the particular municipality involved as specified in the Special Provisions.

B. Gate Valves.

Gate valves shall conform to the requirements of AWWA Standard C500 and/or to the type used by the particular municipality involved as specified in the Special Provisions.

M5.05.4 Acrylonitrile — Butadiene — Styrene (ABS) Pipe.

This type of pipe shall conform to the requirements of AASHTO-M265.

M5.06.0 Copper Tubing.

Copper Tubing shall conform to the requirements of ASTM-B88, Type k, ``annealed''.

M5.07.0 Electrical Conduit-Rigid, Nonmetallic (Type NM).

The walls of the conduit shall have a smooth interior surface free from all substances which may injure any wire or cable covering such as is used on rubber covered or thermoplastic insulated wire or cable.

The bore of the conduit shall be circular in cross section and straight and true so as to pass freely a mandrel 36 in. long and 1/4 in. less in diameter than the nominal inner diameter of the conduit.

The bore of bends, elbows, and other fittings shall pass freely a ball 1/4 in. less in diameter than the nominal inner diameter of the conduit. Couplings, elbows, bends, adapters, reducers, increasers and bell ends, shall be of the same material as the conduit. Couplings made of material other than that of which the conduit is made shall be compatible with the conduit and made of an approved tough non-metallic material suitable for the service.

The minimum acceptable radii dimensions for elbows and bends shall conform to the requirements of the National Electric Code. Joints shall be machined to an accurate taper on both ends to permit a tight joint when assembled with suitable couplings or fittings.

One tapered joint coupling shall be supplied with each length of conduit and each elbow or bend.

At least 85% of the conduit in any lot shall be furnished in standard length; sections of conduit less than 5 ft. will not be accepted. A tolerance of plus or minus 1 in. is permissible in the conduit lengths specified.

A. Bituminous Fibre Conduit and Fittings.

The conduit shall conform to Federal Specification W-C581 for Bituminized Fibre Conduit Type II and shall include the following specific requirements:

Nominal Size	2 in.	3 in.	4 in.
Inside Diameter, Inches Minimum	2.0	3.0	4.0
Wall Thickness, Inches Minimum	0.34	0.39	0.43
Standard Length Feet	5	8	8
Crushing Strength lbs. ft. Minimum	2000	2000	2000
Moisture Absorption % Maximum	2	2	2

Sampling: The conduit shall be subject to project inspection and sampling and any cracked, bent, or damaged material shall be rejected by the Engineer. All conduits delivered on the project shall meet the requirements of this specification.

B. Fire Clay Conduit and Fittings.

This conduit shall conform to Federal Specification W-C571 for Type II Fire Clay Cement Conduit and includes the following specific requirements:

Nominal Size	2 in.	3 in.	3½ in.	4 in.	5 in.	6 in.
Inside Diameter Inches ±0.1	2.0	3.0	3.5	4.0	5.0	6.0
Wall Thickness Inches, Minimum	0.30	0.32	0.32	0.32	0.35	0.35
Standard Length Feet	5	10	10	10	10	10
Crushing Strength Lbs./ft. min.	1400	1200	1110	1200	900	800
Moisture Absorption % Maximum	30	30	30	30	30	30

Sampling: The sampling of Fire Clay Cement Conduit shall conform to the requirement of M5.07.0-A.

C. Plastic Conduit and Fittings.

This conduit shall conform to Federal Specifications W-C1094 for Class II Conduit and Fittings. Non-Metallic. Rigid (Plastic).

M5.07.1 Conduit-Rigid Metallic (Type RM).

A. Steel Conduit and Fittings, Rigid Metallic (Type RM).

This conduit shall conform to Federal Specification WW-C581, Conduit, Rigid, and Couplings. Elbow, and Nipple, Electrical Conduit; Zinc Coated. The following publications form part of this specification to the extent specified. Unless otherwise indicated, the issue in effect on the proposal date shall apply:

1. USA Standard USAS C80.1 — Rigid Steel Conduit, Zinc Coated.
2. Underwriters' Laboratories, Inc. Publication: UL-6 Standard for Rigid Metallic Conduits.

An Underwriters' Laboratories, Inc. labeling shall appear on each length of conduit as well as on elbows, bends, sweeps and nipples to identify such as approved.

B. Steel Plastic Coated Conduit and Fittings.

This conduit shall conform to Federal Specification WW-C581.

C. Aluminum Conduit and Fittings.

This conduit shall conform to Subsection M5.01.1-A except for material which shall be aluminum conforming to Federal Specification WW-C540.

D. Special Alloy Conduit and Fittings.

This conduit shall conform to Federal Specification WW-C581, except material shall be corrosion resistant.

M5.07.2 Conduit-Flexible Metallic (Type FM).

A. Flexible Metal Conduit.

This conduit shall conform to Federal Specification WW-C566, Conduit. Metal. Flexible.

B. Flexible Metal Conduit Liquid-Tight.

This conduit shall conform to Subsection M5.07.2-A above and be covered with an abrasion resistant liquid-tight, plastic cover.

M5.08.0 Pull and Junction Boxes. Metallic.

Metallic pull and junction boxes made of cast iron, welded sheet steel or cast aluminum shall conform to Underwriters' Laboratories, Inc. Publication UL-514, Outlet Boxes & Fittings.

SECTION M6
ROADSIDE DEVELOPMENT MATERIALS

M6.00.0 General.

This section shall contain materials used for soil conditioning, seeding, general planting, and care of plants.

M6.01.0 Limestone.

Limestone shall consist of pulverized limestone obtained by grinding either calcareous or dolomitic limestone so that 95% of the material will pass a No. 20 sieve and at least 50% will pass a No. 100 sieve. The limestone shall have a neutralizing value satisfactory to the Engineer, and shall be only such as will have been marketed in accordance with those provisions of General Laws, as amended, which relate to commercial fertilizers.

M6.02.0 Fertilizer.

Fertilizer shall be furnished in containers plainly marked with the chemical analysis of the product.

Fertilizer for grass seeding shall have the following composition by weight.

	10-20-10
Nitrogen (N)	10% Minimum
Available Phosphoric Acid (P_2O_5)	20% Minimum
Water Soluble Potash (K_20)	10% Minimum

Fertilizer for general planting shall be commercial grade 10-10-10.

No fertilizer shall be used which has not been marketed in accordance with the provisions of General Laws, as amended, relating to fertilizers.

M6.02.1 Bone Meal.

Bone meal shall be fine-ground, steam-cooked, packing house bones with a minimum analysis of 23% phosphoric acid and 1.0% of nitrogen.

M6.03.0 Seed.

Grass seed shall be of the previous year's crop and in no case shall the weed seed content exceed 1% by weight. The grass seed shall conform to the requirements of the following tables:

	Proportion	Germination Minimum	Purity Minimum
For Grassplots & Islands			
Creeping Red Fescue	50%	85%	95%
Kentucky Blue	25%	85%	90%
Domestic Rye	10%	90%	98%
Red Top	10%	85%	92%
Ladino Clover	5%	85%	96%
For Slopes & Shoulders			
Creeping Red Fescue	50%	85%	95%
Kentucky 31	30%	85%	95%
Domestic Rye	10%	90%	98%
Red Top	5%	85%	92%
Ladino Clover	5%	85%	96%

The seed shall be furnished and delivered premixed in the proportions specified above. All seed shall comply with State and Federal seed laws.

The seed mixture specified for slopes and shoulders consists of a tough hardy type for use on slopes graded at the rate of 4:1, and steeper slopes, and on shoulders adjacent to the roadway pavement or as otherwise directed. The mixture for grass plots is of a finer type which will produce finer turf.

A manufacturer's Certificate of Compliance to the specifications shall be submitted by the manufacturers with each shipment of each type of seed. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the Contractor has submitted the certificates.

M6.03.1 Erosion Seed.

This seed shall consist of a mixture of the previous year's crop and shall contain the following mixture by weight with 98% purity:

Seed	% Weight	% Germination Minimum
Winter Rye	80 Minimum	85
Red Fescue (Creeping)	4 Minimum	80
Perennial Rye Grass	3 Minimum	90
Red Clover	3 Minimum	90
Other Crop Grass	0.5 Maximum	
Noxious Weed Seed	0.5 Maximum	
Inert Matter	1.0 Maximum	

A manufacturer's certificate of compliance will be required as specified in Subsection M6.03.0 above.

M6.03.2 Crownvetch (Penngift variety) Seed.

This seed shall be crownvetch (Penngift variety) and shall be sweet, dry and completely free from any musty odor, and general appearance shall indicate sound seed quality. The seed shall be scarified, have a purity of not less than 99.50%, weed seed not exceeding 0.35% by weight and it shall be entirely free from noxious weed seeds. Germination including Hard Seeds shall be not less than 70%. A four ounce package of inoculant is to be furnished with every twenty pounds of seed.

M6.04.0 Mulch.

Materials to be used in mulching shall conform to the following requirements:

M6.04.1 Hay Mulch.

Hay Mulch shall consist of mowed and properly cured grass, clover or other acceptable plants. No salt hay shall be used.

M6.04.2 Straw Mulch.

Straw Mulch shall consist of stalks, or stems of grain after threshing.

M6.04.3 Wood Chip Mulch.

Wood Chip Mulch shall consist of wood chips produced by cutting branches, limbs, etc., of trees, brush or shrubs with chippers approved for use by the Engineer. Wood Chip Mulch must be free from long stringy material and preferably shall be from live growth, except that 35% or less by volume of the Wood Chip Mulch may consist of "slabwood", chipped to an acceptable size by chippers equipped with a 1/4 in. knife set and thoroughly mixed with the live material. The percentage of "slabwood" in the mixture shall be determined by the Engineer.

Wood Chip Mulch containing an excess of fine particles, in the judgment of the Engineer, will not be acceptable for use on the Project.

Wood Chip Mulch may be produced on the project from acceptable cuttings.

M6.04.4 Wood Fibre Mulch.

Wood Fibre Mulch shall consist of wood fibre produced from clean, whole uncooked wood, formed into resilient bundles having a high degree of internal friction and shall be dry when delivered on the project.

M6.04.5 Aged Pine Bark Mulch.

This mulch shall consist of the outer bark of pine trees and a minimum of hardwood bark. Bark shall be processed by removal from the limbs and trunks of trees in the production of lumber and woodchips for paper mills.

This bark or a combination of the bark from various trees must be thoroughly mixed and be allowed to cook and become properly aged in a stock pile for a minimum period of six (6) months. The bark must be partially decomposed and dark brown in color, free of chunks and pieces of wood thicker than 1/4 in.

Mulch must be free from long stringy material.

Aged Pine Bark Mulch containing an excess of fine particles, in the judgment of the Engineer, will not be acceptable for use on the Project.

M6.05.0 Sod.

Collected Natural Growth Sods shall be 12 in. × 12 in. collected sods 4 or more inches in thickness with the kind of plant specified in the item predominating. Natural growth sods shall have 3 or more woody stems of native plants with natural soil clinging to the roots, such as may be obtained near the edge of the woods or along hedgerows. Native plants may consist of sheep laurel, lowbush blueberry, sweetfern and evergreen seedlings, collected from northern areas of the United States.

Mountain Laurel Sods shall have natural growth clumps of Laurel approximately 10 in. in height and 8 in. in spread. The sod shall be approximately 8 inches in diameter and 6 inches in depth. Larger plants in healthy condition will be acceptable.

Field Sod

Shall consist of satisfactory pasture field sods. The sods shall have a healthy root system at least 2 in. in thickness. Measurement for thickness shall exclude top growth and thatch. All sods shall be free from noxious weeds and coarse, burned or bare spots. All broken, dried or otherwise damaged sods shall be rejected as unsatisfactory.

Lawn Sod

Shall be composed of the grass mixture as recommended by the New England Sod Producer's Association and shall be specified as:

No. 1	For sunny turf areas		Kentucky Bluegrass — one or more of these varieties:
	Kentucky Bluegrass	50-100%	Merion
	Red Fescue	0-50%	Fylking
			Pennstar
			Windsor
			Baron

No. 2	For shady turf areas		
	Kentucky Bluegrass	10-25%	Red Fescue:
	Red Fescue	75-90%	Highlight Jamestown or
	Poa trivials	0-10%	Pennlawn
No. 3	For multi-use turf areas		
	Tall Fescue	80-100%	Kentucky 31
	Kentucky Bluegrass	0-20%	
	Perennial Ryegrass	0-20%	Manhattan

Lawn sods shall have been nursery grown on cultivated agricultural land specifically for sod purposes.

The sods shall be free of objectionable grassy and broad leaf weeds. Sods shall be considered free of such weeds if less than 5 such plants are found per 100 sq. ft. of area.

The sod shall be machine cut at a uniform minimum thickness of 3/4 in. at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be 5%. Broken pads and torn or uneven ends will not be acceptable.

M6.06.0 General Planting.

Materials to be used in this work shall conform with the following requirements:

Nomenclature:

All scientific and common plant names of the items specified shall conform with the current edition of *Hortus Third*, compiled by the staff of the L.H. Bailey Hortorium, Cornell University. These standards shall determine all requirements of acceptable shrub and seedling nursery stock. All plants delivered shall be true to name and legibly tagged. Caliper or spread shall govern over height specifications. The Contractor must obtain written permission from the Engineer for any substitutions for the types and sizes specified.

Delivery and Protection:

All plants shall be packed so as to arrive at the delivery point in good growing condition.

Delivery of plants and seedlings shall be made to the site, only according to the Contractor's ability to handle and properly care for them.

Sources of Material:

A. Nursery Stock shall be grown at nurseries in the Northern area of the United States for a minimum of two years, and shall conform with the requirements of subsection M6.06.1 below.

B. Collected Plants shall be carefully dug from approved locations and retain a root system or ball at least 25% larger than that specified for Nursery Stock.

M6.06.1 Nursery Stock.

All nursery stock shall conform to the current edition of the "American Standards for Nursery Stock" as sponsored by the American Association of Nurserymen, Inc.

All plants shall be fully representative of their normal species or varieties unless otherwise specified. All plants must have a good, healthy, well-formed upper growth; a fibrous compact root system; and must be free from disease, injurious insects, mechanical wounds either fresh or healed, broken branches, decay or any other defect; and shall be legibly tagged with their proper names.

All plant materials shall be dug with reasonable care and skill immediately prior to shipment.

Coniferous Evergreens shall be dug before spring "candling" of new growth.

Special precautions shall be taken to avoid any unnecessary injury to or removal of fibrous roots. Each species or variety shall be handled and packed in the approved manner for that particular plant having regard to the soil and climatic conditions at the time and place of digging, transit and delivery, and to the time that will be consumed in transit. All precautions that are customary in good trade practice shall be taken to ensure the arrival of the plants at the site of the project in good condition for successful growth.

All plants which are to be balled and burlapped previous to shipment are designated: "B & B". Balled and burlapped plants shall be lifted so as to retain as many fibrous roots as possible. The burlap shall be untreated 8-ounce burlap and firmly held in place by a stout cord or wire. Nails shall not be used except in the case of broad-leafed evergreens or other similar plants. All plants that are balled and burlapped shall come from soil which will hold a firm ball and the solidity of the ball shall be carefully preserved.

The roots of bare-rooted material shall be carefully protected with wet straw, moss or other suitable material which will ensure the arrival of the plants at the site of the work in good condition.

Deciduous Trees:

The sizes of these trees shall be as called for on the plans and measurements shall be made by calipering at a point 12 in. above the collar.

a) Non-flowering trees shall have been transplanted 3 times, the last transplanting within 2 years. They shall have a single straight leader not cut back. They shall have a symmetrical development of strong, healthy branches beginning 5 feet to 6 feet from the ground; and below this point, the trunk shall be clean for street trees, although park trees will be permitted to branch lower.

b) Flowering trees shall have been transplanted twice, the last transplanting within 2 years. The trunk shall be clean and straight up to the first branch, which shall be about 4 feet from the ground. Grafted and budded trees may branch lower and be pruned off 2 feet from the ground where directed. Flowering trees shall be balled and burlapped and kept moist for delivery.

Deciduous Shrubs:

Deciduous shrubs shall be fully representative of their species and variety. They shall have been transplanted twice; the last transplanting within 2 years. They shall have 4 to 6 branches coming from the roots, shall have a well-branched root system and shall be of good weight for the height specified.

Evergreen Trees:

Evergreen trees shall have been transplanted 3 times, the last transplanting within 2 years. They shall have a good colored top growth and shall be balled and burlapped and kept moist for delivery. Evergreen trees shall conform to AAN specifications; specified spread shall govern over height requirements.

Evergreen Shrubs:

Evergreen shrubs shall have been transplanted twice and shall have a heavy dark-green foliage. They shall be of the size indicated on the plans and, except where noted, each clump shall have not less than 4 stems. Plants shall be balled and burlapped and kept moist for delivery.

Vines and Trailers:

Vines and ground cover in this group shall be 2 year No. 1 stock unless otherwise indicated on the plans.

Herbaceous Perennials:

Herbaceous plants in this group shall be 3 year stocks and clumps shall have nor less than 6 buds, eyes or crowns.

Seedlings.

Seedlings shall have well developed root systems and shall be acclimated and suitable in all respects for field planting. All conifers must have dormant buds and secondary needles.

Evergreen seedlings shall be two (2) year transplants, bare rooted.

Lining out stock seedlings shall be two (2) year seedlings.

Root cuttings shall be established in peat pots 2½ in. deep by 2 in. wide at the open end and tapered to 1 in. inch wide at the closed end (inside measure).

M6.06.2 Crownvetch Potted Seedlings (Emerald, Chemung, or Penngift Variety).

The Crownvetch Potted Seedlings shall have a minimum height of 4 in. above the soil. The plant shall be well established in a peat pot 2½ in. deep by 2 in. wide at the open end and tapered to 1 in. wide at the closed end (inside measure). The plants must be acclimated to outside conditions to be acceptable for field planting.

M6.07.0 Tree Paint.

The paint furnished under this specification shall be suitable for application by brushing on sawed, cut or bruised surfaces of living trees, for the purpose of disinfection and protection of these surfaces.

The raw materials from which this paint is manufactured shall be as follows:

1. Asphalt: Shall conform to the requirements of AASHTO-M18, Grade A.
2. Creosote: Shall be a distillate of coal-gas tar or coke-oven tar, conforming to AASHTO-M133.
3. Fibrous Magnesium Silicate Pigment: Not less than 97% passing through a No. 325 screen.

Composition:

Asphalt	40-70%
Creosote	20-30%
Fibrous Magnesium Silicate	10-15%
Volatile Thinner	0-15%

The proportions of the various ingredients shall be chosen within the above limits to yield a paint of medium brushing consistency.

M6.08.0 Materials for Guying and Staking.

For Type (a) and (b) Staking

The stakes shall be unpainted spruce or other suitable wood free from large knots, dimensioned 2 in. by 2 in. by 8 feet.

Binding straps shall be 0.105 in. diameter galvanized steel wire.

Stake fastenings shall be 10 penny galvanized nails.

For Type II Guying

The guy wire shall consist of 0.135 in. diameter double-galvanized steel wire.

The anchor stake shall be made from locust, cedar or other suitable hard wood and shall be at least 24 in. in length and 2 in. by 2 in. in cross section.

Protective hose required to cover the wires used for Type I and II staking and guying shall be approved commercial 1/2 in. High Pressure reinforced hose and a minimum length of 8 in.

M6.09.0 Wrapping Material.

Wrapping Material for tree trunks shall be 4 to 6 in. wide strips of burlap, paper or plastic manufactured for this purpose. Fastening for the wrapping material shall be either adhesive weather resistant tape or a minimum of 3-ply jute twine.

M6.10.0 Water for Irrigation.

Water used for irrigation of plant materials shall be free from any substance injurious to vegetation, such as oil, acids, alkalis and salts.

SECTION M7
PAINTS AND PROTECTIVE COATINGS

M7.00.0 General Requirements for Paints and Protective Coatings.

A. General.

All paint shall conform to the following general requirements.

1. Materials.

The raw materials used in the following specifications for paints and protective coatings shall conform to the specification designed by ASTM, Federal serial number or AASHTO unless specified otherwise in the individual specification. Subsequent amendments to the specifications quoted shall apply to all raw materials and finished products. No "or equal" substitution for any specified material shall be made without written consent of the Engineer.

2. Proportions.

Paint proportions and percentages given in the following specification are expressed by weight unless stated otherwise.

3. Condition in the container.

Paint and protective coatings shall be homogeneous, free of contaminant and of a consistency suitable for use in the capacity for which it is specified. The finished product shall be well ground and the pigment shall be properly dispersed and suspended in the vehicle according to the requirements of the paint or protective coating. The dispersion shall be of such nature that the pigment does not settle badly, does not cake or thicken in the container, and does not become granular, jelled or curdled. Any settlement of pigment in the paint or protective coating shall be a thoroughly wetted soft mushy mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily dispersed, with a minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. The manufacturer shall include in the paint the necessary additives for control of sagging, pigment settling, leveling, and other qualities of a satisfactory working material. The paint shall possess satisfactory properties in all respects which affect its application and curing.

4. Packaging.

The finished paint or protective coating shall be furnished in new five gallon, round, non-tapered containers no thinner than 0.0250 in. unless otherwise specified. The containers shall have the lug type crimp lids with ring seals and be equipped with ears and bails. The containers shall meet U.S. Department of Transportation Hazardous Materials Shipping Regulations. The container must be lined if necessary so as to prevent attack by the paint. The lining must not come off the can as skins.

The following information shall be labeled on each can in a clear legible manner:

a) Name of Manufacturer
b) Place of Manufacture
c) Manufacturer's Batch Number
d) Mass DPW Specification Number
e) Date of Manufacture

Precautions concerning the handling and the application of the paint or protective coating shall be shown on the label.

B. Sampling and Testing.

1. Sampling.

At least one sample, not less than one quart, shall be taken for each batch or less of each kind of paint to be used. Samples must be taken in clean, dry, airtight, widemouth metal cans and the sample must fill the can to within one inch from the top. Each sample forwarded to the Research and Materials Section shall be accompanied by the name of the manufacturer, the batch number, the specification number and the quantity of paint represented.

Before the Contractor will be permitted to use any paint, the material proposed to be used shall have been sampled, tested and approved.

The manufacturer, as may be required by the Engineer, shall permit access to an inspection of his paint and all operations involved in the manufacture of these materials; shall permit sampling of raw materials and shall furnish such reasonable facilities as the Engineer may require for such inspection.

2. Testing.

Testing of paints will be done at the Research and Materials Section in accordance with the latest methods of Federal Test Method Standard Number 141, ASTM and Methods in use by the Research and Materials Section.

In addition the Department reserves the right to make use of any information or methods of testing to determine the quality of paint and paint materials.

The manufacturer may obtain dry color chips from the Research and Materials Section in order to obtain the proper sample color if he so desires or he may submit a wet sample of the paint which he proposes to furnish. If the color of the wet sample is approved, paints matching the wet sample will, as regards to color, be accepted.

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices or processes used or incorporated in the work and agrees to indemnify and save harmless the Commonwealth of Massachusetts and its duly authorized representative from all suits at law or action of every nature for or on account of the use of any patented materials, equipment, device or processes.

A listing of the paints is below. Any copies of individual specifications or a complete set of the specifications may be obtained from the Research and Materials Section, 99 Worcester Street, Wellesley Hills, Massachusetts 02181.

M7.01 Pavement Markings.

M7.01.03 White Thermoplastic Reflectorized Pavement Markings
M7.01.04 Yellow Thermoplastic Reflectorized Pavement Markings
M7.01.05 White Traffic Paint
M7.01.06 Yellow Traffic Paint
M7.01.07 Glass Beads
M7.01.08 White High Heat Rapid Drying Traffic Marking Material
M7.01.09 Yellow High Heat Rapid Drying Traffic Marking Material
M7.01.10 Fast Drying White Traffic Paint
M7.01.11 Fast Drying Yellow Traffic Paint
M7.01.12 Striping Powder
M7.01.14 Black Non-Reflective Lane Tape
M7.01.15 Black Traffic Paint
M7.01.16 White and Yellow Temporary Reflective Lane Tape
M7.01.18 Preformed Permanent Plastic Pavement Markings or Legends
M7.01.20 Thermoplastic Pavement Marking Compound, Alkyd
M7.01.21 Green Pavement Coatings

M7.02 Structural Paint

M7.02.04 Basic Lead Silico Chromate Paint
M7.02.06 Basic Lead Silico Chromate Intermediate Paint
M7.02.08 Gray Basic Lead Silico Chromate Paint
M7.02.11 Basic Lead Silico Chromate Green Finish Paint
M7.02.12 Basic Lead Silico Chromate Brown Finish Coat
M7.02.13 White Paint (Stain Resistant)
M7.02.17 Aluminum Paint
M7.02.18 Heavy Duty Metal Primer
M7.02.19 Basic Lead Silico Chromate Finish Coat Reddish Brown
M7.02.20 Zinc Rich Primer, Organic Vehicle Type
M7.02.21 Inorganic Zinc Rich Primer
M7.02.25 High Build Brown Vinyl Finish Paint
M7.02.28 Green High Build Vinyl Color Coat
M7.02.29 Lead Free Metal Primer (Iron Oxide, Sr Chromate, Zinc Oxide)
M7.02.61 Epoxy Ester Based Zinc Rich Primer

M7.03 Enamels

M7.03.02 Sign and Equipment Enamel

M7.04 Miscellaneous Coatings

M7.04.01 Coal Tar Protective Coatings
M7.04.02 Primer, Paint, Exterior, (Undercoat for Wood, Ready Mixed White and Tints)
M7.04.03 Paint, Zinc Yellow, Iron Oxide Base Ready Mixed (Type II)
M7.04.04 Paint, Ready Mixed, International Orange
M7.04.05 Paint, Exterior, Black Ready Mixed
M7.04.06 Primer Coating, Basic Lead Silico Chromate, Ready Mixed
M7.04.07 Primer Coating, Zinc Dust-Zinc Oxide (for galvanized surfaces)
M7.04.08 Enamel Undercoat Interior, Tints and White
M7.04.09 Paint, Outside, Dull-Black (Formula 104)
M7.04.10 Primer, Pretreatment (Formula 117 for Metals)
M7.04.11 Paint, High Zinc Dust Content, Galvanizing Repair

M7.05 Epoxy Protective Coating

M7.05.01 Epoxy — Polyamide Red Lead Paint
M7.05.02 Epoxy — Polyamide Green Paint
M7.05.03 Epoxy — Polyamine Concrete Coating
M7.05.05 One Coat High Build Epoxy Mastic Coating

M7.10.0 Galvanized Coatings

All galvanized coatings shall conform to the following general requirements:

ASTM-A143 — Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.

ASTM-A384 — Safeguarding Against Warpage and Distortion during Hot-Dip Galvanizing of Steel Assemblies.

ASTM-A385 — Providing High-Quality Zinc Coatings (Hot-Dip).

AASHTO-M111 — Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip.

AASHTO-M232 — Zinc coating (Hot-Dip) on Iron and Steel Hardware.

The zinc used shall conform to AASHTO-M120 and shall be at least equal to the grade designated as "Prime Western." A minimum of 0.5% nickel (by weight) shall be added to the galvanizing bath.

AASHTO-M298 Coating of Zinc mechanically deposited on iron or steel.

SECTION M8
METALS AND RELATED MATERIALS

M8.00.0 General.

Steel for reinforcing shall be free from imperfections, dirt, loose scale, paint, oil, or other foreign substance that might tend to prevent bonding with concrete. Rust that occurs in scales or that pits the steel will be considered an imperfection. Surface rust will not be considered an imperfection, but the surface shall be brushed to remove loose material.

All welding and welding material shall conform to the requirements of the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5).

Steel castings shall be true to pattern in form and dimensions, without sharp unfilleted angles or corners and shall be free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended.

Iron castings shall be true to pattern in form dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects in positions affecting their strength and value for the service intended. The casting shall be boldly filleted at angles and the arises shall be sharp and perfect. The surfaces shall have a workmanlike finish.

Aluminum castings shall be of uniform quality and condition, free from cracks, blow holes, porous places, hard spots or shrinkage defects which affect the suitability of the castings for their intended use.

Sampling and Testing. Samples for testing shall be taken in accordance with the applicable ASTM and/or AASHTO specification for the material unless otherwise specified. Testing will be done in accordance with latest standard procedures of ASTM and/or AASHTO.

M8.01.0 Reinforcing Bars.

Reinforcing bars shall consist of deformed bars unless otherwise specified. The bars shall be rolled from new billet steel conforming to the requirements of AASHTO-M31, Grade 60. Deformed steel will not be required for spiral reinforcing columns.

M8.01.1 Cold Drawn Steel Wire.

This material shall conform to AASHTO-M32.

M8.01.2 Welded Steel Wire Fabric.

This material shall conform to AASHTO-M55.

M8.01.3 Steel Bar Mats.

This material shall conform to AASHTO-M54.

M8.01.4 Tie Bars and Bolts.

Tie bars for longitudinal joints shall be either deformed bars of new billet steel (AASHTO-M31, Grade 60) or approved tie bolts as shown on the plans which shall conform in all respects to the standard requirements specified for strength and design.

M8.01.5 Anchor Bolts, Nuts and Washers.

Bolts, nuts and washers used for anchoring bridge railing base plates to concrete shall be fabricated from steel conforming to the requirements of ASTM-A325.

Bolts, nuts and washers used for anchoring bridge bearings to concrete shall conform to the requirements of ASTM-A307.

Bolts, nuts and washers used for anchoring signal lighting and sign structures shall conform to the requirements of one of the following:

ASTM A615 Grade 60 with a minimum yield strength of 60,000 p.s.i.

ASTM A687 Type II with a minimum yield strength of 105,000 p.s.i.

ASTM A615 Grade 75 with a minimum yield strength of 75,000 p.s.i.

ASTM A36 with a minimum yield strength of 55,000 p.s.i., tensile strength of 75,000 to 95,000 p.s.i., and maximum elongation of 18% in 8″.

Nuts and washers for the above shall be suited to the approved bolts.

High tension bolts, where specified, shall conform to ASTM A325. A galvanized hexagon nut, leveling nut and flat washer shall be furnished with each bolt.

All bolts, nuts and washers shall be galvanized in accordance with ASTM-A153.

M8.01.6 Anchor Rods (Prestressed Beams).

This material shall be fabricated from billet steel conforming to requirements of AASHTO-M31, Grade 60.

M8.01.7 Epoxy Coated Reinforcing Bars.

Epoxy coated reinforcing bars shall conform to AASHTO-M284.

M8.02.0 Drill Steel Rods.

This material shall conform to the requirements of AISI-W1.

M8.03.0 Iron Castings.

These materials shall conform to the requirements of AASHTO-M105, Class No. 30 unless otherwise specified. Test bars required shall be Test Bar B, 1.20 inches in diameter.

M8.03.2 Steel Castings.

Type A-3 grates shall be cast to the dimensions shown on the plans and composed of cast steel conforming to the requirements of AASHTO-M103, Grade 65-35, full anneal.

Castings shall be shot blasted prior to painting. Painting shall consist of one shop coat of structural basic lead silico chromate paint, (M7.02.04) and one shop coat of structural basic lead silico chromate, intermediate paint (M7.02.06) and the Contractor shall apply one field coat of basic lead silico chromate green finish paint (M7.02.11) or other color paint as directed.

M8.04.1 Stud Shear Connectors.

1. General Requirements.

A. Shear connector studs shall be of a design suitable for end welding to steel beams and girders with automatically timed stud welding equipment. The type, size or diameter, and length of stud shall be as specified by the plans, specifications, or special provisions as approved by the Engineer, with the following allowable tolerances and dimensions.

Standard Dimensions — Inches

Diameter of Shank in Inches	Length of Welded Stud*	Diameter of Head	Thickness of Head
3/4 - .015	4 + .062 - .125	1¼ ± 1/64	3/8 min.
7/8 - .015	4 + .062 - .125	1⅜ ± 1/64	3/8 min.

*4 in. length is standard. Other lengths may be obtained by special order. Length is from outside of head to face of base metal after welding is completed.

B. An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud. The material shall not be detrimental to the welds or cause excessive slag and shall have sufficient strength so as not to crumble or break due to thermal or structural shock before the weld is completed.

C. Flux for welding shall be furnished with each stud, either attached to the end of the stud or combined with the arc shield for automatic application in the welding operation.

D. Studs shall not be painted or galvanized.

E. Only qualified studs shall be used. A stud, to be qualified, shall have passed the tests prescribed under part 3, "Shear Connector Stud Weldability Qualification Procedure". The arc shield used in production shall be the same as used in the qualification tests.;

F. Before placing orders for studs, the Contractor shall submit to the Engineer for approval, the following information on the studs to be purchased:

1. The name of the manufacturer.
2. A detailed description of the stud and arc shield to be furnished.
3. A certification from the manufacturer that the stud is qualified as specified in 1.E hereinbefore.
4. A copy of the qualification test report as certified by the testing laboratory.

G. The studs, after welding, shall be free from any defect or substance which would interfere with their function as shear connectors.

Material Requirements.

A. Shear connector studs shall conform to the requirements of the Specification for Cold Finished Carbon Steel Bars and Shafting, ASTM-A108, cold-drawn bar, Grades 1015, or 1020, either semi-killed or killed. If flux-retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM-A109.

B. Tensile properties as determined by tests of the bar stock after drawing or of finished studs shall conform to the following requirements:

Tensile Strength	(min.)	60,000 PSI
Yield Strength*	(min.)	50,000 PSI
Elongation	(min.)	20% in 2 in.
Reduction of area	(min.)	50%

*As determined by a 0.2% offset method.

C. Tensile properties shall be determined in accordance with the applicable sections of ASTM-A370, Mechanical Testing of Steel Products. Tensile tests of finished studs shall be made on studs welded to test plates. If fractures occur outside of the middle half of the gage length, the test shall be repeated.

D. Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends or other injurious defects. Finish shall be as produced by cold drawing, cold rolling, or machining.

E. The manufacturer shall certify that the studs as delivered are in accordance with the material requirements of this Section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer.

3. Shear Connector Stud Weldability Qualification Procedure.

A. Purpose.

The purpose of this procedure is to prescribe weldability tests which will qualify a shear connector stud for welding under shop or field conditions. The tests may be performed by a university, independent laboratory or other testing agency. The agency performing the tests shall submit to the manufacturer of the stud a certified report giving procedures and results for all tests including the information listed under 3H hereinafter.

B. Duration of Qualification.

A type and size of stud with arc shield, once qualified, is considered qualified until the manufacturer makes any change in the base of the stud, the flux, or the arc shield which effect the welding characteristics.

C. Preparation of Specimens.

Test specimens shall be prepared by welding representative studs to the center of square specimen plates, 1/2 to 3/4 in. thick, of structural steel, ASTM-A36. At the option of the manufacturer, studs may be welded to a large plate and the specimen plates cut to a size suitable for test equipment used.

Studs shall be welded with power source, welding gun and control equipment as recommended by the manufacturer. Welding voltage, current and time (see D below) shall be measured by suitable instrumentation and recorded for each specimen.

Lift and plunge shall be at the optimum setting as recommended by the manufacturer.

D. Number of Test Specimens

1. Thirty test specimens shall be welded consecutively with optimum current and time. Optimum current and time shall be the mid-point of the range normally recommended by the manufacturer for production welding.

2. Thirty test specimens shall be welded consecutively with time held constant at optimum but with current 10% below optimum.

3. Thirty test specimens shall be welded consecutively with time held constant at optimum but with current 10% above optimum.

E. Qualification Tests.

1. Tensile Tests — Ten of the specimens welded in accordance with D.1, ten in accordance with D.2, and ten in accordance with D. 3 shall be subjected to a tensile test in a fixture approved by the Department's Research and Materials Section. A stud shall be considered as qualified if all test specimens have a tensile strength above the minimum specified in 2.B hereinbefore.

2. Bend tests — Twenty of the specimens welded in accordance with D.1, twenty in accordance with D.2, and twenty in accordance with D.3 shall be placed in the bend testing device approved by Department's Research and Materials Section and bent alternately 30 ° in opposite directions until failure occurs. A stud shall be considered as qualified if, on all test specimens, fracture occurs in the shank of the stud and not in the weld.

F. Retests.

If a weld failure occurs in any of the tensile or bend tests groups, that group may be retested. If weld failure repeats, the stud shall fail to qualify.

G. Qualification.

For a manufacturer's studs and arc shields to be qualified, each group of thirty studs shall, by test or retest, meet the requirements prescribed in E.1 and E.2 above.

H. Report of Tests.

The laboratory report shall include the following:

a) Drawings which show shapes and dimensions with tolerances of studs, arc shields, and flux.

b) A complete description of materials used in the studs and arc shields, including the quantity and analysis of the flux

c) A certification that the studs and arc shields described in the report are qualified in accordance with 3G herein.

M8.04.2 Steel Pins.

Pins more than 9 inches in diameter shall be manufactured from carbon steel conforming to the requirements of AASHTO-M102, Classes C, Cl, or E, or AASHTO-M102, Classes C, C1, or E, or AASHTO-M169, grades 1016 thru 1030 inclusive.

M8.04.3 High Tensile Strength Bolts.

Bolts, nuts and washers shall conform to the requirements of AASHTO-M164. Bolts manufactured to this specification are identified by marking on the top of the head with three radial lines and the symbol A325.

M8.05.0 Structural Steel.

Unless otherwise specified, all structural steel shall conform to the requirements of AASHTO-M183.

High strength low allow steel, when specified, shall conform to the requirements of AASHTO-M222 or AASHTO-M223, Grade 50.

The requirements of AASHTO-M222 or AASHTO-M223, Grade 50 shall be further supplemented with the following:

The producer shall make and report to the Engineer, for heat qualification, one impact test from the thickest material and one impact test from the thinnest material for each heat and/or product furnished. The impact test shall be longitudinal Charpy V-notch conforming to the requirements of ASTM-A370, Paragraph 23. Products are defined as plates, shapes and bars. If less than 50 tons are supplied from a heat, one impact test from the thickest material only is required for that heat.

For a heat to qualify, the energy absorbed to 40 °F shall not be less than 15 foot pounds, except when subsize specimens are required; then the minimum energy absorption shall be as follows:

Size	Foot Pounds (Min.)
10 mm × 7.5 mm	12.5
10 mm × 5 mm	10.0

Each impact test constitutes the average value of three adjacent specimens. The results on one specimen may be below the above specified minimum values but in no case below two-thirds of the value. If more than one value is below the specified minimum, or if one specimen is below two-thirds of the specified minimum, a retest of three additional specimens shall be made, each of which must equal or exceed the specified minimum.

If the thickest or thinnest material tested fails, that gage or gages shall be rejected; however, the next thinner or thicker gage may be tested, and if the test results meet the requirements, the heat will be considered qualified for those gages represented by the retests.

The governing thickness for beams and channels shall be the average flange thickness. Test specimens shall be taken at a point one-third the distance from the outer edge of the flange or leg to the web or heel of the section.

Welding and Welding procedures shall comply with the provisions of the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5).

"Longitudinal Charpy V-Notch"

Material designated on the bridge plans as main load carrying members shall meet the longitudinal charpy V-Notch tests specified in the following table:

Material	Thickness	Min. Energy Absorbed of *
AASHTO-M183 (ASTM-A36)	Up to 4 in. thickness	15 ft. lb. at 40 °F
AASHTO-M222 (ASTM-A588)	Up to 2 in. welded Up to 4 in. mech. fastened	15 ft. lb. at 40 °F
AASHTO-M222 (ASTM-A588) Yield Point 65 ksi	Over 2 in. to 4 in. welded	20 ft. lb. at 40 °F
AASHTO-M223 Grade 50	Up to 1½ in. welded	15 ft. lb. at 40 °F

*Minimum Service Temperature from –1 °F to –30 °F

Sampling and testing procedures shall be in accordance with AASHTO-T243 (ASTM-A673). The (H) frequency of heat testing shall be used.

M8.05.1 Steel Piles.

Steel piles shall consist of structural steel shapes of the section shown on the plans. The steel shall conform to the requirements of AASHTO-M183. Copper bearing steel will not be required.

M8.05.2 Steel Shells, Cast-in-Place Piles.

This specification covers steel shell type piles where the steel shell is not considered to act as a permanent load carrying member.

Steel shells shall be of sufficient strength and rigidity to permit driving and to prevent distortion caused by soil pressures or the driving of adjacent piles, until filled with concrete. The shells shall be also sufficiently watertight to exclude water during the placing of concrete.

Any pile with a wall thickness greater than 0.188 in. will not be considered a shell for a Cast-in-Place Pile.

Steel shells for cast-in-place concrete piles shall have a uniform taper, or a combination of uniform sections of increasing diameter, or a combination of uniform sections of equal length that increase progressively not more than twice the thickness of the shell at each change in diameter, or a uniform section throughout; but only one type shall be used for the contract. The tip shall be of steel fully welded to tightly close the bottom of the pile to make a watertight closure. Care must be exercised to avoid the use of more than one short section at the butt end when necessary to extend the pile length.

If steel shells consisting of a succession of cylindrical sections of increasing diameter are used, all sections shall be of equal length and increasing in diameter by not more than one inch between adjoining sections from the section at the tip to the section at the butt of the pile.

The minimum tip diameter shall be 8 inches. The minimum butt diameter at the point of cut-off shall be 12 inches when the specified loading is 40 tons or less, or shall be 14 inches when the specified loading is over 40 tons and less than 50 tons.

Steel reinforcement shall conform to the requirements of M8.01.0 and shall be as detailed on the plans.

M8.05.3 Steel Baffles and Drainage Troughs.

Steel used for the manufacture of baffles and drainage troughs shall conform to the requirements of ASTM-A242 with the additional requirement that the steel shall exhibit a corrosion resistance at least 4 times that of ASTM-A36 Steel.

M8.05.4 Steel Sheeting.

Steel sheeting shall be an approved standard section either new or used, weighing not less than 22 pounds per square foot of wall. Steel sheeting which is to be left in place shall conform to the requirements of AASHTO-M202 (ASTM-A328).

M8.05.5 Steel Pipe Piles.

This specification covers cylindrical steel pipe of uniform cross section and diameter throughout its length and in which the cylindrical pipe acts as a permanent load-carrying member.

The steel pipe shall be new and shall conform to the requirements of ASTM-A252, Grade 2 except where it is in conflict with other parts of the specifications. In such cases these Specifications shall govern.

Pipe having seams of spiral-lap welded construction will not be permitted under this specification.

The outside diameter and wall thickness of the pipe shall be as shown on the plans. All piles shall be driven as a closed end pipe and filled with concrete conforming to M4.02.00 for 4,000 psi, 3/4 in., 610 cement concrete. A steel plate having the same outside diameter as the pipe and a thickness as shown on the plans shall be welded to the bottom of the pipe with a full penetration weld using an approved backing ring, which shall develop the full strength of the pipe in compression and bending.

The bottom end of the pipe shall be beveled in accordance with the ASTM-A252 specification and the top end of the pipe shall not be beveled.

Steel reinforcement shall conform to the requirements of M8.01.0 and shall be as detailed on the plans.

M8.05.6 Precast-Prestressed Piles.

Piles shall be standard 14 in. square precast-prestressed concrete piles, designed and manufactured in accordance with the joint AASHTO and PCI Committee recommendations, latest revision. Piles shall support design loads and moments shown on the Plans.

No piles shall be delivered to the site until at least three (3) days after casting and until concrete strength is at least 5,000 psi as determined by compression tests on 4-inch or 6-inch-diameter standard concrete cylinders.

M8.05.7 Pressure Injected Footing Piles.

Concrete

Materials, mixing and testing of concrete shall conform to requirements of Section M4, Cement and Cement Concrete Materials, of these Specification for 4000 psi concrete, using 3/4 in. as the nominal maximum size of coarse aggregate. Zero-slump concrete shall be developed by reducing water in the regular-mix concrete to quantities that cause slump to approach zero as measured at the point of discharge into the casing.

Steel Reinforcement

Steel reinforcement shall be made of new billet steel complying with ASTM designation A-615 Grade 60, or as shown on the drawings.

Permanent Casings

Permanent casing, where required, shall be of steel with strength and rigidity sufficient to prevent distortion caused by driving adjacent piles, or collapse due to soil or hydrostatic pressure, and to maintain shape. Casings shall be free from dents and deformations and shall be water tight to assure placing concrete in the dry.

M8.07.0 Steel Beam Highway Guard Type SS.

The materials for this work shall conform to the following requirements:

A. Fabrication.

All metal work shall be fabricated in the shop. No punching, cutting or welding shall be done in the field. Holes for special details in exceptional cases may be made in the field when approved but such holes shall be drilled. Field punching may be permitted, if approved by the Engineer, after it has been demonstrated that such punching will not result in damage to the surrounding metal. Fabrication shall include all operations such as shearing, cutting, punching, forming, drilling, milling, bending, welding and riveting. Components of bolted assemblies shall be galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating.

Galvanized surfaces that are abraded or damaged at any time after application of the zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating after which the cleaned areas shall be painted with two (2) coats of paint, high zinc dust content, conforming to the requirements of M7.04.11.

B. Posts.

1. Steel Posts.

Steel posts and channel members for anchor posts shall be fabricated from new structural steel sections conforming to the dimensions and design shown on the plans. All posts, including end anchor posts, and anchor posts for use at drives, shall be steel "H" sections.

All holes drilled in the galvanized post sections shall be cleaned and painted, before bolts are installed, with two coats of paint, high zinc dust content, conforming to M7.04.11.

Structural steel shall conform to the requirements of AASHTO-M183, except that copper bearing steel will not be required. Galvanizing shall meet the requirements of AASHTO-M111. Each member shall be stamped with AASHTO designation and the amount of galvanizing per square foot of surface area.

Posts may be of the conventional Hot Rolled Structural Shape or of the Welded Type as approved by the Department.

2. Wood Posts.

The Posts and Offset Blocks shall be rough sawn (unplaned) with nominal dimensions as indicated on the plans and with tolerances of 1 in. in length and 1/4 in. in width and thickness. All holes in the Posts and Offset Blocks shall be drilled prior to the application of the preservative.

The timber used for Wood Posts and Offset Blocks shall be of the same species. The Stress Grade shall be 1000 psi or more, extreme fiber in bending.

Testing for Stress Grade shall be in accordance with the Northeastern Lumber Manufactures Association Inc., Northern Hardwood and Pine Manufacturers Association, Inc., Southern Pine Inspection Bureau, West Coast Lumber Inspection Bureau, or the Western Wood Products Association, Standard Grading Rules. If another Timber Association is proposed, it must receive the approval of the Department before it will be considered or accepted.

Prior to treatment, all Posts and Offset Blocks shall be seasoned, conditioned and completely machined in accordance with AWPA Standard M1.

Posts and Offset Blocks shall be treated with either pentachlorophenol, chromated copperarsenate (CCA) or ammoniacal copper arsenate (ACA). Treatment shall be full length under pressure by the empty-cell or full-cell process in accordance with AWPA Standards C1 and C4. The preservatives, minimum retention thereof and applicable AWPA standards are listed in the following table:

Preservative	Retention	AWPA
	lbs./cu. ft. of Post	Standards
Pentachlorophenol	0.60	P8, P9
ACA	0.60	P5
CCA, Type A	0.60	P5
CCA, Type B	0.60	P5
CCA, Type C	0.60	P5

When water borne preservatives are used, temperature requirements, as stipulated in Section 2.221 of AWPA Standard C1, shall be closely regulated. Species of wood that are difficult to penetrate shall be incised in accordance with Section 2.2 of AWPA Standard C6. No unnecessary cutting of treated posts will be allowed after treatment. All posts and blocks with surfaces damaged by cutting, drilling or any other cause shall be field treated with a hot preservative solution in accordance with AWPA Standard M4. Preservatives used for this purpose shall be the same as those used for the basic treatment and shall conform to the same specifications.

Certificates of compliance and certificates of inspection for each lot of Wood Posts and Offset Blocks must be presented before any Posts are installed. The certificates bearing the approved inspection agencies verification must specify the species.

The certificates of inspection and compliance do not signify mandatory acceptance of the entire lot. The Engineer still has the option of rejecting Posts or Offset Blocks (included in any particular lot) that he may consider sub-standard because of unsound knots and shakes, excessive checking or other defects that may be detrimental to the structural integrity of the posts or offset blocks.

The fabricator shall retain a Department approved Agency to inspect and certify the treated Posts and Blocks in accordance with these specifications and AWPA Standard M2.

All treated Posts shall be marked in accordance with AWPA Standards M1 and M6. (The mark is to include the identifying lot number). The Post shall also be stamped with the Inspector's identification. The mark is to be placed on an upper side of the Post and located so that it is not obstructed by the offset blocks, rails, or any other appurtenances. The Inspector's stamp shall be legibly hammer-stamped on the head of the post, in accordance with AWPA Standard M2 and the above.

C. Rail Element and Terminal Sections.

The steel rail element and terminal sections shall conform to AASHTO-M180. Class A, (base metal thickness = 0.105 in.), Type 2 with the following additions:

The length of the railing shall be according to the plans and not over 13 ft. 6½ in.

Each end of the steel rail for every stretch of guard shall be fitted with a terminal section as shown on the plans. The terminal section shall have the same splice detail as the rail.

The projecting heads of all connection and splice bolts shall be rounded and shallow so that no appreciable projection will obstruct a vehicle sliding along the rail.

Where railing is to be constructed on curves which have a radius of 150 ft. or less, the rail elements shall be fabricated to the proper radius with the road side of the rail either concave or convex as required.

D. Bolts, Nuts and Washers.

All bolts, nuts and washers used in the assembling and erecting the rail shall conform to the requirements of ASTM-A307 and shall be of the size shown on the plans. They shall be designed to develop the required joint strength. Galvanizing shall be by the hot-dip process to conform to the requirements of AASHTO-M111.

M8.09.0 Chain Link Fences and Gates.

A. General.

All material used shall conform to AASHTO-M181 except aluminum alloy items which shall conform to ASTM-B211, B221 and B429. The fence fabric shall be Type 1 (Zinc Coated Steel) or Type 2 (Aluminum-Coated Steel) as set forth in the proposal. Tie wires, hog rings and post clips shall be zinc coated steel, aluminum coated steel or aluminum alloy. "H" posts shall be zinc coated steel. Tension wire may be either zinc coated steel or aluminum coated steel. All zinc coated hardware shall be in conformance with AASHTO-M232. All materials shall be new and undamaged when installed. Imperfectly coated materials will be rejected.

B. Posts.

Metallic coated steel line posts over 5 ft. shall be 2.375 in. O.D. pipe, Type A with a weight of 3.65 pounds per linear foot (±5%); or Type B with a weight of 3.117 pounds per linear foot (±5%); or Type D with a weight of 3.07 pounds per linear foot (±5%); or 1.95 in. inch by 2.25 in. "H" column with a weight of 4.10 pounds per linear foot (±5%). Line posts 5 ft. or less shall be 1.90 in. O.D. pipe, Type A with a weight of 2.72 pounds per linear foot (±5%) or Type B with a weight of 2.29 pounds per linear foot (±5%); or Type D with a weight of 2.25 pounds per linear foot (±5%); or 1.625 in. by 1.875 in. "H" column with a weight of 2.70 pounds per linear foot (±5%).

Gate posts shall be 4 in. O.D. pipe, Type A with a weight of 9.10 pounds per linear foot (±5%). End and corner posts over 5 feet shall be 2.875 in. O.D. pipe, Type A with a weight per linear foot of 5.79 pounds (±5%) or Type B with a weight per linear foot of 4.64 (±5%) or Type D with a weight per linear foot of 4.09 pounds (±5%).

End and corner posts 5 feet or less shall be 2.375 in. O.D. pipe Type A with a weight of 3.65 pounds per linear foot (±5%) or Type B with a weight of 3.117 pounds per linear foot (±5%); or Type D with a weight of 3.07 pounds per linear foot (±5%). All Type A round pipe shall conform to ASTM A120, Schedule 40. All Type B round pipe shall conform to ASTM A569. Sheet material for Type D round pipe shall conform to ASTM A463. Types B and D round pipe shall have a minimum yield strength of 50,000 psi.

The weight of zinc coating for Type A round pipe and "H" column shall not be less than 2.0 oz. per square foot of metal surface. For Type B round pipe the external coating shall be 1.0 oz. of zinc per square foot (±0.1), 30 ± 15 micrograms of chromate per square inch, plus 0.5 ± 0.2 mils of clear cross-linked polyurethane acrylic coating. The internal surface shall be coated with a zinc-rich based organic coating containing not less than 87% zinc powder and capable of providing galvanic protection. For Type D round pipe, the external and internal coating shall be commercially pure aluminum applied by the hot dip process before forming. The minimum weight of coating shall be 0.75 oz. per square of material (sum of both sides) triple spot test, 0.70 oz. per square foot of material (sum of both sides) single spot test, as measured in accordance with test method ASTM A428. The seam shall be electric resistance welded and the outside surface shall be scarfed and metallized with commercially pure aluminum to provide protection equal to that provided by the hot dipped coating. Type D posts to be placed in concrete shall have imbedded section coated with two coats of a tar based mastic conforming to M7.04.01. A 24 hour drying period shall be allowed between coatings. All posts shall be fitted with an approved top, so designed as to fit securely over the post and carry the top rail or cable. The base of the top fitting shall carry an apron around the outside of the post.

C. Top Rail, Cable and Spring Tension Wire.

1. Rail.

Steel top rails shall be tubular pipe, 1.66 in. O.D.:

a) Type A with a nominal weight of 2.27 pounds per linear foot in accordance with ASTM-A120, Schedule 40.

b) Type B with a nominal weight of 1.83 pounds per linear foot.

c) Type D with a nominal weight of 2.24 pounds per linear foot.

For zinc coated rails the weight of coating shall be a minimum of 2.0 oz. per square foot of metal surface. For aluminum coated rail the minimum weight of coating shall be 0.75 oz. per square foot of material (sum

of both surfaces), triple spot, 0.70 oz. per square foot of material (sum of both sides), single spot test in accordance with test method A428. Couplings or expansion sleeves shall be outside sleeve type and at least six inches long.

2. Cable.

Top tension cable shall be 3/8 in. diameter hot-dip galvanized, 7 strand steel cable conforming to ASTM-A475, Common Grade, Galvanizing shall be Class "A"

Cable Attachments.

Shoulder eye bolts shall be 5/8 in. diameter and of sufficient length to fasten to the type of posts used. Turnbuckles shall be of shackle end type, 1/2 in. diameter, with standard takeup of 6 in. and provided with 3/8 in. diameter pins. Thimbles shall be lightweight wire rope thimbles for use with 3/8 in. diameter cable.

Wire rope clips shall have a U-bolt diameter of 7/16 in. for use with 3/8 in. diameter cable. Anchor shackles shall be 3/8 in. diameter with a minimum distance between eyes of 11/16 in. and a pin diameter of 7/16 in. Seizing shall be 0.0181 in. diameter galvanized annealed iron wire.

3. Spring Tension Wire.

Tension wire shall be coil spring steel 0.1770 in. diameter. The base metal shall have a minimum tensile strength of 80,000 pounds per square inch, coated with 1.6 oz. of zinc per square foot of surface area, or with an aluminum coating applied at a rate of 0.40 oz. per foot of surface area.

D. Braces and Truss Rods:

Compression braces shall be the same type and size as top rail. Tension truss rods shall be 3/8 in. round rods with drop forged turnbuckles, or other approved type of adjustments. Galvanizing shall conform to the requirements of AASHTO-M232.

E. Fence Fabric.

The fabric shall consist of (0.148 in.) wire. It shall be woven into approximately 2 in. diamond mesh.

The width of the fabric shall be as specified or shown on current standard drawings. Chain link fabric shall be finished at top and bottom as shown on the standard drawings, with a "twisted and barbed" selvage. Barbing shall be done by cutting the wire on the bias.

1. Zinc-Coated Steel Fabric.

The base metal of the fabric shall be a good commercial quality of steel wire coated with prime western spelter or equal (AASHTO-M120) applied at the rate of not less than 2.0 oz. per square foot of uncoated wire surface either before or after weaving, with a minimum tensile strength of 80,000 pounds per square inch.

2. Aluminum-Coated Steel Fabric.

The base metal of the fabric shall be of steel wire having a minimum tensile strength of 80,000 pounds per square inch coated with aluminum alloy applied at the rate of not less than 0.40 oz. per square foot or uncoated wire surface.

F. Fabric Band and Stretcher Bars.

Fabric bands shall not be less than 1/8 in. × 3/4 in. in section and stretcher bars not less than 1/4 in. × 3/4 in. in sections. Galvanizing shall conform to requirements of AASHTO-M232.

G. Tie Wire.

Tie wire shall be zinc or aluminum coated 0.148 in. steel wire or aluminum alloy 1100-H14 ASTM-B211. Hog rings shall be zinc or aluminum coated 0.120 in. steel wire or aluminum alloy 6061 ASTM-B221.

Aluminum coated hog rings shall have a minimum coating of 0.24 oz. per square foot of aluminum.

Post clips for steel fence shall be zinc or aluminum 0.192 in. inch steel wire or aluminum alloy 1100 H14 ASTM-B211.

Aluminum coated post clips shall have a minimum coating of 0.30 oz. per square foot of aluminum.

Zinc coated articles shall be in accordance with AASHTO-M232.

H. Barbed Wire.

Barbed wire shall consist of two strands of 0.0985 in. inch diameter wire with 0.0800 in. inch diameter 4 point barbs approximately 5 in. apart. All wire shall be zinc coated with a minimum coating of 0.80 oz. per square foot of surface area on 0.0985 in. diameter wire and 0.65 oz. per square foot of surface area on 0.800 in. diameter wire.

Barbed wire Extension Arms shall be at an angle of approximately 45° and shall be fitted with clips or other means for attaching three lines of barbed wire, and with top outside wire approximately 12 in. horizontally from the fence line and the other wires spaced uniformly between the top of the fence fabric and the outside barbed wire.

I. Gates.

Gate frames shall be constructed of either zinc or aluminum coated steel of sizes and weights shown below. The corners of the gate frame shall be fastened together and reinforced with suitable fittings designed for the purpose, or they may be welded.

Single gate frames, 6 feet or less in width shall be 1.66 in. O.D. pipe either galvanized or aluminum coated steel conforming to Section C of this specification.

Single gate frames over 6 feet wide shall be either 1.90 in. O.D. galvanized or aluminum coated steel pipe conforming to Section B-1 of this specification.

Cross trussing shall be 3/8 in. galvanized iron adjustable rods.

Chain link fence fabric for filling the gage frame shall conform to Section E of this specification.

Each gate shall be furnished complete with necessary hinges, latch and drop bar locking device designed for the type of gate posts and gate used.

Gate sizes shall be as specified with the height conforming to the height of the fence.

J. Drive Anchors and Shoes.

Drive anchors shall be zinc coated steel angle iron or aluminum alloy 6061-T6 angle iron. Minimum dimensions shall be 1¼ in. × 1/8 in. The zinc coated steel shall have a minimum of 1.5 oz. of zinc per square foot of metal surface.

Shoes for drive anchors shall be zinc coated cast or malleable steel, or extruded aluminum alloy 6061-T6. The weight of zinc for galvanized specimens shall be 2.0 oz. per square foot of metal surface.

M8.09.1 Woven Wire Fence

Materials for this work shall conform to the following requirements:

A. Posts:

1. Steel line posts shall be 1⅝ in. by 1⅞ in. "H" column with a nominal weight of 2.70 lbs. per linear foot of good commercial grade steel.

2. Aluminum alloy line posts shall be 1⅝ in. by 1⅞ in. "H" column with a weight per linear foot of 1.03 lbs. (±5%). Aluminum alloy post shall conform to ASTM-B221, Alloy 6061-T6. Aluminum posts to be placed in concrete shall have the imbedded section coated with 2 coats of a tar-based mastic conforming to M7.04.01. A 24 hour hour drying period shall be allowed between coats.

3. End and corner posts shall be 2⅞ in. O.D. pipe conforming to either ASTM-A120, schedule 40 (if steel) or ASTM-B221. Alloy 6061-T6 and ASTM-B429 (if aluminum alloy). All steel posts shall be protected on all surfaces with 2 oz. of zinc coating per sq. ft. of metal surface. Aluminum alloy posts to be placed in concrete shall have the imbedded section coated with 2 coats of a tar-based mastic conforming to M7.04.01. A 24 hour drying period shall be allowed between coats.

B. Fence Fabric.

Fence fabric shall be 5 ft. high 2 in. by 4 in. rectangular mesh with top and bottom wires of 0.148 in. and a field of 0.120 in. and shall be zinc coated conforming to the requirements of ASTM-A116, class 3 or shall be aluminum coated as per ASTM-A491.

C. Gates.

Gates shall have a nominal width of 12 ft. and a minimum height of 59 in. Frames for gates shall be made from steel tubing not less than 1.31 in. outside diameter with a wall thickness of 3/32 of an inch.

The vertical brace shall not be less than 1 in. in diameter and the diagonal tie-rod shall be 3/8 in. in diameter.

All gate frame materials shall be zinc coated conforming to AASHTO-M181. The wire for gate frames shall conform to Section B of this specification.

The entire gate assembly, including fittings shall conform to the plans for Woven Fence Gates.

D. Fence Fasteners.

Post clips shall be 0.192 in. zinc coated steel, aluminum coated steel or aluminum alloy (ASTM-B211-Alloy 1100-H-14).

E. Concrete Bases.

Concrete for the bases shall be 4,000 psi, 1½ in. 565 cement concrete conforming to the requirements of M4.02.0 with the following additions:

1. Hand mixing shall be permitted.

2. It may be proportioned by volume, and when proportioned by Volume, 5% additional cement shall be added to the mix.

F. Drive Anchors and Shoes.

Drive anchors shall be zinc coated steel angle iron or aluminum alloy 6061-T6 angle iron. Minimum dimensions shall be 1¼ in. by 1½ in. by 1/8 in. The zinc coated steel shall have a minimum of 1.5 oz. of zinc per square foot of metal surface.

Shoes of drive anchors shall be zinc coated cast of malleable steel, or extruded aluminum alloy 6061-T6. The weight of zinc for galvanized specimens shall be 2.0 oz. per square foot of metal surface.

G. General.

Items manufactured from aluminum alloy shall conform to ASTM-B221, Alloy 6061-T6.

M8.09.2 Bonded Vinyl Coated Chain Link Fences, Posts, Rails, Fabric, Gates and Accessories.

The fence fabric shall have a bonded polyvinyl chloride (PVC) coating over zinc or aluminum coated steel. The weight of zinc coating on the steel wire shall be 0.3 oz. per square foot minimum. The weight of aluminum coating on the steel wire shall be 0.40 oz. per square foot minimum. The fabric shall consist of 9 gauge wire (0.148 in. outside diameter metal wire) ± 0.005 in. The wire gauge is the metal wire diameter and includes the metallic coating only, the PVC coating shall not be considered when determining wire size. The steel wire shall have a 75,000 pounds per square inch minimum tensile strength when tested in accordance with ASTM-A370.

The thickness of the PVC coating on the fabric wire shall be 0.007 in. minimum as determined by measuring the diameter of the coated wire, stripping off the coating, measuring the diameter of the stripped wire and dividing the difference by two. The PVC coated wire shall be woven into a 2 in. diamond mesh. The coating shall not crack, craze, or peel. The color of the PVC coated fabric and accessories shall be medium green unless otherwise specified by the Engineer.

End, corner and line posts, top rail, gates, truss rods, stretcher bars, tension bands, and expansion sleeves shall have dimensions and/or weights in accordance with M8.09.0. The bonded PVC coating shall be 0.007 in. minimum.

Tie wires, tension wires and clips shall have bonded PVC coating of 0.007 in. minimum. Tie wires and clips shall be 9 gauge (0.148 in.) or larger wire. Tension wire shall be 0.177 in.

Post caps, rail ends and other fittings and appurtenances shall be pressed steel or malleable iron, PVC coated by dipping, thermal fusion or any other method that meets the requirements of this specification. The PVC coating shall be 0.007 in.

M8.10.0 Steel Pipe Rail or Fence.

Materials for this work shall conform to the following requirements:

A. Rails and Posts.

Steel pipe for rails and posts shall conform to requirements of ASTM-A53, Grade B. Galvanized pipe ordered under this specification shall be coated with zinc inside and outside by the hot-dip process. The weight of zinc coating shall be not less than 2.0 oz. per sq. ft. of surface area.

B. Fittings.

All fittings shall be steel conforming to ASTM-A307. They shall be galvanized in accordance with ASTM-A153.

C. Lead Wool.

Lead wool for caulking shall be of standard manufacture and shall be approved for such use by the Engineer.

D. Bitumen.

Bitumen for use with pipe sleeves shall be approved for that use by the Engineer.

M8.10.1 Aluminum Pipe Rail or Fence.

Materials for this work shall conform to the following requirements:

A. General.

All materials shall be new and free from any surface coatings of paint or other materials. All castings shall be sound, free from blow-holes or other imperfections and have smooth surfaces.

B. Steel anchor bolts, nuts and washers shall conform to M8.01.5.

C. Stainless Steel screws shall conform to ASTM-A193, Grade B8.

D. Rails, posts and bases shall conform to ASTM-B221, Alloy 6061-T6, or Alloy 6351-T5.

E. Splices and clamp bars shall conform to ASTM-B221, Alloy 6061-T6.

F. Rivets shall conform to ASTM-B316, Alloy 6061-T6.

G. Aluminum washers shall conform to ASTM-B209, Alloy Alclad 2024-T4.

H. End plugs shall conform to ASTM-B26, Alloy S5A-F or SG 70 A-F.

I. Aluminum Screen Frame shall conform to ASTM-B221, Alloy 6061-T6.

J. Aluminum Screen Fabric shall conform to ASTM-B211, Alloy 6061-T94.

8.11.0 Bronze Self-Lubricating Bearing Plates.

The self-lubricating bronze plates shall conform to one of the following materials as called for on the design drawings:

A. Leaded Tin Bronze, conforming to the requirements of ASTM-B22, Alloy D modified to the extent that 1.5 to 2.5% lead will be required.

B. Tin Bronze, conforming to the requirements of ASTM-B22, Alloy B.

Finishes and Tolerances.

The surfaces of the bronze and steel plates which bear upon each other shall have a surface roughness not exceeding 125 micro inches when measured in accordance with American Standards Association B46.1 for surface roughness, waviness and lay. The lay of the tool marks shall be in the direction of expansion or contraction of the bridge.

The flat surfaces of the bronze and steel plates which bear upon each other shall be flat within 0.0005 in. per inch of length and width.

Bronze Bearing plates having radial convex surfaces shall have a negative tolerance of 0.010 in. maximum and a positive tolerance of .000 inches on the specified radius. Concave radial surfaces of steel bearing plates shall have a positive tolerance of 0.010 in. maximum and a negative tolerance of .000 in. on the specified radius.

Lubricated Recesses.

The recesses for the containment of the solid lubricant in the bronze bearing plates shall consist of annular rings or drilled holes with a minimum vertical wall depth of 3/16 in. The recesses shall be arranged in a geometric pattern in such a manner that each successive row shall overlap in the direction of motion. The entire area of all bearing surfaces which have provision for motion shall be lubricated by means of these lubricant filled recesses. The total area of these recesses shall comprise not less than 25% nor more than 35% of the total bearing area of the plate.

Lubricant.

The lubricant for filling the recesses shall be of the solid type and shall consist of graphite and metallic lubricants with a lubricating binder. The lubricant shall be compressed into the lubrication recesses by hydraulic pressure of at least five times the design unit loading as shown on the contract drawings to form a dense non-plastic insert which shall project not less than 0.010 in. above the surface of the bronze bearing plate.

Testing.

A self-lubricating bronze test plate measuring not less than 5 in. long by 5 in. wide shall be prepared and shall conform to one of the above materials and all other requirements of the specifications.

An assembly consisting of the fixed self-lubricating test plate and a movable steel plate shall be subjected to the design vertical unit loading specified in the contract drawing. The steel plate shall then be subjected to not less than 100 cycles of horizontal movement at a speed not to exceed 30 cycles per minute. Each cycle shall consist of a forward and return movement of not more than 1/2 in. in each direction. The recorded horizontal force divided by the recorded vertical force shall be established as the co-efficient of friction between the sliding surfaces.

The co-efficient of friction determined by the foregoing method shall not exceed 0.010. If the tests indicate a co-efficient of friction greater than 0.10, the entire lot of solid lubricant shall be rejected.

Where no inspection of materials is arranged for by the Party of the First Part and before such materials are incorporated into the work, the manufacturer of the bronze bearings will be required to certify that the bronze bearing material with lubricant. when tested as hereinbefore described, shall not have a co-efficient of friction greater than 0.10. Batches of solid lubricant that successfully meet the friction co-efficient requirements shall be properly identified by the manufacturer with a lot number and date marked "Approved for use on Commonwealth of Massachusetts projects".

Preparation of Mating Steel Plates.

The sliding surfaces of the mating steel plates shall be coated, just prior to installation, with a liquid lubricant recommended and furnished in sealed containers by the manufacturer of the bronze bearing plates.

Material Certifications.

Certified copies of the chemical analysis and physical properties of the bronze used in manufacturing of the bearing plates shall be supplied for each project.

Certifications shall be identified with the heat numbers of the bronze, solid lubricant lot numbers, and a statement that the solid lubricant used in the manufacture of the bronze bearing plates has successfully passed the test requirements of this specification.

M8.13.0 Bridge Railings, Aluminum, Types AL-1 & AL-3.

Materials used in the fabrication of aluminum bridge railings shall conform to the following requirements:

A. General.

All materials shall be new and free of paint or other materials. All castings shall be sound, free from blow-holes or other imperfections and have smooth surfaces.

B. Steel anchor bolts, nuts and washers shall conform to M8.01.5.

C. Stainless Steel screws shall conform to ASTM-A193, Grade B8.

D. Rails, posts and bases shall conform to ASTM-B221, Alloy 6061-T6, or Alloy 6351-T5.

E. Splices and clamp bars shall conform to ASTM-B221, Alloy 6061-T6, or Alloy 6351-T5.

F. Rivets shall conform to ASTM-B316, Alloy 6061-T6.

G. Aluminum washers shall conform to ASTM-B209, Alloy Alclad 2024-T4.

H. End plugs shall conform to ASTM-B26, Alloy S5A-F or SG70 A-F.

I. Aluminum Screen Frame shall conform to ASTM-B211, Alloy 6061-T94.

J. Aluminum Screen Fabric shall conform to ASTM-B211, Alloy 6061-T94.

M8.13.1 Bridge Railings, Steel, Types ST-1 & ST-3.

Materials used in the fabrication of steel bridge railings shall conform to the following requirements:

A. General.

Materials shall be new and free from any surface coatings of paint or other materials. All castings shall be sound, free from blow-holes or other imperfections and have smooth surfaces.

B. Steel anchor bolts, nuts and washers shall conform to M8.01.5.

C. Steel posts and base plates shall conform to ASTM-A441.

D. Steel pipe rails shall conform to ASTM-A53, Grade B.

E. Steel shims shall conform to ASTM-A441.

F. Woven wire fabric shall be No. 11 gauge galvanized steel and shall conform to AASHTO-M181.

G. Panels shall be galvanized in accordance with ASTM-A123.

H. Sheet lead shall conform to AASHTO-M112.

I. When steel bridge railing is galvanized in lieu of painting, the galvanizing shall conform to the requirements of ASTM-A123.

J. Galvanized areas that are damaged shall be thoroughly cleaned and given one coat of zinc rich paint conforming to M7.04.11.

M8.13.2 Metal Bin-Type Retaining Wall.

Metal sheets used in fabricating the retaining wall shall be of U.S. Standard Gauge thickness as specified on the plans, but no unit shall be formed from sheets thinner than 0.062 in. The base metal and spelter coating shall conform to the requirements of AASHTO-M218.

All bolts and nuts used in the erection of the wall shall be galvanized. Bolts shall have a diameter of 5/8 of an inch and a minimum length of 1¼ in., measured from the under side of the bolt head.

M8.14.0 Load Transfer Assembly.

A. Load transfer assemblies for transverse joints shall consist of slip-bars and a metal device so designed as to hold the slip-bars exactly and firmly in their correct positions during concreting operations. The complete assembly shall conform to the requirements and dimensions as shown on the plans or as approved by the Engineer.

B. The slip-bars shall be fabricated from either plain new billet steel of the grade designated or plain rail steel. They shall be free from burring or other deformations restricting slippage in the concrete.

C. One half the length of each slip-dowel bar of load transfer units shall be rendered bondless with a coat of either a graphite lubricant or a wax base grease.

1. The graphite lubricant shall consist of flake graphite mixed with a vehicle having quick drying characteristics. The graphite paste shall be thoroughly mixed and have the following composition (Percentage by weight).

	Minimum	Maximum
Pigment: (Flake Graphite)	55%	65%
Graphite Carbon	85%	
Passing No. 100 sieve	84%	92%
Passing No. 325	46%	50%
Vehicle	35%	45%

Vehicle shall consist of 52% fixed oils; remainder to be volatile thinners and driers.

To prepare lubricant for application, approximately 3 to 4 pounds of the graphite paste shall be placed in a suitable container and 40% by weight of 60/40 mixture of carbon tetrachloride and naphtha shall be added thereto. The resulting lubricant shall be thoroughly mixed.

2. The wax base grease shall be applied hot at temperatures of 170 °F to 190 °F. It shall conform to the following requirements:

a) Consistency, cone penetration at 77 °F	120-160
b) Melting point	140 °F (min.)
c) Stability	No separation at 200-210 °F for 1 hr.
d) Abrasives	Free from abrasives
e) Volatile matter (% by weight)	2% max. when heated at 210 °F ±3 °F for 1/2 hr.
f) Drying	Shall not dry in 14 days
g) Corrosion	There shall be no evidence of corrosion on steel.
h) Acidity (pH)	5 (min.)
i) Adhesion	Shall not slip, sag or drip at 130 °F
j) Removability	Shall be readily removable with a cleaning solvent

M8.15.0 Strand Chuck.

The chuck shall be of a design suitable for securely gripping high tensile strand steel without deformation or slippage. It shall be manufactured from a corrosion resistant steel alloy capable of withstanding repeated use and overload conditions in excess of the ultimate tensile strength of the strand without fatigue or failure. The surface body of the chuck shall be treated to increase corrosion resistance.

M8.16.0 Electrical Wire & Cable.

This specification covers all electrical wire and cable for traffic control devices, signals, highway lighting, signs and supports. Unless otherwise specified, all wire and cable herein are for copper conductors rated for 600 volts, all traffic signal cable conductors shall not be less than No. 14 AWG, solid or stranded and all conductors for mast arm wiring shall be not less than No. 16 AWG stranded.

M8.16.1 Type 1 Traffic Signal Cable (Installed above ground or in Duct).

Traffic signal cable shall be thermoplastic and conform to requirements of IMSA Specification 19-1.

M8.16.2 Type 2 Traffic Signal Cable (Installed above ground or in Duct).

Traffic signal cable shall be thermoplastic and conform to requirements of IMSA Specification 20-1.

M8.16.3 Traffic Signal Cable (Installed above ground).

Traffic signal cable shall be thermoplastic and conform to requirements of IMSA Specification 19-3 or 20-3.

M8.16.4 Type 4 Traffic Signal Cable (Installed above ground).

Traffic signal cable shall be thermoplastic and conform to requirements of IMSA Specification 19-4 or 20-4.

M8.16.5 Type 5 Traffic Signal Cable (Direct Burial).

Traffic signal cable shall be thermoplastic and conform to requirements of IMSA Specification 19-5 or 20-5.

M8.16.6 Type 6 Traffic Signal Wire (TFF or TEW).

Traffic signal head wire shall be color coded No. 18 AWG or larger conforming to requirements of UL Standard UL-62, "Flexible Cord and Fixture Wire" for TFF or TEW listed wire.

M8.16.7 Type 7 General Purpose Wire (RHH, RHW or XHHW).

General Purpose Wire shall conform to requirements of UL Standard UL-44 "Rubber-Insulated Wires and Cable."

M8.16.8 Type 8 Direct Burial Wire (USE).

Direct burial wire shall be insulated as specified for Type 8 and conform to requirements of UL Standard UL-854 "Service-Entrance Cables" for USE listed cable.

M8.16.9 Type 9 Special Purpose Wire (TW-THW-UF).

Special purpose wire shall be TW or THW conforming to requirements of UL Standard UL-83 "Thermoplastic-Insulated Wires" or UF conforming to the requirements of UL Standard UL-719 "Nonmetallic-Sheathed and Underground Feeder Cables" as specified.

M8.16.10 Type 10 Grounding and Bonding Wire (Solid or Standard, Insulated or Bare).

Ground and bonding wire shall be copper conforming to requirements of ASTM-B3 for soft or annealed copper wire, ASTM-B8 for stranded copper wire.

Where wire is provided with an individual covering, the covering shall be finished a continuous green color or a continuous green color with one or more yellow stripes.

M8.16.11 Shielded Loop Detector Lead-In Cable.

Two conductor No. 14 AWG, tinned copper stranded (19 × 27) conductors, polyethylene insulated (0.032 inches thick), conductors cabled, aluminum-polyester shield (100% shielding), No. 16 AWG stranded tinned copper drain wire. Chrome vinyl outer jacket (0.035) inches thick), nominal cable outside diameter 0.340 inches and conform to the requirements of IMSA specification 50-2.

M8.16.12 Type 12 Multi-conductor heavy duty portable power cord.

This material shall conform to the requirements of Underwriters Laboratories Standard UL-62, Flexible Cord and Fixture wire for Type 50, 600 Volt flexible cord.

M8.16.13 Type 13 Loop Detector Wire THHN with Tube.

Loop detector wire shall be PVC insulated, nylon jacketed, loose encased in a PVC or PE tube and conform to requirements of IMSA specification 51-5.

M8.17.0 Ground Rod.

Ground Rods shall be nominal 5/8 inch diameter (measured diameter shall not be less than .558 inch) by a minimum of 8 feet long copper bonded to steel rod, with bolt type clamps, conforming to the requirements of UL-467.

M8.18.0 Signal Posts.

Signal posts shall be 4 inch standard seamless steel pipe conforming to ASTM-A 53. Grade A or B. Interiors shall be coated as specified in Underwriters Laboratories UL-6 for enameled conduit, or aluminum conduit conforming to M5.07.1C.

M8.18.1 Octagonal Bases.

Octagonal Bases shall be cast iron conforming to AASHTO-M105 or cast aluminum alloy SG70A (ASTM-B26, B108).

M8.18.2 Pedestal Bases.

Pedestal Bases shall be made of not less than No. 10 Manufacturers Standard Gauge steel and galvanized after fabrication to meet the requirements of ASTM-A 123 or Cast Aluminum Alloy SG70A (ASTM-B26, B108).

M8.18.3 Aluminum Signal Posts & Bases.

Aluminum signal posts shall be tapered seamless tube aluminum alloy 6063 (ASTM-B221, B241, B429), having a minimum wall thickness of 0.156 inches. The posts shall taper from approximately 6 inches at the base to 4½ inches at the top. The post shall have a satin brush finish. The transformer base shall be of cast aluminum alloy SG70A (ASTM-B26, B108) and shall be provided with a means for grounding and a waterproof door for wiring purposes.

The post shall be wrapped for protection during handling and shipping. The base shall be capable of being mounted on a concrete foundation with a 12¾ inch bolt circle.

M8.18.4 Mast Arms.

Mast arms shall be made of aluminum or steel as specified.

A. Aluminum

1. Shaft — Aluminum alloy 6005-6061-6351-6063 (ASTM-B221, B241, B429).
2. Base flange — Aluminum alloy SG70A (ASTM-B26, B108).
3. Transformer base — Aluminum alloy SG70A (ASTM-B26, B108).
4. Arm — Aluminum alloy 6063 (ASTM-B221, B241, B429).
5. Shaft cap — Aluminum alloy SG70A or S5A (ASTM-B26, B108), or aluminum alloy 3003 (ASTM-B209).
6. Hardware — Stainless steel.
7. Anchor bolt covers — Aluminum alloy SG70A, SG100B or S5A (ASTM-B26, B85, B108), or aluminum alloy 3003 (ASTM-B209).

B. Steel

1. Shaft ASTM-A595 (55,000 psi min. yield strength); ASTM-A607, Grade 45 or ASTM-A572, Grade 65.
2. Base flange — ASTM-A181 or ASTM-A126, Class A or ASTM-A27, Grade 65-35 or ASTM-A36.
3. Transformer base — SAE-1020 or ASTM-A36.
4. Arm ASTM-595 (55,000 psi, min. yield strength) ASTM-A607, Grade 45; ASTM-53, Grade B ASTM-A36.
5. Shaft cap — ASTM-A126, Class A or aluminum alloy SG70A or S5A (ASTM-B26, B108) or aluminum alloy 3003 (ASTM-B209).
6. Hardware — Stainless steel or ASTM-A307 or ASTM-A325.
7. Anchor bolt covers — ASTM-A181 or ASTM-A27, Grade 65-35 or ASTM-A36 or ASTM-A126, Class A or aluminum alloy 3003 (ASTM-B209).
8. Galvanizing — ASTM-A123.

When a steel other than those listed above is proposed for use, the weldability of the steel and the welding procedure shall be established by the requirements prescribed by the Engineer prior to review of the material for approval.

M8.18.5 Steel Supports.

Tapered steel components shall be fabricated from steel conforming to the following requirements.

ASTM A595 (55,000 psi min. yield strength)

ASTM A607 Grade 45

Seamless steel pipe shall conform to ASTM-A53.

Hot-formed welded and seamless carbon steel, square, rectangular and special shape structural tubing shall conform to ASTM-A501.

Cold-formed welded and seamless carbon steel, round, square, rectangular and special shape structural tubing shall conform to ASTM-A500.

All other standard structural shapes shall conform to ASTM-A 36.

Gussets, flanges, baseplates, wing plates and connecting end plates shall be of steel plate conforming to ASTM-A36.

For baseplates that are more than 1 inch in thickness ASTM-A572, Grade 42 may be used.

Anchor bolts shall conform to Subsection M8.01.5.

All flange bolts, complete with hexagon nuts and washers, shall be of high strength steel conforming to ASTM-A193, Grade B-7 or ASTM-A325. The bolts and attached nuts shall be hot-dip galvanized conforming to ASTM-A153.

Truss and cantilever beam connections shall be furnished with the necessary beam support clamps. The ends of beams shall have a special mounting cleavis and closure plate fabricated from steel plate as an assembly. A matching clamp-on shall be furnished for each post.

All structural steel used for fabricating sign support structures shall be galvanized in accordance with ASTM-A123. Steel hardware shall be galvanized in accordance with ASTM-A153.

All damaged or scraped galvanized steel shall be spot primed with primer meeting the requirements of Subsection M7.04.11.

When a steel other than those listed above is proposed for use, the weldability of the steel and the welding procedure shall be established by requirements prescribed by the Engineer prior to review of the material for approval.

The diameter of the vertical main members of all sign supports shall not exceed 18 inches.

The wall thickness of all members of the sign supports shall be minimum of 1/8 inch for steel.

M8.18.6 Aluminum Supports.

Structural aluminum standard shapes shall conform to ASTM-B308, alloy 6061-T6. Extruded tubes, round or other than round, shall conform to ASTM-B221, Alloy 6061-T6 or Alloy 6063-T6. Tapered aluminum poles shall conform to ASTM-B221, Alloy 6063-T6.

Bolts, nuts and washers and all fastenings which are not aluminum or stainless steel shall be galvanized in accordance with ASTM-A153.

Anchor bolts for aluminum supports shall conform to the requirements of Subsection M8.01.5.

Anchor baseplates shall be aluminum alloy SG70A-T6 and shall conform to the requirements of ASTM-B108 "Aluminum Base Alloy Permanent Mold Castings."

The diameter of the vertical main members of all sign supports shall not exceed 18 inches.

The wall thickness of all members of the sign supports shall be a minimum of 5/32 inch for aluminum.

M8.19.0 Steel Sign Panels.

Steel Sign Panels, base metal and spelter coating shall conform to Federal Specification QQ-S-775c, Class D. The steel shall be galvanized at the rolling mill by the continuous process and the base metal shall be 0.078 inch thick.

M8.19.1 Aluminum Sign Panels.

Aluminum sign panels shall be fabricated from ASTM-B209, Alloy 6061-T6, (0.080 inches thick) with 3 inch minimum diameter amber reflectors affixed thereto.

M8.20.3 Modular Guidance Systems.

The MGS blade and base tail are manufactured from a glass fiber and marble reinforced thermosetting composite and shall conform to the following requirements:

A. MGS Blade (Nominal Values)	GSB-600
linear weight	0.88 lb./ft.
web thickness	0.100 in.
rail thickness	0.250 in.
width	6.030 in.
min. specific gravity	1.70
min. rail tensile strength	40,000 psi
min web tensile strength	25,000 psi
B. Flexible Base Rail (Nominal Values)	
linear weight	1.18 lb./ft.
width	5.75 in.
min. specific gravity	1.70
min. web tensile strength	25,000 psi
min. rib tensile strength	40,000 psi

C. Anchor Bolts

The approved base anchoring system shall consist of the following two styles listed by preferred application.

1. Adhesive System

Flush mounting anchor recommended for temporary installations.

Adhesive anchor shall consist of a two part adhesive composed of a vinylester or polyester resin with a hardening agent and an internally threaded metal sleeve. Anchor bolt shall be installed with lockwasher and 4 inch circular flat washer. The adhesive should be in a self-contained cartridge which mixes the two components as they are dispersed. The adhesive shall be Hilti HIT C-10 or approved equal.

2. Mechanical System

Stud mounting anchor recommended for permanent installations.

Mechanical anchor shall consist of stud type steel expansion anchor with two independent steel wedges. Anchors shall meet Federal Specification FF-S-325, Group II, Type 4, Class 1, for Concrete Expansion Anchors.

3. **Material Specifications**

Anchor	Component	Material	
Adhesive:	HCFA, 1/2″ × 2-1/1″ Sleeve	AISI 12L-14 Steel	Zinc Plated[1]
	Bolt, 1/2″ × 1¼″	Grade 5 Steel	Zinc Plated[2]
	Flatwasher, 4″	SAE 1005/1020	Zinc Plated[2]
	Lockwasher, 1/2″	Spring Steel	Zinc Plated[2]
	Adhesive	Poly or Vinyl Ester Resin	
Mechanical:	Expansion Anchor, 1/2″ × 3¾″	AISI 11L-41 Steel or AISI 304 S.S.	Zinc Plated[1]
	Flatwasher, 4″	SAE 1005/1020	Zinc Plated[2]
	Flatwasher, 1/2″	Type A ANSI-B 18.22.1 or AISI 304 S.S.	Zinc Plated[1]
	Lockwasher, 1/2″	Spring Steel or AISI 304 S.S.	Zinc Plated[2]
	Nut, 1/2″	ASTM A563 Grade A or AISI 304 S.S.	Zinc Plated[1]

[1]Zinc Plating ASTM B633, Sec. I, Type III
[2]Zinc Plating ASTM QQZ-325, Type II, Class II

4. **Strength Specifications**

Anchor	Ultimate Pullout Strength*	Ultimate Shear Strength*
Adhesive	4000 lbs.	3700 lbs.
Mechanical	4000 lbs.	3700 lbs.

Based upon 3000 psi concrete strength.
Blade pullout strength from bracket = 4000 lbs. min.
Bracket pullout strength from base rail = 1800 lbs. min.

D. Mounting Brackets and Hardware

The MGS Blade attachment assembly shall consist of two (2) angle brackets fastened to each blade with four (4) rivets, factory installed. The blade/bracket shall be fastened to the composite base rail with two (2) "T" bolts and nylon insert nuts.

Component	Material	
Bracket	304. S.S.	ASTM QQS-766
Rivet	303. S.S.	ASTM QQS-766
"T" Bolt, 3/8″ × 3/4″	Grade 5	Zinc Plated*
Nut, Nylon Insert, 3/8″	A563 Steel	Zinc Plated*
Lockwasher, 3/8″	Spring Steel	Zinc Plated*

Brackets shall conform to diagrams in the Department's Standards for Signs and Sign Supports.

*Zinc Plating Type II, Class II, ASTM QQZ-325

E. Weatherability

All thermosetting composites, (MGS blade and base rail) shall retain mechanical properties over a temperature range of −40 °F and +150 °F and show minimum degradation after 3,000 hours in a weatherometer.

M8.21.0 Stay-in-Place Bridge Deck Forms.

Stay-in-Place Bridge Deck Forms and supports shall be fabricated from steel conforming to ASTM Specification A446 (Grades A through E) having a coating class of G210 according to ASTM Specification A525.

SECTION M9
MISCELLANEOUS MATERIALS

M9.00.0 General.

All materials in this category shall be sampled and tested in accordance with the standard methods applicable to that particular material.

M9.01.0 Calcium Chloride.

Calcium Chloride shall conform to the requirements of AASHTO-M144, Type I or Type II.

M9.01.1 Sodium Chloride.

Sodium Chloride to be used for road purposes shall conform to the requirements of AASHTO-M143, except that the grading shall conform to the following:

Sieve	Percent Passing
3/8"	100
No. 4	82 Max.
No. 8	50 Max.
No. 30	7 Max.

M9.02.0 Herbicides.

These specifications cover chemicals used to destroy and/or control the growth of plants both indiscriminately (non-selective herbicides) and selectively (selective herbicides). Only those herbicides currently approved by the State Pesticide Board and the Department may be used.

M9.03.0 Insecticides.

These specifications cover chemicals to be used in the control of insects which are harmful to trees and desirable growth. Only those insecticides currently approved by the State Pesticide Board and the Department may be used.

M9.04.0 Curb and Edging.

All granite curb and edging shall be basically light gray in color, free from seams and other structural imperfections or flaws which would impair its structural integrity, and of a smooth splitting appearance. Natural color variation characteristic of the deposit from which the curbing is obtained will be permitted.

Whenever curbing is sawed, all surfaces that are to be exposed shall be thoroughly cleaned and any iron rust or iron particles removed by sand blasting or other approved methods satisfactory to the Engineer and any saw mark in excess of 1/8 inch shall be removed.

M9.04.1 Granite Curb.

The stones for the several types of granite curb shall be cut to the dimensions and curvature hereinafter stated:

Type	Minimum Length	Width at Top	Depth	Minimum Width at Bottom
VA1	6 feet	7 in.	17-19 in.	4 in. (for 2/3 length)
VA2	6 feet	7 in.	19-21 in.	4 in. (for 2/3 length)
VA3	6 feet	6 in.	19-21 in.	4 in. (for 2/3 length)
VA4	6 feet	6 in.	17-19 in.	4 in. (for 2/3 length)
VA5	5 feet	6 in.	See Plans	5 in. (for 2/3 length)
VB	3 feet	5 in.	15-17 in.	3½ in. (for 2/3 length)

Except for the three (3) following conditions, ten percent of the length of each type of VA curb installed on the project may consist of stones no more than 6 inches (6 ") shorter than the length specified in either table.

1. Stones used in making closures may be as much as one third shorter than specified in either table, except that for VA5 the closure piece shall have a minimum length of 4 feet.

2. Stones used in making closures on bridge decks at paraffin joints may have one piece, no less than 4 feet between any two paraffin joints or between one paraffin joint and the end of the run of curbing.

3. On curves with radii greater than 100 feet but less than 500 feet, type VA stones may be 4 feet to not more than 6 feet in length.

Type VA stones to be set on a radius of 100 feet or less shall be cut to the required curvature unless otherwise directed and except for making closures shall be of minimum lengths as follows:

Radius	Minimum Length
50 feet to 100 feet	6 feet
25 feet to less than 50 feet	4 feet 6 inches
Less than 25 feet	3 feet

Type VB stones to be set on a radius of 100 feet or less shall be cut to the required curvature unless otherwise directed.

All VB stones shall have a minimum length of 3 feet regardless of curvature.

The ends of all curved stones shall be cut on radial lines.

Finish

The finish and surface dimensions for the several types of curb shall conform to the following requirements:

A. Type VA Curb.

This type of curbstone shall have a top surface free from wind, shall be peen hammered or sawed to an approximately true plane, and shall have no projections or depressions greater than 1/8 inch. The front and back arris lines shall be pitched straight and true and there shall be no projection on the back surface for 3 inches down from the top which would exceed a batter of 4 inches in 1 foot, except on VA5 the back surface shall have no projection or depression greater than 1½ inches.

The front face shall be at right angles to the planes of the top and ends and shall be smooth quarry split, free from drill holes and with no projection of more than 1 inch and no depression of more than 1/2 inch measured from the vertical plane of the face through the arris or pitch line for a distance down from the top of 8 inches for types VA1 and VA4, 10 inches for VA2 and VA3, and the full depth of VA5. For the remaining distance there shall be no projection or depression greater than 1 inch measured in the same manner.

The ends of all stones shall be square with the planes of the top and face so that when the stones are placed end to end as closely as possible no space shall show in the joint at the top and face of more than 1/2 inch for the full width of the top and for 8 inches down on the face for Type VA1 and VA4, 10 inches for VA2 and VA3, and the full depth of VA5, after which the end may break back not over 8 inches from the plane of the joint. The arris formed by the intersection of the plane of the joint with the planes of the top and exposed faces shall have no variation from the plane of the top and exposed faces greater than 1/8 inch.

B. Type VB Curb.

This type of curbstone shall have a top surface free from wind, shall be pointed, peen hammered or sawed to an approximately true plane and shall have no projections or depressions greater than 1/4 inch. The front and back arris lines shall be pitched straight and true.

The front face shall be at right angles to the plane of the top, and shall be smooth quarry split, free from drill holes and with no projection of more than 1½ inches and no depression greater than 1 inch measured from the vertical plane of the face through the arris or pitch lines for the full depth of the face.

The ends of all stones shall be square with the planes of the top and face so that when stones are placed end to end as closely as possible no space shall show in the joint in the top and face of more than 1/2 inch for the full width of the top and 8 inches down on the face after which the ends may break back not more than 1 foot from the plane of the joint. On pieces less than 4 feet in length, the ends shall not break back more than 9 inches. The arris formed by the intersection of the plane of the joint with the planes of the top and exposed faces shall have no variation from the plane of the top and exposed faces greater than 1/8 inch.

M9.04.2 Granite Edgestone.

The stones for the several types of edging shall be cut to the dimensions given in the following table:

	Type SA	Type SB	Type SC
Minimum Length	3 feet	2 feet	1 foot
Maximum Length	6 feet	6 feet	6 feet
Thickness	5 in. to 8 in.	3 in. to 6 in.	3 in. to 6 in.
Width of Face	12 in.	11 in. to 13 in.	11 in. to 13 in.

When the edging is used on a curve of 160 foot radius or less the length shall be as directed by the Engineer except that where the edging is to be set on a radius of 10 feet the maximum length shall be 1 foot.

Finish.

Type SA Edging.

The exposed face shall be smooth quarry split to an approximately true plane having no projections or depressions which will cause over 1 inch to show between a 2-foot straight-edge and the face when the straight-edge is placed as closely as possible on any part of the face.

If projections on the face are more than that specified they shall be dressed off. The top and bottom lines of the face shall be pitched off to a straight line and shall not show over 1/2 inch between stone and straight-edge when straight-edge is placed along the entire length of the top and bottom lines and when viewed from a direction at right angles to the plane of the face, and for the top line only not over 1/2 inch when viewed from a direction in the plane of the face. The ends shall be square to the length at the face and so cut that when placed end to end as closely as possible no space shall show in the joint at the face of over 3/4 inch, except that where the edging is to be used on a curve having a radius of 10 feet or less the ends of the stones shall be so cut as to provide a finished joint at the face of not more than 1/2 inch. The arris formed by the intersection of the plane of the face with the plane of the end joint shall not vary from the plane of the face or the plane of the joint more than 1/4 inch. Drill holes may show on the exposed face but only along the bottom edge. The sides shall not be broken under the square more than 4 inches and the side adjacent to the grass shall not project over 1 inch.

Type SB Edging.

The exposed face shall be smooth quarry split to an approximately true plane having no projections or depressions which will cause over 1 inch to show between a 2 foot straight-edge and the face when the straight-edge is placed as closely as possible on any part of the face.

If projections on the face are more than that specified they shall be dressed off. The top and bottom lines of the face shall be pitched off to a straight line and shall not show over 1 inch between stone and straight-edge when straight-edge is placed along the entire length of the top and bottom lines and when viewed from a direction at right angles to the plane of the face, and for the top line only not over 1 inch when viewed from a direction in the plane of the face. The ends shall be square to the length at the face and so cut that when placed end to end as closely as possible, no space shall show in the joint at the face of over 1 ½ inches, except that where the edging is to be used on a curve having a radius of 10 feet or less the ends of the stones shall be so cut as to provide a finished joint at the face section of not more than 1/2 inch. The arris formed by the intersection of the plane of the face with the plane of the end joint shall not vary from the plane of the face more than 1/4 inch. Drill holes not more than 3 ½ inches in length and 1/2 inch in depth will be permitted. The sides shall not be broken under the square more than 4 inches and the side adjacent to the grass shall not project over 1 inch.

Type SC Edging.

The exposed face shall be smooth quarry split to an approximately true plane having no projections or depressions which will cause over 1/2 inch to show between a 2 foot straight-edge and the face when the straight-edge is placed as closely as possible on any part of the face. If projections on the face are more than that specified they shall be dressed off. The top and bottom lines of the face shall be pitched off to a straight line and shall not show over 1 inch between stone and straight-edge when straight-edge is placed along the entire length of top and bottom lines and when viewed from a direction at right angles to the plane of the face, and for the top line only, not over 1 inch when viewed from a direction in the plane of the face. The ends shall be square to the length at the face and so cut that when placed end to end as closely as possible no space shall show in the joint at the face of over 1 ½ inches, except that where the edging is to be used on a curve having a radius of 10 feet or less the ends of the stones shall be so cut as to provide a finished joint at the face of not more than 1/2 inch. The arris formed by the intersection of the plane of the face with the plane of the end joint shall not vary from the plane of the face more than 1/4 inch. Drill holes not more than 3 ½ inches in length and 1/2 inch in depth will be permitted. The sides shall not be broken under the square more than 4 inches and the side adjacent to the grass shall not project over 1 inch.

M9.04.4 Field Stone Masonry.

Stone for field stone masonry shall consist of sound durable blasted or field stone free from seams, cracks and other structural defects and of an approved and satisfactory quality and shape.

The stone shall have straight edges without re-entrant angles. The faces shall be flat but not necessarily rectangular in shape.

Individual stone shall have, when set in the wall, no face dimension less than 8 inches. Stretchers shall have a depth in the wall at least 1 ½ times the rise, and a length on the face at least twice the rise. Headers shall have a length on the face at least equal to the rise. Headers shall hold in the heart of the wall the same size as shown on the face and shall extend at least 12 inches more than the stretchers into the backing.

When Field Stone Masonry in Cement Mortar is specified, mortar shall conform to the requirements of Subsection M4.02.15.

M9.04.5 Granite Curb Inlets.

The granite for curb inlet shall conform to M9.04.0. It shall have a horizontal bed and the top shall be free from wind. The stone shall be sawn or peen hammered on top and the front and back edges shall be pitched true to line. The back face for a distance of 3 inches down from the top shall have no projection greater than 1 inch. The front face shall be straight split, free from drill holes, and it shall have no projection greater than 1 inch or depresion greater than 1/2 inch for a distance of 10 inches down from the top, and for the remaining distance there shall be no depression or projection greater than 1 inch. The ends shall be squared with the top for the depth of the face finish and so cut that the curb inlet can be set with joints of not more than 1/2 inch.

The granite curb inlet shall be 6 feet in lenght, plus or minus 1/2 inch, from 17 to 19 inches in depth, 6 inches wide at the top and at least 6 inches wide at the bottom.

Curb inlets to be set on a radius of 160 feet or less shall be cut to the curve required, unless otherwise directed by the Engineer. The joints of all curved curb inlets shall be cut on radial lines.

A gutter mouth at least 3 inches in depth and at least 2 feet in length shall be cut in the front face of the stone as shown on the plans.

Granite curb inlets shall match the adjacent curbing in color.

M9.04.6 Granite Curb Corners.

The granite for curb corners shall conform to M9.04.0 and shall have horizontal beds. They shall match the adjacent curbing in size, color and quality. The front arris lines shall extend through 1/4 of a circle having a radius of 2 feet or 3 feet respectively for Type A or Type B Curb Corner. The back arris line shall be straight. The plane of back shall be normal to top.

M9.04.8 Granite Bounds.

Granite bounds shall be of sound granite, the top and bottom faces parallel and the front and back shall be straight split. The bounds shall be cut to the dimensions shown on the plans and shall be plain or lettered as indicated on the plans or as directed.

The stone shall be pointed on the top and on three sides and hammer dressed on the face for a distance of not less than 12 inches below the top. The top shall be 6 inches square and shall have a drill hole in the center 1 ½ inch in depth and 1/2 inch in diameter, with the bottom somewhat flared.

M9.04.9 Dry Stone Masonry.

Stone for dry stone masonry shall be hard and durable and free from seams or other imperfections and of an approved quality and shape. No stone shall be less than 6 inches in its least dimension. The stone shall be roughly square on joint beds and faces.

M9.05.0 Lumber and Wood Sheeting.

Lumber and Wood Sheeting shall be sound Spruce, Douglas fir, white or yellow Lodgepole or Ponderosa pine, or western hemlock plank, planed on one side and either tongue and grooved or splined. Lumber sheeting shall not be less than nominal 4 inches thick. Wood sheeting shall not be less than nominal 2 inches thick.

M9.05.1 Treated Timber.

Treated timber shall meet AASHTO M133 except that only material meeting current EPA or DEQE regulations will be allowed.

The properties of the timber selected for preservative treatment shall conform to the requirements of AASHTO M168, Structural Timber, Lumber, and Piling.

M9.05.2 Wood Posts and Braces.

Wooden posts shall be round, well seasoned, straight, sound, cedar, oak, spruce or other approved wood not less than 4 inches in diameter, after the bark is removed. Timber braces shall be 4 inches square in

cross section. The posts and braces shall be wholly treated with an oil-borne preservative conforming to the requirements of AASHTO-M133, Type C, Retention of the pentachlorophenol solution shall be at the rate of 6 pounds per cubic foot of wood.

M9.05.3 Wooden Rails and Posts.

Fences shall consist of wooden rails, braces and posts constructed as shown in the Department Standards.

Post for permanent barrier fences shall be select structural Douglas Fir or select structural spruce, well-seasoned, straight-grained, sound, planed on all sides and of the dimensions shown on the plans. Rails and braces shall be select structural longleaf yellow pine or select structural Douglas Fir well-seasoned, straight-grained, sound, planed on all sides and free from loose and unsound knots.

Post, rails and braces for portable barrier fences shall be select structural Douglas Fir or select structural longleaf yellow pine, well-seasoned, straight-grained, sound, planed on all sides and of the dimensions shown on the plans.

M9.05.4 Wooden Pegs.

Wooden pegs shall be wedge shaped and approximately 1″ × 2″ at the butt end and 10 inches or more in length as may be required.

M9.05.5 Timber Preservatives.

Timber preservatives shall conform to the requirements of AASHTO-M133. The method of treatment shall conform to American Wood-Preservers Association Standards C1, C2 and C3.

M9.05.6 Timber Piles.

A. General Requirements.

Timber piles shall conform to the requirements of ASTM-D25 and shall be cut from sound and live trees, preferable during the winter season. Piles shall be free from any defects which will impair their strength or usefulness for the purpose intended or that will prevent proper driving.

Unless otherwise specified, untreated timber piles shall have the bark unpeeled. Treated timber piles shall be clean-peeled so that all of the outer bark and at least 80% of the inner bark well distributed over the outer surface of the pile shall be removed. In order to obtain proper preservative treatment, no strips of inner bark wider than 1/2 inch shall remain.

All piles shall be cut above the ground swell, shall have a uniform taper from butt to tip end, and shall be free from short kinks. Knots or blemishes shall be trimmed off close and even with the body of the pile. A line from the center of the butt to the center of the tip must lie wholly within the body of the pile.

B. Inspection.

All piles will be subject to inspection before or after shipment to the site, or both, at the option of the Engineer. Any pile that does not conform to all the requirements will be rejected.

C. Specific Requirements.

The kind of timber to be used for treated piles will be Southern Yellow Pine or Douglas Fir and shall be treated in accordance with AWPA Standard C3 for C.C.A. All piles for which treatment is specified shall have not less than 1 inch of sapwood at the butt end for Douglas Fir and a 2-inch ring of sapwood at the butt end for Southern Pine.

Untreated piles shall be new spruce, oak, Douglas Fir, yellow pine, or any other species, subject to the approval of the Engineer, which will withstand the specified driving without injury.

Butt and tip dimension for various lengths of piles shall be as set forth in the following table:

Length	Minimum Dimension 3 Feet from Butt	Minimum Tip Dimension
Up to 40 feet	12 inches	8 inches
40 feet and up to 50 feet	12 inches	7 inches
50 feet and over	13 inches	6 inches

For all piles the maximum dimension 3 feet from the butt shall be 20 inches. Measurements are under the bark in all cases. Where the piles are to support a concrete cap, the maximum butt dimensions shall be 6 inches less than the designated width of the concrete cap.

Where piles are to be in line in a bent, all piles in the bent shall be of uniform size to permit the proper fastening of the bracing. Cutting of piles to accommodate the bracing will not be permitted.

D. Preservative Treatment.

Preservative treatment, when specified, shall conform to Subsection M9.05.5.

M9.06.0 Waterproof Paper Covers.

Waterproof paper covers shall conform to the requirements of AASHTO-M171. The name of the manufacturer shall be marked or imprinted clearly on the paper for proper identification.

M9.06.1 Polyethylene Covers.

A. Black Polyethylene Sheeting.

Black polyethylene sheeting suitable for use in covering storage piles of bulk or bag salt, or sand piles which have been blended with salt shall meet the requirements of NBS Product Standard PS-17.

The covers shall be 8 mils (.008 in.) in thickness, black in color and contain suitable inhibitors to prevent deterioration due to sunlight and heat.

The sheeting shall be 40 feet in width and 100 feet in length. It shall be folded when packaged into rolls, so that the shipping width is not greater than 10 feet.

B. White Polyethylene Sheeting.

This material shall conform to the requirements of AASHTO-M171.

C. Reinforced Polyethylene Sheeting.

Reinforced Polyethylene Covers for stockpiles of salt and treated sand shall be reinforced with non-woven nylon or rayon cord, shall have a minimum tear strength of 110 lbs. in all directions, and shall weigh no less than 20 lbs. per 1,000 sq. ft. They shall be black in color. The material shall be free from any additive which would reduce its resistance to water penetration or adversely affect the durability of the film. The covers shall contain suitable inhibitors to prevent deterioration due to sunlight and heat. They shall be 40 feet in width and 100 feet in length. They shall be folded when packaged into rolls, so that the shipping width is not greater than 10 feet.

M9.06.2 Tar Paper.

Tar impregnated felted paper shall conform to the requirements of ASTM-D227.

M9.06.3 Burlap.

Burlap shall conform to the requirements of AASHTO-M182, Class 3. It shall not have been used as a container for sugar or other substances deleterious to concrete and shall be in good condition, free from holes, tears, or other defects that would render it unsuitable for curing concrete. It shall be furnished in strips not less than 3 feet nor more than 6 feet in width and not more than 2½ feet longer than the width of the pavement slab.

M9.06.4 Polyethylene Coated Burlap.

This material shall conform to the requirements of AASHTO-M171, White Burlap-Polyethylene Sheet.

M9.06.5 Impervious Liquid Membrane.

This material shall consist of an impervious liquid conforming to the requirements of AASHTO-M148, Type 1 or 2. When tested in accordance with AASHTO-T155, the liquid membrane forming compound shall restrict the loss of water present in the test specimen at the time of application of the curing compound to not more than 0.055 grams per square centimeter of surface after 3 days. When Type I is specified, it shall contain a fugitive dye.

M9.07.0 Plastic Waterstops.

Waterstops shall be fabricated from a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain any additional resins, plasticizers, inhibitors or other materials such that when compounded it shall meet the performance requirements hereinafter specified. No reclaimed polyvinyl chloride shall be used.

Waterstops shall be extruded in such a manner that any cross section shall be dense, homogenous and free from porosity or other imperfections. The cross section of waterstops shall be as shown on Department Standard Sketches.

Physical Requirements.

The waterstops shall meet the following requirements:

1. Tensile Strength, Die C, ASTM-D412	Min. 2000 psi
2. Ultimate Elongation, Die C, ASTM-D412	Min 250%
3. Cold Bend Test (See Appendix I)	No Cracking
4. Impact Resistance (See Appendix II)	No Cracking
5. Resistance to Alkalis (See Appendix III)	No Cracking
Increase in weight after 7 days	Max. 0.25%
Increase in weight after 30 days	Max. 0.40%
Decrease in weight after 7 days	Max. 0.10%
Decrease in weight after 30 days	Max. 0.30%
Change in dimensions after 30 days	Max. 1.00%
6. Hardness Durometer (Shore A) ASTM-D2240	75 ± 5
7. Water Absorption (48 hours) ASTM-D570	Max. 0.5% (by weight)

General Requirements.

The waterstops shall be spliced only at jointing made necessary by construction design.

Where joints are required, they shall be made in accordance with the manufacturer's instructions, without appreciable loss in strength, elasticity or permeability of the material.

The waterstop material shall be practically impervious to water and unaffected by most common acids, alkalis, sea water and mineral oils. The material shall be such that it will not engage in electrolytic action with steel, and will not discolor concrete.

The approved waterstop when properly installed, as in a concrete construction or expansion joint, shall be capable of maintaining a head of 75 feet of water without leakage.

Qualification Samples.

A manufacturer requesting approval of a waterstop shall furnish to the Research and Materials Section, 99 Worcester Street, Wellesley Hills, Massachusetts 02181, a 3 foot length of each type of waterstop he intends to supply and a certificate of analysis shall be furnished with the samples. The certificate shall state that the material furnished conforms without exception to all the requirements specified herein; and shall also include all qualitative and quantitative test results.

M9.08.0 Preformed Sheet Membrane.

Only products pre-approved by the Department will be accepted for use. Chemical composition, physical properties and dimensional requirements of the sheet membrane shall conform to the manufacturer's specifications for the material.

Also, all accessory materials; such as, flashing, primer, etc., used in the application of the sheet membrane will be considered a part of this specification and shall conform to the manufacturer's requirements.

M9.09.0 Bentonite Waterproofing System.

Bentonite waterproofing system shall consist of a biodegradable corrugated kraft paper panel with flutes filled with sodium bentonite and ends sealed. The system shall also include trowel grade bentonite and protection board when necessary.

Panels shall meet the following specifications:

Bentonite content	1 lb. per square foot minimum
Panel thickness	3/16 in.
Panel dimensions	4 feet × 4 feet
Panel weight	18 lbs. minimum

Bentonite shall be pure, high swelling Wyoming sodium montmorillonite. The gel volume shall be 10 to 15 times dry volume and the swelling action shall be indefinitely reversible. The granular bentonite shall pass 90% through a 20 mesh sieve and less than 10% through a 200 mesh sieve. Mineralogical composition is 90% minimum montmorillonite with a 10% maximum native sediments of feldspars, mica, and unaltered volcanic ash. Proximate chemical analysis is silica 60%, alumina 20%, iron oxides 5%, magnesia 3%, soda 3% and lime 1%. It shall contain chemically bound water of 6% with minor of 2%.

When a joint seal is necessary it shall be bentonite hydrated to partial gel strength. In sub-freezing weather use a gel with glycol added.

The protection board (where required) shall be a puncture resistant 48″ × 48″ × 1/16″ multi-layer flexible board composed of pressure bonded cellulose fibers weighing approximately 17 lbs. per 100 square feet. Typical puncture resistance: 132 inch pounds, typical Mullen Burst Strength: 168 psi.

M9.10.0 Jointing Materials for Pipes.

A. Jute or oakum furnished for use in pipe joints shall be of an accepted grade approved for common usage.

B. Mortar shall conform to the requirements of Section M4.02.15.

C. Rubber ring or plastic gaskets, shall be of tough, flexible, chemical-resistant material, and of such size and shape as to ensure satisfactory pipe joints when incorporated in the work and shall conform to ASTM-C443.

D. Mechanical joints shall conform to the requirements of the ASA Specifications A21.11.

E. The yarning material for cast iron bell-and-spigot pipe joints shall be sterilized braided hemp or untarred twisted jute, clean and dry and free from oil, grease, or any other deleterious matter.

F. Clay pipe may also be joined using pipe having factory-cast mating collars of bituminous or plastic-resilient materials. These collars shall be of approved bituminous materials with demonstrated ability to make tight joints, of plastic-resilient materials conforming to ASTM-C425. Prior to jointing, bituminous joints shall be treated with a satisfactory non-oily solvent; plastic-resilient joints shall be treated with a satisfactory lubricant-adhesive, each supplied by the manufacturer.

M9.11.0 Insulation and Waterproof Jackets.

Where water pipe is installed or hung on structures, it shall be covered with insulation conforming to the following requirements:

The insulating material shall be fiberglass, cellular glass, expanded polystyrene, or urethane, and shall be covered with a waterproof jacket as specified. Section lengths and thickness shall depend on the pipe size and the recommendations of the insulation manufacturers. Under no conditions shall the minimum total thickness be less than 3 inches, except when urethane is the insulating material and then the total thickness shall be no less than 2 inches. Unless the type of insulating material is specified the Contractor may use any one of the foregoing. However, only one type of insulating material shall be used throughout an installation.

M9.11.1 Cellular Glass.

Cellular glass insulation shall conform to the requirements of Federal Specification, HH-1-551, Insulation Block and Pipe Covering, Thermal Cellular Glass or revisions thereof.

The following installation accessories shall be part of this specification:

a) Stainless steel strapping, 3/4″ × 0.015″ and stainless steel clips.

b) Asphalt coated glass fabric, 20 × 20 mesh conforming to M3.06.1.

M9.11.2 Fiberglass.

Fiberglass insulation shall conform to the requirements of Federal Specification, HH-1-562, Insulation, Thermal, Mineral Wool, Block or Board and Pipe Insulation (Molded Type) Type II, Class 2 and 3, or revisions thereof.

The following installation accessories shall be part of this specification:

a) One inch galvanized wire netting.

b) Corrugated aluminum jacket, 0.02 inch thick.

M9.11.3 Polystyrene.

Expanded polystyrene insulation shall conform to the requirements of Federal Specification, HH-1-524, Insulation Board, Thermal, Type I, Class 2 or revision thereof.

The following installation accessories shall be part of this specification:

a) Stainless steel strapping, 3/4″ × 0.015″ and stainless steel clips.

b) Corrugated aluminum jacket, 0.02 inch thick with integral vapor barrier.

c) A suitable polystyrene adhesive.

d) Asphalt coated glass fabric, 20 × 20 mesh conforming to M3.06.1.

M9.11.4 Urethane.

Urethane insulation shall conform to the requirements of Federal Specification, HH-1-00530, Insulation Board, Thermal (Urethane), Type II, Class 2 or revisions thereof.

The following installation accessories shall be part of this specification:

a) Stainless Steel Strapping 3/4″ × 0.015″ and stainless steel clips.

b) Corrugated aluminum jacket 0.02 in. thick with integral vapor barrier.

c) A suitable urethane adhesive.

d) Asphalt coated glass fabric, 20 × 20 mesh conforming to M3.06.1.

M9.11.5 Waterproof Jackets.

Waterproof jackets for covering insulation on water pipes shall be assembled as specified from any of the following materials or combinations thereof.

a) Asphalt coated glass fabric, 20 × 20 mesh conforming to M3.06.1.
b) Stainless steel strapping, 3/4″ × 0.015″ and stainless steel clips.
c) One inch galvanized wire netting.
d) Corrugated aluminum jacket, 0.02 inch thick.
e) Corrugated aluminum jacket, 0.02 inch thick with integral vapor barrier.
f) A polystyrene adhesive.
g) A urethane adhesive.

M9.12.0 Reflectors for Barriers.

An oversized yellow reflectorized cluster, diamond shape 24″ × 24″, and a 28″ × 22″ × 3/4″ thick plywood panel shall be bolted onto barrier as directed.

The yellow reflectorized cluster (Type H1-2) shall conform to the requirements of Section 2D of the Department's "Manual on Uniform Traffic Control Devices" and the approved standard detail sheets. Copies of these items are available upon request to the Department's Research and Materials Division.

The 28″ × 22″ panel shall be 3/4″ exterior type (Grade A-A, Commercial Standard PS-1).

M9.13.0 Hydrated Lime.

Hydrated Lime shall consist of a minimum of 95% calcium and magnesium oxides, pulverized so that at least 99.5% will pass a No. 30 sieve and at least 85% pass a No. 200 sieve.

M9.14.0 Preformed Expansion Joint Filler.

This specification covers nonextruding and resilient non-bituminous types of preformed expansion joint fillers and shall conform to AASHTO-M153.

M9.14.1 Preformed Compression Joint Seals (Bridges).

This specification covers the materials requirements for preformed polychloroprene elastomeric joint seals for bridges. The seal consists of a multiple-web design composed of polychloroprene and functions only by compression of the seal between the faces of the joint with the seal folding inward at the top to facilitate compression. The seal is installed with a lubricant adhesive and is designed to seal the joint and reject incompressibles. The compression seal and the lubricant-adhesive shall conform to AASHTO-M297.

M9.14.3 Polyurethane Joint Sealer.

This specification covers the requirements for a cold applied, two component, elastomeric joint sealing compound suitable for use as a joint sealer and/or caulking compound on joints in portland cement concrete or steel surfaces. This material shall meet Federal Specification TT-C-00227E, Type I, Class A.

M9.14.4 Polyurethane Joint Sealer, Non-Sag.

This specification covers the requirements for a cold applied, single component elastomeric joint sealing compound for sealing, caulking vertical joints on bridges and other structures. This material shall meet Federal Specification TT-C-00230, Type II, Class A.

M9.14.5 Elastomeric Bridge Bearing Pads.

Elastomeric bearing pads includes plain bearings (consisting of elastomer only) and laminated bearings (consisting of layers of elastomers restrained at their interfaces by bonded metal laminates). The type of bearing (plain or laminated), durometer, and dimensions will be as specified on the plans. The elastomer portion of the elastomeric compound shall be 100% virgin chloroprene (neoprene) meeting the requirements of Section 25 of the AASHTO Standard Specifications for Highway Bridges.

M9.15.0 Liquid Penetrant/Sealant.

Liquid penetrant/sealant for portland cement concrete surfaces used to protect concrete surfaces from chloride intrusion shall be a material previously approved by the Department for the purpose intended and listed on the Qualified Product Listing maintained by Research and Materials Section.

M9.16.0 Sheet Lead Bearing Pad.

Sheet lead shall be 1/8 inch thick and shall conform to AASHTO-M112, common desilverized lead.

M9.16.1 Rubber-Cotton Duck Bearing Pad.

The bearing pads shall be manufactured of all new (unused) materials and composed of multiple layers of prestressed duck, 8.1 ounce per net square yard, duck warp count 50±2 threads per inch and filling count 40± threads per inch, 64 plies per inch of finished pad thickness, impregnated and bound with a high quality rubber compound, containing rot and mildew inhibitors and anti-oxidants, compounded into resilient pads of uniform thickness.

The pads shall withstand compressive loads perpendicular to the plane of laminations of not less than 10,000 psi before breakdown. Load deflection properties in accordance with procedures of MIL-C-882 shall be the following maximum percentages of total pad thickness: 10% at 1000 psi, 15% at 2000 psi. When loaded to 1500 psi, permanent set as load is removed in accordance with procedures of MIL-C-882 shall be a maximum of 2.5% of the original "zero point" thickness. Shore Durometer shall not be less than 85 nor more than 95. The ratio of lateral expansion to vertical deflection shall not exceed 0.25 when loaded to 1500 psi. The material shall not lose effectiveness throughout a temperature range of −65 °F to +200 °F. No visual evidence of damage or deterioration by environmental effects of sunshine, humidity, salt spray, fungus, and dust in accordance with MIL-E-5272. Thickness shall be as shown on drawings within tolerances of ±5%.

M9.16.2 Moulded Fabric Bearing Pad.

The preformed pads shall consist of a fabric and rubber body.

The pad shall be made with new unvulcanized rubber and unused fabric fibers in proper proportion to maintain strength and stability.

The surface hardness expressed in standard rubber hardness figures shall be 80 Shore A Durometer ± 10 durometer average, the ultimate breakdown limit of the pad under compression loading shall be no less than 7,000 lbs. per square inch for the specified thickness without extrusion or detrimental reduction in thickness.

The pads shall be furnished to specified dimensions with all bolt holes accurately located.

M9.30.0 Reflective Sheeting.

Reflective sheeting shall meet the requirements of AASHTO-M268.

This specification covers flexible, retroreflective sheeting designed to reflectorize traffic control signs, delineators, barricades and other devices.

Types:

Type II — Engineer Grade
Type III — High Performance
Type IV — Flexible High Performance

M9.30.3 Acrylic, Prismatic Reflectors and Embossed Aluminum Frames for Signs.

Shall meet the requirements of AASHTO M-290.

M9.30.4 Acrylic Plastic 3¼ in. Diameter Center-Mount Reflector (Type A).

A. General Description.

The reflector shall consist of a hermetically-sealed optical system having an appropriate backing and a metal grommeted central mounting hole.

B. Detailed Specifications.

B.1 Optical System:

The optical system shall consist of a round, clear and transparent acrylic plastic face with a reflective area of not less than 7 square inches (herein referred to as the lens) and any additional reflective media if necessary to meet the optical requirements specified hereinafter. The unit shall be so fused about its peripheral areas and central mounting hole to provide an optical system permanently sealed against dust, water and water vapor. The reflector lens shall be colorless, amber or red.

The lens shall consist of a smooth front surface free from projection or indentations other than a central mounting hole and identification, with a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

B.2 Backing and Grommet.

The optical system shall have a backing .020 in. thick aluminum ASTM B209 Alloy 5052-0. The backing shall be embossed with circular ribs (aluminum type) or other deformed design for reinforcement and shall be fastened about the peripheral edges and center mounting hole to form a single reflector unit. The center mounting hole shall be fixed with an expanded aluminum grommet of such size to accommodate a 3/16 in. diamter fastener of 3/16 in. aluminum ASTM B211. Alloy 2.024-74 bolts or cadmium plated button head steel bolts with vandal proof nut.

C. Optical Requirements:

C.1 Definitions.

Entrance Angle shall mean the angle at reflector between direction of light incident on it and direction of reflector axis.

Observation Angle shall mean the angle at reflector between observer's line of sight and direction of light incident on reflector.

Specific Intensity shall mean candlepower returned at the chosen observation angle by a reflector for each foot-candle of illumination at the reflector.

C.2 Specific Intensity.

The specific intensity of each reflector intended for use in delineators or markers shall be equal to or exceed the following minimum values regardless of reflector orientation. Failure to meet the specific intensity minimum shall constitute failure of the reflector being tested; failure of any reflectors out of 50 subjected to test shall constitute failure of the lot.

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candlepower Per Foot Candle Crystal	Yellow	Red
0.1	0	119	71	29
0.1	20	47	28	11
1/3	0	20	12	5
1/3	20	8	5	2

C.3 Optical Testing Procedure.

The reflex-reflector to be tested shall be located at a distance of 100 feet from a single light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photoelectric photometer having a minimum sensitivity of 1×10^{-7} foot candles per mm scale division. The photometer shall have a receiver aperture 0.5 in. diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 in. for 0.1° observation angle and 6.9 in. for 1/3° observation angle.

If a test distance other than 100 feet is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

D. Durability Tests.

D.1 Seal Test.

The following test shall be used to determine if a reflector is adequately sealed against dust and water.

Submerge 10 samples in water bath at room temperature. Subject the submerged samples to a vacuum of 10 in. gage for thirty minutes. Restore atmospheric pressure and leave samples submerged for 30 minutes. Wipe the surface of the lens dry and test the optical characteristics of the reflectors. The specific intensity of each reflector shall be not less than the respective values set forth in Section 3.2.

D.2 Heat Resistance Test.

Three reflectors shall be tested for 24 hours in an air oven at 140°F ±5°F. The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

M9.30.6 Temporary Raised Pavement Markers.

General Description.

Markers shall consist of a plastic shell to which is hermetically sealed one or two prismatic reflective lenses as required to reflect incident light from a single or opposite directions. The markers shall be in the shape of a shallow round cornered square with a spherical dome for enhancing the daytime signal. Adhesive shall be as recommended by the manufacturer.

Detailed Specifications.

1. Design and Fabrication.

A. Dimensional Details.

Overall Dimensions	4″ × 4″ × 0.75″ (10.16 cm × 10.16 cm × 1.90 cm)
Slope of Reflecting Lens Face	24° min.
Area of Each Reflecting Surface	0.38 sq. in. (2.45 sq. cm)

B. Material.

The shell shall be molded of methyl methacrylate conforming to Federal Specification L-P-380C, Type 1, Class 3.

Optical Requirements.

1. Definitions.

Horizontal entrance angle shall mean the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.

Observation angle shall mean the angle at the reflector between observer's line of sight and the direction of the light incident on the reflector.

Specific intensity (S.I.) shall mean the candle power of the returned light at the chosen observation and entrance angles for each foot candle of illumination at the reflector on a plane perpendicular to the incident light.

2. Optical Performance.

Day Signal:

The shape, finish and color of the marker shall be designed to provide a diffused specular daytime signal.

Night Signal:

The specific intensity of each white reflecting surface at 0.2° observation angle shall be not less than the following when the incident light is parallel to the base of the marker.

Horizontal Entrance Angle	S.I.
0°	1.0
20°	0.4

For yellow reflectors, the specific intensity shall be 60% of the value for white. For red reflectors, the specific intensity shall be 25% of the value for white.

M9.30.7 Demountable Reflectorized Delineator-Guard Rail.

Demountable reflectorized delineators for guard rail shall be fabricated in accordance with the Standard Drawings for Signs and Supports. The panel shall conform to ASTM A525, Steel Sheet, Zinc-Coated (galvanized) by the Hot-Dip Process, Coating Designation G210. Reflectorized sheeting shall conform to M9.30.0, Type III.

M9.30.8 Reflectorized Flexible Delineator Post.

Reflectorized Flexible Delineator Posts shall be used as directed for delineation of roadways and ramps. Only those products previously approved for the purpose intended and listed on the Qualified Product Listing maintained by the Research and Materials Section may be used.

M9.30.9 Reflectorized Plastic Drum.

Reflectorized plastic drums are to be used as channelizing devices in highway work zones. Drums shall be constructed of an approved ultraviolet resistant, low density, impact resistant linear polyethylene (or approved equal) with a minimum thickness of 3/32 in. They shall be approximately 36 in. in height and a minimum of 18 in. in diameter. Drum design and application shall conform to applicable sections of the Massachusetts MUTCD. Reflective sheeting shall meet the requirements of M9.30.0 Type IV.

M9.40.1 Well Casing Pipe

Well casing pipe shall conform to the requirements for welded and seamless steel pipe, ASTM A-53.

M9.40.2 Water Pumps.

Water pumps (jet, submersible or shallow well) shall be of a standard commercial quality. The capacity of the pump shall be such that it will be capable of discharging water at the rate and pressure for the pumping depth specified for the installation.

The motor voltage of the pump shall be compatible with the voltage available at the electrical source unless otherwise specified.

The Contractor shall submit for approval to the Engineer five days before placing any purchase orders for the water pump, accessories and electrical equipment, the name of the manufacturer, the specifications for the pump, accessories and electrical equipment that he proposes to furnish.

M9.40.3 Chlorine Solution.

Chlorine solution used for disinfecting springs, wells and other water systems, shall consist of a solution of water and liquid chlorine, sodium hypochlorite, calcium hypochlorite or chloride of lime.

Liquid forms of chlorine or sodium hypochlorite and powder forms of calcium hypochlorite or chloride of lime shall be used according to the instructions supplied by the manufacturer and as recommended by the Massachusetts Department of Environmental Quality Engineering.

If sodium hypochlorite is already in solution as a laundry bleach containing 5.25% sodium hypochlorite, it shall be used at the rate of one quart per 3000 gallons of water to be disinfected. The dosage should be sufficient to produce a chlorine taste in the water.

M9.40.4 Plastic Water Pipe, Flexible.

Flexible plastic pipe shall be polyethylene plastic pipe schedule 40 or 80 suitable for the transportation of potable water and conform with the requirements of AASHTO M258. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 160 psi at 73.4 °F. Unless otherwise specified or directed by the Engineer the pipe shall be inside diameter controlled. Fittings may be either nylon, copper or bronze. Clamps shall be stainless steel.

M9.40.5 Plastic Water Pipe, Rigid (PVC).

Rigid polyvinyl chloride (PVC) plastic pipe shall be suitable for transportation of potable water and conform with the requirements of AASHTO M258. The material grade and standard pipe dimension ratio (SDR) shall be capable of withstanding a minimum sustained water pressure of 160 psi at 73.4 °F. Fittings shall be PVC plastic conforming with AASHTO M258. The burst strength of the fittings shall be not less than that of the pipe being furnished.

M9.40.6 Plastic Water Pipe, Rigid (ABS).

Rigid Acrylontrile-Butadiene-Styrene (ABS) plastic pipe shall be suitable for the transportation of potable water and conform with the requirements of AASHTO M258. The material grade and SDR shall be capable of withstanding a minimum sustained water pressure of 160 psi at 73.4 °F. Fitings shall be ABS plastic conforming with AASHTO M258. The burst strength of the fittings shall be not less than that of the pipe being furnished.

M9.40.7 Copper Water Tube, Seamless.

Seamless copper water tube suitable for general plumbing shall conform to the requirements of AASHTO M258. Tube material shall conform to ANSI/ASTM 888, Type k.

M9.40.8 Steel Water Pipe, Galvanized.

Galvanized steel water pipe shall be the standard weight class conforming to the requirements of AASHTO M258. Pipe material shall conform with the ASTM A120 option.

M9.50.0 Geotextile Fabrics.

General.

The geotextile fabric shall be a woven or nonwoven fabric consisting only of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide or polyvinylidene-chloride formed into a stable network such that the filaments of yarns retain their relative position to each other. The fabric shall be inert to commonly encountered chemicals, and free of defects or flaws which significantly affect its physical, and/or filtering properties.

The fabric, except wrapping placed directly against perforated pipe, shall be formed in widths of at least 6 feet. Sheets of fabric may be sewn together at the point of manufacture or other approved locations.

The geotextile manufacturer is responsible for establishing and maintaining a quality control program so as to assure compliance with the requirements of this specification.

Packaging.

During all periods of shipment and storage, the fabric shall be wrapped in a heavy duty protective covering to protect the fabric from direct sunlight, ultraviolet rays, temperatures greater than 140°F, mud, dirt, dust, and debris.

Physical Requirements.

The fabric furnished may be either woven or non-woven, at the Contractor's option. The fabric shall meet the requirements of Table I, Table II, Table III or Table IV as specified for each use.

Table I — Type I Fabric
Slope Protection and Channel Lining

Property	Minimum Value*	Test Method
Grab Strength (lbs.)	200	ASTM D-4632
Elongation (%)	15	ASTM D-4632
Sewn Seam Strength** (lbs.)	180	ASTM D-4632
Puncture Strength (lbs.)	80	ASTM D-3787
Burst Strength (lbs.)	320	ASTM D-3786
Trapezoid Tear (lbs.)	50	ASTM D-4533
Apparent Opening Size (U.S. Standard Sieve)	Hole Size Equal to or Smaller than a U.S. Standard No. 40 (0.425 mm)	Corps of Engineers Standards CW-02215
Permeability (cm/sec)	0.010	AASHTO M-288
Flow Rate	40	AASHTO M-288

*Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). Stated values are for non-critical, non-severe applications.

**Values apply to both filed and manufactured seams.

Table II — Type II Fabric
Underdrains

Property	Minimum Value*	Test Method
Grab Strength (lbs.)	80	ASTM D-4632
Elongation (%)	N/A	ASTM D-4632
Sewn Seam Strength** (lbs.)	70	ASTM D-4632
Puncture Strength (lbs.)	25	ASTM D-3787
Burst Strength (lbs.)	130	ASTM D-3786
Trapezoid Tear (lbs.)	25	ASTM D-4533
Apparent Opening Size (U.S. Standard Sieve)	Hole Size Equal to or Smaller than a U.S. Standard No. 40 (0.425 mm)	Corps of Engineers Standards CW-02215
Permeability (cm/sec)	0.010	AASHTO M-288
Flow Rate	40	AASHTO M-288

*Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). Stated values are for non-critical, non-severe applications.
**Values apply to both filed and manufactured seams.

Table III — Type III Fabric
Subgrade or Embankment Stabilization

Property	Minimum Value*	Test Method
Grab Strength (lbs.)	180	ASTM D-4632
Elongation (%)	N/A	ASTM D-4632
Sewn Seam Strength** (lbs.)	160	ASTM D-4632
Puncture Strength (lbs.)	75	ASTM D-3787
Burst Strength (lbs.)	290	ASTM D-3786
Trapezoid Tear (lbs.)	50	ASTM D-4533
Apparent Opening Size (U.S. Standard Sieve)	Hole Size Equal to or Smaller than a U.S. Standard No. 40 (0.425 mm)	Corps of Engineers Standards CW-02215
Permeability (cm/sec)	0.005	AASHTO M-288
Flow Rate	20	AASHTO M-288

*Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). Stated values are for non-critical, non-severe applications.
**Values apply to both filed and manufactured seams.

Table IV — Type IV Fabric
Drainage Blankets

Property	Minimum Value*	Test Method
Grab Strength (lbs.)	180	ASTM D-4632
Elongation (%)	15	ASTM D-4632
Sewn Seam Strength** (lbs.)	160	ASTM D-4632
Puncture Strength (lbs.)	80	ASTM D-3787
Burst Strength (lbs.)	290	ASTM D-3786
Trapezoid Tear (lbs.)	50	ASTM D-4533
Apparent Opening Size (U.S. Standard Sieve)	Hole Size Equal to or Smaller than a U.S. Standard No. 40 (0.425 mm)	Corps of Engineers Standards CW-02215
Permeability (cm/sec)	0.010	AASHTO M-288
Flow Rate	40	AASHTO M-288

*Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table). Stated values are for non-critical, non-severe applications.
**Values apply to both filed and manufactured seams.

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