SUPPLEMENTAL SPECIFICATIONS

to the

1988 English Standard Specifications for Highways and Bridges

and the

1995 Metric Standard Specifications for Highways and Bridges

APRIL 1, 2019

SUPPLEMENTAL SPECIFICATIONS

The 1988 English and 1995 Metric Standard Specifications for Highways and Bridges are amended by the following modifications, additions and deletions. These are supplemental specifications and shall prevail over those published in the Standard Specifications for Highways and Bridges. This supplement incorporates all previous Error & Addenda sheets, and Supplemental Specifications, and therefore supersede all previous supplements and addenda.

ALL SECTIONS

Global Changes

Replace the words *Qualified Product Listing maintained by the Research and Materials Division, 400 D Street, South Boston Ma. 02110-1953, telephone number 617-526-8686* and all variations thereof with *Qualified Construction Materials List* at each occurrence.

Change the words *Bituminous Concrete* and *Class I Bituminous Concrete Type I-1* to *Hot Mix Asphalt* at each occurrence.

Change the words *Cement Concrete Masonry* to *Cement Concrete* at each occurrence.

Change the words *Linear Foot* and *Vertical Foot* to *Foot* at each occurrence.

Change the words *ground granular blast-furnace slag* to *slag cement* at each occurrence.

DIVISION I
GENERAL REQUIREMENTS AND COVENANTS

SECTION 1.00

DEFINITION OF TERMS

SUBSECTION 1.02 Abbreviations.

(page 3 English, page I.3 Metric) Revise the abbreviation list to read as follows:

AASHTO – American Association of State Highway and Transportation Officials
ACI – American Concrete Institute
AISC – American Institute of Steel Construction
AISI – American Iron and Steel Institute
ANSI – American National Standards Institute
ASTM – American Society of Testing and Materials
ATSSA - American Traffic Safety Services Association
AWPA – American Wood Preservers Association
AWWA – American Water Works Association
AWS – American Welding Society
DEP – Commonwealth of Massachusetts Department of Environmental Protection
EPA – United States Environmental Protection Agency
FHWA – Federal Highway Administration
IES – Illumination Engineering Society
IMSA – International Municipal Signal Association
ITE – Institute of Traffic Engineers
MEC – Massachusetts Electrical Code
MASH – AASHTO Manual for Assessing Safety Hardware
MUTCD – Manual on Uniform Traffic Control Devices
NEC – National Electrical Code
NEMA – National Electrical Manufacturers Association
NEPCOAT – Northeast Protective Coating Committee

SUBSECTION 1.02 (continued)

NPCA – National Precast Concrete Association
NTPEP – National Transportation Product Evaluation Program
OSHA – Occupational Safety and Health Administration
PCI – Precast/Prestressed Concrete Institute
SAE – Society of Automotive Engineers
SSPC – Society for Protective Coatings
UL – Underwriters Laboratories

SUBSECTIONS 1.03 through 1.43 Definition of Terms.

(pages 4, thru 7 English) Replace the existing definitions with the following, renumber existing definitions 1.39 (Subgrade) through 1.43 to 1.40 through 1.44, and add new definitions 1.45 and 1.46.

(pages I.7 thru I.8 Metric) Replace Subsection 1.40 with the definition of Subbase below and renumber existing definitions 1.40 (Subgrade) through 1.45 to 1.41 through 1.46.

1.06	**Bid**	See Proposal.
	Bid, Informal as to form	A bid which contains a minor deficiency or deviation from what is requested by the Department.
	Bid, Informal as to substance	A bid which fails to comply with the requirements of the public bidding law.
1.17	**Department**	The Massachusetts Department of Transportation.
1.22	**Invitation for Bids**.....	The advertisement for Proposals for all work or materials on which bids are required. Such advertisement will indicate the approximate project value, category of work and location of the work to be done and the time and place of the opening of Proposals.
1.30	**Project**.....	The specific section of highway together with all appurtenances and construction to be performed thereon under the contract.
1.39	**Subbase**.....	The layer of material placed on the subgrade as a foundation for roadway or sidewalk.
1.45	**Notice to Proceed**.....	A written communication issued by the Department to the Contractor authorizing him to proceed with the work and establishing the date of commencement of the work.
1.46	**Substantial Completion**.....	Shall mean either that the work required by the contract has been completed except for work having a contract price of less than one percent of the then adjusted total contract sum, 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. Substantial completion shall be conclusively determined by the Engineer after inspection of the work.

SECTION 2.00 PROPOSAL REQUIREMENTS AND CONDITIONS.
(page 7 English, page I.9 Metric) Replace this Subsection with the following:

2.01 Proposal Forms and Plans.

A. Prequalification Prior to Requesting Proposal Forms.

Subject to the requirements of Chapter 29, Section 8B of the Massachusetts 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 Chapter 90, Section 34 of the Massachusetts General Laws must be prequalified in accordance with 720 CMR 5.00, "Prequalification of Contractors and Prospective Bidders for Statewide Engineering Field Survey Services", if the amount of the proposal added to the value of the uncompleted work already under contract with the Department will aggregate $50,000 or more.

For work aggregating under $50,000, prequalification requirements shall be at the discretion of the Department.

Except for projects for which prequalification is not required under 720 CMR 5.04(2), proposals for a project shall be limited to those bidders who have been prequalified by the Prequalification Committee in the specified class of work on or before the time of bid opening.

B. Issuance of Proposal Forms and Plans.

All prospective Bidders who intend to bid on work to be awarded by the Department, may obtain the plans and specifications from the Department at the place specified in the Notice to Contractors.

For projects to be awarded under the provisions of Section 34, Chapter 90 of the Massachusetts General Laws, bidders may obtain plans and specifications from the applicable municipality at the place specified in the Notice to Contractors.

Contractors intending to bid on any project must first obtain "Request for Proposal Forms" (R-109 Form), from the Prequalification Office, which form must be completed and submitted to the Director of Prequalification for approval. Upon approval, the official bidder shall be entitled to receive official proposal documents. Other interested parties may receive an informational copy of the plans and specifications.

Official proposal documents shall contain plans and specifications showing the location and description of the contemplated work; an itemized proposal form listing the 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 for the particular project.

The Department is not responsible for loss of or damage to the official proposal documents after they have been mailed or given to the bidder. If loss or damage occurs, the bidder may request another copy.

Modifications to any official proposal documents will be made through the Addendum process and posted on www.bidx.com and www.commbuys.com. The bidder shall take responsibility for incorporating the revised data into the proposal upon notification from the Department. The bidder must provide an e-mail address to the Department for receipt of addenda notification.

2.02 Interpretation of Basic Estimate of Quantities.

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:

The work has been divided into items in order to enable the Bidder to bid on the different portions of the work in accordance with the Bidder's estimate of their cost, so that in the event of an increase or decrease in the quantities of any particular item of work the actual quantities executed shall be paid in accordance with the contract.

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 Subsections 4.06, 8.10 and 9.03.

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.

All bidders shall use Bid Express for submittal of bids. Bidders shall subscribe to the BidExpress on-line bidding exchange by following the instructions provided at www.bidx.com or by contacting:

Info Tech Inc.
5700 SW 34th Street, Suite 1235
Gainesville, FL 32608-5371
email:customer.support@bidx.com

In order to submit a bid, the Bidder shall have a digital identification (ID) issued by the Department on file with Info Tech Inc. and enabled by Info Tech Inc. This Digital ID represents the firm as an individual, partnership, corporation, limited liability company, or joint venture. By entering and submitting the Digital ID the authorized parties obligate the firm to the bid. Using this digital ID shall constitute the Bidder's signature for proper execution of the Proposal.

Electronic bid files are provided through the Bid Express on-line bidding exchange at http://www.bidx.com/. The bidder shall follow the on-line instructions and review the help screens provided to assure that the schedule of items is prepared properly. Bidders shall download and acknowledge any and all addenda files prior to submitting their final bid. Bids shall be submitted in accordance with the requirements of the Bid Express Web site.

At the designated time of the bid opening the Department will accept, as the official bid, the set of proposal forms generated from the Expedite Proposal file submitted by the bidder which includes the bid item sheets, bid bond submittal acknowledgement, addendum acknowledgement, and affidavit acknowledgement.

The Department will not be responsible for any communications or hardware breakdowns, transmission interruptions, delays, or any other problems that interfere with the receipt or withdrawal of proposals as required above either at the Bidder's transmitting location, at the Department's receiving location, or anywhere between these locations will not be considered grounds for a bid protest. The Department will not be held responsible if the bidder cannot complete and submit a bid due to failure or incomplete delivery of the files submitted via the Internet.

2.05 Delivery of Proposals.

The Bidder shall submit the proposal prior to the time set for opening of the bid.

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 of 5 percent of the bid.

The bid deposit shall be a bid bond in a form satisfactory to the Department 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 Department; 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 Massachusetts Department of Transportation.

2.07 Withdrawal of Proposals.

Prior to the designated bid opening time, the Bidder may electronically withdraw a proposal.

After the deadline for submitting bids, a bidder may submit a written request to withdraw its bid to the Department. The Department will only grant the request on a clear showing to the satisfaction of the Department that the bid amount resulted from bona fide clerical or mechanical error of a substantial nature or from other similar unforeseen circumstances. When the Department grants a request to withdraw a bid, the Department will return the bidder's bid deposit.

2.08 Public Opening of Proposals.

The total price of each compliant proposal submitted by the deadline indicated in the Notice to Contractors, will be posted on www.bidx.com forthwith after the bid submission deadline. Bids may be examined on www.bidx.com or at MassDOT after the bid submission deadline and posting of the results on www.bidx.com.

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, 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 Department 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/her directly or indirectly. Any Proposals will be rejected if there is reason for believing that collusion exist among the Bidders. (See Subsection 3.01.)

In accordance with 720 CMR 5.00, Proposals may also be rejected if:

(i) award of the contract would result in the Bidder exceeding the Aggregate Bonding Capacity established by its Surety Company, or the Bidder's Proposal exceeds its single project limit, or the Bidder was not prequalified in the specified class of work on or before the time of bid opening; or

(ii) the Bidder is presently debarred from performing work of any kind under the provisions of Massachusetts General Laws, Chapter 29, Section 29F, or any other applicable debarment provisions of the Massachusetts General Laws or any rule or regulation promulgated thereunder; or

(iii) the Bidder is presently debarred from performing work of any kind under the laws of any state other than the Commonwealth of Massachusetts, or by any Federal agency or authority; or

(iv) there is substantial reason to believe that the condition of the Bidder's firm is less favorable than at the time of its last Application for Prequalification; or

(v) the Bidder does not have sufficient equipment, or sufficient assets to provide necessary equipment either through purchase or lease agreements; or

(vi) the Bidder's performance on past or current work with the Department or other awarding authorities is or has been unsatisfactory; or

(vii) on current projects of the Department or other public authorities the Bidder frequently fails or has failed to pay its subcontractors or material suppliers in a timely manner, or that 5 or more subcontractors or material suppliers of the Contractor for a project currently under construction have filed demands for direct payment with the project's awarding authority in accordance with Massachusetts General Laws, Chapter 30, Section 39F;or

(viii) the Bidder is not otherwise an eligible and responsible Bidder capable of performing the work.

2.10 Disqualification of Bidders.

Bidders whose Proposals have been rejected because of evidence of collusion may be subject to debarment under applicable provisions of state and federal law.

2.11 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.

2.12 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 CONTRACT

SECTION 3.00 AWARD AND EXECUTION OF THE CONTRACT.

(page 10 English, page I.13 Metric) Replace this Subsection with the following:

3.01 Consideration of Proposals.

The Department reserves the right to reject any and all bids, or any bid item, to advertise for new Proposals for the project, to waive technicalities, to waive informalities as to form, or to proceed to do the work otherwise, as may be deemed to be in the best interest of the Department.

Nothing herein shall be construed as depriving the Department of the right to reject any bid when such bid does not fully comply with the specifications for the project or the applicable public bidding laws or regulations, or the Contractor is otherwise not eligible or responsible to receive award of the contract.

A proposal will be considered irregular and will be rejected if it is determined that any of the unit prices are materially unbalanced to the detriment of the Department. The bidder will be required to justify in writing the price or prices bid for the work in question before the Department decides to award the contract or reject the bid.

3.02 Award of Contract.

Subject to the reservations in Subsection 3.01, the contract will be awarded to the lowest eligible and 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.

No municipality may award a contract until the Department has determined that the bidder was prequalified in the specified class of work on or before the time of bid opening, and has not exceeded the Aggregate Bonding Capacity established by the bidder's surety company, and has, if applicable, a Single Project Limit in an amount equal to or in excess of the Proposal amount, and is otherwise in compliance with 720 CMR 5.00, “Prequalification of Contractors and Prospective Bidders for Statewide Engineering Field Survey Services”.

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, prior 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 Department will endeavor to return the Proposal guaranties of all Bidders other than the two lowest Bidders 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 Performance Bond in the full amount of the Contract will be required by the Department to ensure the faithful performance of the Contract and in accordance with Subsection 7.18.

A Payment Bond in an amount of the contract price will be required to be furnished by the Contractor to the Department 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 Massachusetts 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 Department, 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 by the Department. The Contractor shall be responsible for notifying the surety or sureties regarding changes to the Contract. The Contractor shall provide evidence of revised bond.

Where the Contract utilizes additional artisans, equipment rental, materials, engineering services and specialty services to complete work assignments approved by the Engineer, the Contractor is responsible for additional bond associated with the increased value of the Contract.

3.05 Execution of Contract.

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

The Contract shall be in writing. When the awarding authority is the Massachusetts Department of Transportation, 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 awarding authority 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 Department may, at its option, determine that the Bidder has abandoned the Contract and thereupon the Proposal and acceptance shall be null and void. In accordance with Chapter 30, Section 39M of the Massachusetts General Laws, the guaranty accompanying the Proposal may be retained and collected by the Department as liquidated damages for the delay and expense caused by the abandonment of the Contract.

SECTION 4.00
SCOPE OF WORK

SUBSECTION 4.01 Intent of the Contract.

(page 12 English, page I.15 Metric) Add the following paragraph after the 4th paragraph:

The Contract shall include technical submittals, schedule submittals, materials Certificates of Compliance (COCs), payroll records and any and all other documents required by the plans and specifications to support the physical work of the contract.

SUBSECTION 4.03 Extra Work (Also see Subsection 4.05).

(page 12 English, page I.15 Metric) Change the words Subsection 8.10, Part F. to Subsection 8.10. in the second paragraph.

SUBSECTION 4.04 Changed Conditions.
(page I.16 Metric) In the third sentence of the second paragraph delete the words "… or a change in the cost of performance of the work…".

SUBSECTION 4.04 (continued)
(page 13 English, page I.16 Metric) Replace the second sentence in paragraph (a) with the following:

The Engineer shall promptly investigate the conditions and shall promptly prepare a written report of the findings with a copy to the Contractor. If the Engineer 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.

(page 14 English, page I.16 Metric) Replace the last three paragraphs of this Subsection with the following:

The provisions of Section 39N of Chapter 30 of the General Laws, as amended, do not apply to construction contracts entered into on behalf of a municipality under the provisions of Section 34, Chapter 90 of the General Laws.

SUBSECTION 4.05 Validity of Extra Work.
(page 14 English, page I.17 Metric) Delete the words "…Chapter 29, Section 20A and…".

SUBSECTION 4.06 Increased or Decreased Contract Quantities.
(page 14 English, page I.17 Metric) Replace this Subsection with the following:

The quantities contained in the Contract are set forth as a basis for the comparison of bids only and may not necessarily reflect the actual quantity of work to be performed. The Department reserves the right to increase, decrease or eliminate the quantity of any particular item of work.

Where the actual quantity of a pay item varies by more than 25 percent above or below the estimated quantity stated in the Contract, an equitable adjustment in the Contract Price for that pay item shall be negotiated upon demand of either party regardless of the cause of the variation in quantity.

No allowances will be made for loss of anticipated overhead costs or profits suffered or claimed by the Contractor resulting directly or indirectly from such increased, decreased or eliminated quantities or from unbalanced allocation among the contract items from any other cause. It is the intention of this provision to preserve the bid basis while limiting the Contractor's risk exposure to 25% of each bid quantity.

In the case of an overrun, the contractor will be compensated at the Contract Unit Price for a quantity up to 125% of the Contract quantity. The adjusted unit price shall only be applied to that quantity above 125% of the contract quantity.

Neither party shall be required to demonstrate any change in the cost to perform the work based solely on the overrun. The original Contract unit bid price shall have no bearing on determining the adjusted unit price for an overrun. The adjusted unit price shall be based on the estimated cost of performing the added work over 125% of the bid quantity.

To assist the Engineer in the determination of an equitable adjustment for an overrun, the Contractor shall prepare a submission in the following manner and accept as full payment for work or materials an amount for an equitable adjustment in the Contract Price equal to the following:

(1) The actual cost or a reasonable cost estimate 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 or a reasonable cost estimate of Worker'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) for profit and other unallocated costs;
(4) Plus the estimated proportionate cost of surety bonds.

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

For work performed by a Subcontractor, the Contractor shall accept as full payment therefore an amount equal to the actual cost or the reasonable cost estimate to the Contractor of such work as determined by the Engineer, plus 10 percent of such cost. The Subcontractor is bound by the same criteria for the determination of an equitable adjustment as the Contractor.

SUBSECTION 4.06 (continued)

In the case of an under-run, the unit price for the actual quantity installed, if less than 75% of the bid quantity, shall only be adjusted to account for documented increased unit costs that result solely from the decreased quantity. Actual cost to perform the under-run quantity of work shall not be used to determine payment for an under-run. The adjusted unit price for the under-run shall be the bid price plus the documented change in the unit cost of performing the work due solely to the decreased quantity. In no case shall the total payment for an under-run item exceed the total bid value for the item.

The Contractor is required to furnish itemized statements of cost and give the Department access to supporting records.

In the event that an adjusted unit price cannot be agreed upon within 30 days after being requested by either party, a unit price will be established that is deemed to be fair and equitable by the Engineer, whether higher or lower than the unit price bid. Payment will be made at that rate until agreement is reached or until the Contractor chooses to exercise his rights under Section 7.16.

SECTION 5.00
CONTROL OF WORK

SUBSECTION 5.02 Plans and Detail Drawings.

(page 15 English, page I.20 Metric) Replace this Subsection with the following:

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.

Contract drawings, supplemental plans and detail drawings designed by the Department are part of the complete plans. Shop drawings, detail drawings, erection drawings, catalog cuts, temporary structures and other plans designed and or submitted by the Contractor as required in the Specifications shall, upon approval by the Engineer, become part of the complete set of plans.

Drawings or plans for which the Contractor is responsible for the design, such as for, but not limited to, steel sheeting; cofferdams; sign, signal and lighting supports; temporary structures; temporary traffic control plans, erection drawings; demolition drawings; and computations submitted by the Contractor for approval shall bear the seal of a Professional Engineer of the appropriate discipline registered in Massachusetts.

Approval of shop drawings by the Engineer does not relieve the Contractor of any responsibility under the Contract for conformance to the applicable codes, standards, etc.; nor for errors in dimensions, details or quantities; nor for compliance with the details of the original approved design.

Structural steel shop drawings shall be prepared and presented in accordance with the AASHTO/NSBA *Steel Bridge Collaboration G1.3 Shop Detail Drawings Presentation Guidelines Documentation with Sample Drawings*. Structural steel shop drawings shall be reviewed and approved in accordance with the AASHTO/NSBA *Steel Bridge Collaboration G1.1 Shop Detail Drawing Review/Approval Guidelines.* If there are any conflicts between these guides and the Standard Specifications, the Standard Specifications shall govern.

The Contractor shall not receive payment for, nor be allowed to install any item or materials which require shop drawing approval until the shop drawings for that item have been approved by the Engineer.

The title block of shop drawings shall include, at a minimum, the following information: fabricator's name and address; city(ies) or town(s) where the project is located; location(s) where the material is to be used; MassDOT contract number; Federal aid project number, when applicable; MassDOT Projis Number; name of the general contractor; date of drawing and date of all revisions. The title block for shop drawings of bridge projects shall also include: the bridge number and BIN; facility on the bridge; the feature under the bridge.

The Contractor shall submit two sets of full-scale shop drawing prints to the Engineer for approval. If corrections are required, one set of the marked-up drawings will be returned to the Contractor for revision and subsequent re-submittal. The Engineer shall make all copies of the approved shop drawings as indicated in Table 1 of Subsection 5.02 and will distribute the drawings. No changes shall be made to the approved drawings without the written consent of the Engineer.

Shop drawings for any fabricated steel or aluminum product will not be accepted from anyone other than approved suppliers as noted in Subsection 6.01.

Within 15 days after receipt of an approved shop drawing for any item, the Contractor shall provide the Department written proof that the approved materials have been ordered.

SUBSECTION 5.02 (continued)

The Contractor, upon approval of shop drawings shall submit to the Engineer a TIFF (tagged image file format) file for each of the structural shop drawing sheets. Shop drawings that will require a TIFF submission are those for all primary load carrying bridge members and all attachments to them, such as bridge beams and diaphragms, and for structural reinforcing rebars. Depending upon the bridge type, the construction documents may require TIFF submissions for additional bridge components. The TIFF files shall be in black and white at a resolution of 300 dpi (dot per inch) and group 4 or group 3 compression. Each TIFF file shall be named using the bridge BIN (Bridge Identification Number), followed by up to eight digit description such as STGIRDER, CONCBEAM, TIMBSTRI, APPRSLAB, BRIDDECK, followed by a 3 digit sheet number. The sheet number in the TIFF files name shall correspond to the sequential number of the shop drawings. A typical TIFF file would be: 2ULSTGIRDER002. All TIFF files corresponding to the same shop drawings set shall be grouped and saved under a separate folder. The folder shall be named using the BIN and description combination. The TIFF files shall be created from the original stamped approved drawings and shall be submitted to the Department on compact discs (CD's).

The contract prices shall include the cost of furnishing all detail drawings and the TIFF files on compact discs (CD's) and the Contractor will be allowed no extra compensation therefore. The Engineer may withhold a portion of the payment until all required files have been received and accepted.

TABLE 1: NUMBER OF SETS REQUIRED FOR APPROVAL

TYPE OF SUBMITTAL	DESCRIPTION	NUMBER OF SETS
Shop Drawings	TRAFFIC: PRECAST CONCRETE UNITS, SIGNS, SUPPORTS, CASTINGS, SIGNAL MECHANISMS, HIGHWAY LIGHTING, ETC.	9
	STRUCTURAL STEEL; METAL BRIDGE RAILINGS; PROTECTIVE SCREENS; METAL CASTING; METAL PLATES AND MACHINERY; PRESTRESSED CONCRETE STRUCTURAL UNITS; NOISE BARRIER; ELASTOMERIC BEARINGS; ARMORED STRIP SEAL AND FINGER JOINTS	8
	SPECIAL METAL PIPES; PIPE ARCHES; STRUCTURAL PLATE ARCHES; STRUCTURAL PIPES AND STRUCTURAL PLATE PIPES	7
	REINFORCING STEEL; SPECIAL NON-TRAFFIC PRECAST CONCRETE UNITS (PIPES, MANHOLES, ETC.)	6
Construction Procedures	STEEL BEAM ERECTION; PRESTRESSED CONCRETE BEAM ERECTION; PRECAST CONCRETE ARCH / FRAME UNIT ERECTION; BRIDGE DEMOLITION; DECK REMOVAL & SHIELDING DESIGN; SHEETING / COFFERDAM DESIGNS; TEMPORARY BRIDGES; BEAM OR PIPE JACKING PROCEDURE	6 (9 sets required when a railroad is involved)
	PILE DRIVING (WAVE EQUATION METHOD); PILE LOAD TESTS; EMBANKMENT SETTLEMENT; SIGN SUPPORTS / STRAIN POLES	6
	PILE CAPACITY (UNDER 50 TONS); SCHEDULES & CONSTRUCTION EQUIPMENT	3

SUBSECTION 5.05 Cooperation by Contractor.
(page 17 English, page I.21 Metric) Add the following sentence to the end of the first paragraph:

The documents are to be picked up by the Contractor within 30 days of the Award of contract. Contractors requesting the documents after the 30 day period will be required to purchase the requested documents.

SUBSECTION 5.09 Inspection of Work.
(page 18 English) Add the following to the first paragraph of page 19:

The Department strongly encourages the use of recycled products. The Contractor must identify wherever recycled products are to be used.

SUBSECTION 5.10 Removal of Defective or Unauthorized Work.
(page 19 English, page I.24 Metric) Replace the last paragraph of this subsection with the following:

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 withhold the estimated costs therefor from any moneys due or to become due the Contractor until the work is corrected. Upon the further failure of the Contractor to remove and satisfactorily dispose of any or all defective or unauthorized work, and to remedy the same, the Engineer may cause such defective work to be remedied, removed and replaced; and such unauthorized work to be removed, and may deduct the costs therefor from any moneys due or to become due the Contractor.

SUBSECTION 5.11 Final Acceptance.
(page 19 English, page I.24 Metric) Replace second sentence of the first paragraph with the following:

If all construction provided for and contemplated by the Contract is found completed to the Engineer's satisfaction, that inspection shall constitute the final inspection and the 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.

(page 19 English, page I.24 Metric) Replace the last paragraph with the following:

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.

The cost of electrical energy consumed by the operation of traffic signals, highway lighting or other electrical devices during the construction, fine tuning, adjustment and testing of the devices will be borne by the owner of the existing device. In the case of an installation requiring a new electrical service, the cost of electrical energy consumed will be borne by the Contractor until final acceptance.

SECTION 6.00
CONTROL OF MATERIALS

SUBSECTION 6.01 Source of Supply and Quality.

(page 20 English, page I.27 Metric) Add the following paragraph above the second paragraph from the end of this subsection:

These Certificates of Compliance (COCs) shall be delivered to the contract site at the same time that the materials are delivered and before such materials are incorporated into the work. Payment for the item in which the materials are incorporated may be withheld until these COCs are received in a form that meets the contract requirements.

(page 20 English, page I.26 Metric) Replace the 5th paragraph (English), 5th and 6th paragraph (Metric) with the following:

Fabricators of structural steel, miscellaneous steel and aluminum products, and producers of precast concrete and prestressed concrete must be on the Department's approved fabricators list on the date the bids are opened. Only approved fabricators will be allowed to perform work for the Department.

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. For any materials named or described in these specifications, an approved equivalent to that named or described in the said specifications may be furnished.

(page 20 English, page I.26 Metric) Replace the 11th paragraph in the amended Subsection, which begins "Unless otherwise provided…" with the following:

Materials for permanent construction shall be new, shall conform to the requirements of these specifications, and shall be approved by the Engineer.

Materials for temporary structures or supports adjacent to traveled ways, the failure of which would compromise the safety of the public or the traveled ways, need not be new but the Contractor shall be required to submit certification by a Structural Professional Engineer that the material meets the requirements for the intended use and shall be approved by the Engineer. Any fabrication shall conform to the requirements of these specifications.

These requirements shall not apply to gantry systems and supports as well as other mechanized systems.

(page 20 English) Replace the 13th paragraph in the amended Subsection with the following:

Where no inspection of materials is arranged for by the Department and before such materials are incorporated into the work, the Contractor shall submit to the Department for approval, three notarized 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:

SUBSECTION 6.04 Defective Materials.

(page 21 English, page I.27 Metric) Replace this Subsection with the following;

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 non-conforming material within the time indicated in writing, the Engineer may withhold the estimated cost of the removal and replacement of the non-conforming material from any moneys due or to become due the Contractor. Upon further failure of the Contractor to remove and replace the non-conforming material, 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 THE PUBLIC

SUBSECTION 7.01 Laws to be Observed. (A. General.)
(page 22 English) After the 5th full paragraph on the page add the following new paragraph.

The Contractor shall not, otherwise than as provided by law for the proper discharge of official duty, directly or indirectly, give, offer or promise anything of value to any present or former state employee, for or because of any official act performed or to be performed by such employee or person selected to be such employee. The phrase "anything of value" as used herein means any item of value, including but not limited to invitations or tickets to sporting events, social gatherings, outings or parties, or the provision of meals or lodging, or the use of vehicles of any kind, and any other item or thing of monetary value. In the event that the Contractor breaches this provision, the Department may take action against the Contractor including but not limited to the following: (A) ordering the Contractor to cease the work or any part thereof, (b) termination of the contract, (c) requiring Contractor's sureties to complete the work, and (d) suspend or terminate the Contractor's prequalification status.

(page 22 English) Delete the last section of part A. General entitled "Minimum Dump Truck Rates.".

(page I.30 Metric) Delete the last section of part A. General entitled "Dump Truck Rates.".

SUBSECTION 7.02 Prevention of Water Pollution – Sanitary Provisions.
(page 23 English, page I.30 Metric) Change the title of this Subsection and add the Air Pollution Requirements below to the beginning of this Subsection, followed by the header for the Water Pollution Requirements which pertains to the remainder of this Subsection.

7.02 Pollution Prevention.

I. Air Pollution Prevention Requirements.

A. Diesel Construction Equipment.

The Massachusetts Department of Transportation is a participant in the MassCleanDiesel Program established by the Massachusetts Department of Environmental Protection (DEP) and the purpose of this specification is to achieve documentable diesel emission reductions that result in beneficial air quality improvements to construction workers and the general public through the retrofit of diesel-powered non-road construction equipment.

The Contractor shall certify that all Contractor and Sub-Contractor diesel-powered non-road construction equipment and vehicles greater than 50 brake horsepower (hp) that will be utilized in performance of the work under this contract (hereinafter "Diesel Construction Equipment" or "DCE") have (1) engines that meet the EPA particulate matter (PM) Tier emission standards in effect for non-road diesel engines for the applicable engine power group or, (2) emission control technology verified by EPA or the California Air Resources Board (CARB) for use with "non-road engines" or (3) emission control technology verified by EPA or CARB for use with "on-road engines" provided that such equipment is operated with diesel fuel that has no more than 15 parts per million (ppm) sulfur content (i.e., Ultra Low Sulfur Diesel (ULSD) fuel) or (4) emission control technology certified by manufacturers to meet or exceed emission reductions provided by either "on-road" or "non-road" emission control technology verified by EPA or CARB. Emission control devices, such as oxidation catalysts or particulate filters, shall be installed on the exhaust system side of the diesel combustion engine equipment. The Contractor is responsible to insure that the emissions control technology is operated, maintained, and serviced as recommended by the manufacturer. Note: See Exemptions below regarding the use of rental equipment. See Compliance section regarding minimum emission reductions that must be provided by non-verified EPA or CARB emission control devices.

For the latest up-to-date list of EPA-verified technologies, see: http://www.epa.gov/otaq/retrofit/verif-list.htm.
For the latest up-to-date list of CARB verified technologies, see: http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm.

SUBSECTION 7.02 (continued)
Exemptions

A. Rented diesel equipment greater than 50 brake hp that will be used on site for 30 days or less over the life of the project (i.e., 30 days cumulative) are exempt from this specification. However, if the rented equipment will be used more than 30 cumulative days, then the equipment must comply with this specification. In either case, rental equipment must be included as part of the detailed records of DCE under Submittals and Reporting. Note: Any contractor owned equipment that are more than 50 brake hp that are used on site for 30 cumulative days or less over the life of the project, are not exempt from complying with this specification.

B. Large cranes (such as Sky cranes or Link Belt cranes) which are responsible for critical lift operations are exempt from installing Retrofit Emission Control Devices if they adversely affect equipment operation. Technical justification must be submitted to the Engineer for approval to document the impact on operations.

C. The Engineer may create an exemption when there is a compelling emergency need to use diesel vehicles or engines that do not meet the contract conditions for emission controls. Examples include the need for rescue vehicles or other equipment to prevent or remedy harm to human beings or additional equipment required to address a catastrophic emergency such as structure collapse or imminent collapse. Once the emergency is controlled, such non-compliant equipment must be removed from the project. Meeting contract deadlines will not be considered a compelling emergency.

D. Diesel-powered non-road construction equipment greater than 50 brake horsepower need not be equipped with either EPA of CARB verified emission control technology if the non-road construction equipment diesel engine is certified to meet the EPA particulate matter (PM) Tier emission standards in effect for non-road diesel engines for the applicable engine power group. Note: If emissions from the DCE at the start of the project meets the most current EPA PM emissions standards in effect at the time but are superseded by newer Tier emission standards (i.e., Tier 3 emission standards replaced by Tier 4 emission standards), then the superseded DCE must be retrofitted prior to the end of the contract with emission control technology per Section 2.

E. If an additional DCE (greater than 50 brake hp), or permanent replacement is brought on site after work has commenced, the Contractor has 15 calendar days from the time the DCE is brought on site, to install emission control technology per this specification (unless the DCE has an engine that meets the EPA particulate matter (PM) Tier emission standards in effect for non-road diesel engines for the applicable engine power group).

Submittals and Reporting

The Contractor shall fill out and return the following forms within 14 days of the date of contract Award:
Certification of Construction Equipment Standard Compliance Form
Diesel Equipment Data Sheet
These forms are available on the MassDOT website at www.mass.gov/massdot/highway/

Should the successful bidder fail to execute the said form, MassDOT may, at its option, determine the Contractor has abandoned the Contract and shall take action in accordance with Subsection 3.06.

The Diesel Equipment Data Sheet is a certified list of all DCE to be utilized on the project and provide the following information for each DCE in tabular form.

Contractor/subcontractor name.
Identify if owned/rented equipment.
Equipment type.
Equipment make, model and VIN.
Engine model, year of manufacture and HP rating.
Type of fuel used.
Emission Control Device (ECD) type (DOC or DPF).
ECD manufacturer, make and model.
ECD EPA/CARB Verification Number or ECD performance certification provided by manufacturer(s) that the DOC or DPF meets or exceeds emission reductions when compared to an EPA or CARB verified device.
ECD installation date.

For each piece of DCE, the Contractor shall also submit digital color pictures showing the machine and the MassDOT-issued compliance label (with inspection tag number).

SUBSECTION 7.02 (continued)

The Contractor and subcontractor shall maintain detailed records of all DCE used on the project, including the duration times the DCE is used on the project site. Records shall be available for inspection by MassDOT. The Engineer shall be immediately notified of any new DCE brought onto the project.

Compliance

A. All DCE that are not exempt, must comply with these provisions whenever they are present on the project site. If a non-verified EPA or CARB emissions control device is used for compliance with this specification, then the device must provide the following minimum emission reductions:

Diesel Oxidation Catalysts	Diesel Particulate Filters
Particulate Matter: 20%	Particulate Matter: 85%
Carbon Monoxide: 40%	
Volatile Organic Compounds: 50%	

Note: If emission reductions for a non-verified ECD appear to be questionable as determined by MassDOT, the Contractor shall provide all supporting emission test data, including test procedures, as requested by MassDOT for the ECD. If emission reductions cannot be substantiated by supporting test data, then the ECD in question must be replaced with a different ECD.

B. Upon confirming that the Diesel Construction Equipment meets the EPA particulate matter (PM) Tier emission standards in effect for non-road diesel engines for the applicable engine power group or has the requisite pollution control technology installed, MassDOT will issue a non-transferable compliance label that will assign a compliance tracking number to the DCE.

C. All DCE subject to this Specification shall display the compliance label in a visible location.

D. When leased or rented equipment which has been retrofitted by the Contractor is returned to the rental company, the Contractor will remove the Compliance label and return the label to the Engineer.

E. Use of a DCE which has been issued a compliance label and which is found without the device is a breach of this contract and will be subject to a stipulated penalty of $2,500 per day. See Non-compliance section below.

F. If an emission control device which was purchased and/or utilized on or after March 1, 2005 and was in compliance with the MassDOT diesel retrofit requirements in place between March 1, 2005 and the issuance of this specification, the retrofit device will be considered in compliance with this specification. Note: If a retrofit device (i.e., DOC or DPF) used between March 1, 2005 and issuance of this specification does not have a performance certificate which shows the pollutant emission reductions being provided by the retrofit device meets or exceeds emission reductions provided by either an EPA or CARB verified “on-road” or “non-road” emission control device, then the device will be considered non-compliant with this specification.

Non-compliance

All DCE may be inspected by the Engineer or designated agent without prior notice to the Contractor. If any DCE is found to be in non-compliance, the Contractor must either remove the DCE from the project or retrofit it within 15 calendar days. Failure to comply will subject the Contractor to an Environmental Deficiency Deduction described below. A Notice of Non-Compliance will be issued by the Engineer or his agent at the time the noncompliance is identified.

If the Contractor fails to take corrective action within 15 calendar days of issuance of the Notice of Non-Compliance, a daily monetary deficiency deduction will be imposed for each calendar day the deficiency continues. The deduction will be $2,500 per calendar day for each piece of DCE determined to be in non-compliance. The deficiency deduction is irrevocable and shall not be reimbursed. Pay estimates will be held and no payments made until all equipment is brought into compliance.

SUBSECTION 7.02 (continued)
Costs

All costs associated with the installation of emission control technology are the responsibility of the Contractor and shall be considered incidental to the cost of the project. No additional compensation is provided. In addition, all DCE greater than 50 brake hp shall comply with the requirements of this specification at the start of work commencing on site. The Contractor's compliance with this specification shall not be grounds for claims.

B. Construction Dust Control.

The Contractor shall comply with the provisions of the Massachusetts Department of Environmental Protection Code of Massachusetts Regulations (CMR) Regulations 310 CMR 7.09 "Dust, Odor, Construction and Demolition."

The Contractor is responsible for control of dust at all times, 24 hours per day, 7 days per week. The Contractor shall treat soil at the site, haul roads, stockpiled materials and other areas disturbed by the operations with dust suppressors or other means to control dust. Dry power brooming will not be permitted. The Contractor shall use vacuuming, wet sweeping, regenerative air sweeping, or wet power broom sweeping. The use of sandblasting and compressed air will be permitted only with acceptable dust controls in place. Only wet cutting of concrete block, concrete and asphalt will be permitted.

Trucks and equipment leaving the site and entering public streets shall be cleaned of mud and dirt adhering to the vehicle body and wheels. Trucks and equipment arriving at and leaving the site with materials shall be loaded in a manner that will prevent the dropping of materials or debris on the streets. The contractor shall secure and cover transport equipment and loose materials to ensure that materials do not become airborne during transit. Material with high water content shall not be allowed to leak from truck cargo areas during transport over streets. Spills of materials in public areas shall be removed immediately without additional compensation.

C. Vehicle Engine Anti-Idling

The Contractor is responsible for control of unnecessary engine idling at all times, 24 hours per day, 7 days per week.

Contractor shall perform all Work specified under this Section in compliance with the provisions of the Massachusetts DEP Code of Massachusetts Regulations (CMR) 310 CMR 7.11 "Transportation Media."

The engines to all equipment and vehicles on or adjacent to the work site that are not being actively used in excess of five minutes shall be turned-off. Equipment and vehicles exempt from the five minute anti-idling requirement include: cranes involved with critical lift operations, equipment and vehicles being serviced, vehicles engaged in the delivery or acceptance of equipment or material, and vehicles engaged in an operation which engine power is necessary for an associated power need.

D. Construction Noise Control

The Contractor shall comply with the provisions of the Massachusetts DEP Code of Massachusetts Regulations (CMR) 310CMR 7.10 "Noise."

Contractors and sub-contractors owning, leasing, or controlling equipment that is a source of sound shall not willfully, negligently, or through failure to provide necessary equipment, service, or maintenance, cause, allow, or permit excessive noise emissions.

All construction related activities which characteristically emit sound as well as construction and demolition equipment, should be fitted with and/or accommodated with equipment and/or material to suppress sound as necessary, or be operated in a manner so as to suppress sound.

II. Water Pollution Requirements.

SUBSECTION 7.04 Motor Vehicles.
(page 24 English, page I.32 Metric) Replace the first paragraph with the following:

All motor vehicles (except vehicles used solely for transporting employees to and from the project) and trailers 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.

SUBSECTION 7.05 Insurance Requirements.

*(page 25 English) Replace the 1st sentence of the 3rd paragraph under **A. Workmen's Compensation Insurance.** with the following:*

Such insurance shall not be canceled or otherwise terminated until ten days after written notice of cancellation or termination is given by the party proposing cancellation to the other party or until notice has been received that the employer has secured insurance from another insurance company or has otherwise insured the payment of compensation provided for by Massachusetts General Laws Chapter 152 as amended.

*(page 25 English, page I.33 Metric) Replace the entire section under **B. Public Liability Insurance.** with the following:*

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 the Contractor performs, the Contractor carries regular Contractors' Public Liability Insurance providing for a limit of not less than $1,000,000 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 $2,000,000 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 $1,000,000 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 $2,000,000 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/her by Subcontractors, the Contractor carries on his/her own behalf regular Contractor's Protective Public Liability Insurance providing for a limit of not less than $1,000,000 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 $2,000,000 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 $1,000,000 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 $2,000,000 for all damages arising out of injury 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 the Contractor or any of his/her Subcontractors perform, the Contractor has provided for and on 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.

4. Asbestos Liability Insurance.

In addition to the above, when items for asbestos testing or removal are contained in the bid items for the project, the Contractor shall furnish evidence to the Department that, with respect to the work the Contractor or any of his/her Subcontractors perform, the Contractor carries on behalf of him/her self Asbestos Liability Insurance providing for a limit of not less than $1,000,000 for all damages arising out of bodily injuries to or death of one person, and subject to that limit for each person, a total or aggregate limit of $2,000,000 for all damages arising out of bodily injuries to or death of two or more persons in any one asbestos related incident.

(page 26 English, page I.34 Metric) Add the following new paragraph under C. General:

6. Insurers shall be licensed and registered in accordance with Massachusetts General Laws. Policies shall indemnify against loss with no deductible amount. Policies shall not contain any provision for Contractor self-insurance.

SUBSECTION 7.06 Patented Devices, Materials and Processes.

(page 26 English, page I.34 Metric) Replace this Subsection with the following:

It is mutually understood and agreed that, without exception, contract prices are to include all royalties and costs arising from patents, trademarks and copyrights in any way involved in the work. It is the intent that whenever the contractor is required or desires to use any design, device, material or process covered by letters patent or copyright, the right for such use shall be provided for by suitable legal agreement with the patentee or owners. A copy of this agreement shall be filed with the Engineer; however, whether or not such agreement is made or filed as noted, the contractor and the surety in all cases shall indemnify and save harmless the Department from any and all claims for infringement by reason of the use of any such patented design, device, material or process to be involved under the contract. The Contractor and the surety shall indemnify the Department for any cost, expenses and damages which it may be obliged to pay, by reason of any such infringement, at any time during the prosecution or after the completion of the work.

SUBSECTION 7.09 Public Safety and Convenience.

(page 27 English) Change the word include to included in the last sentence of the third paragraph.

(page 27 English, page I.35 Metric) Add the following paragraph after the fourth paragraph:

The Contractor shall provide to the Engineer and to the police and fire departments of each affected municipality a contact list of contractor personnel who can be notified in the event of an emergency. The list shall have the names and telephone numbers of personnel available 24 hours a day, 7 days a week for the duration of the field work. The list shall be kept current and shall include secondary contacts as needed to ensure that an authorized person is available at all times to mobilize crews as required to respond to emergencies. If contacted directly by emergency response personnel, the Contractor shall immediately notify the Engineer.

(page 27 English, page I.35 Metric) Replace the 6th paragraph with the following:

The safety and convenience of the travelling public takes precedence over the convenience of the Contractor.

Where the construction impacts the traveled way, traffic flow shall be maintained in accordance with the approved traffic management plan.

At any time during operations when a traffic delay occurs resulting in conditions which, as determined by the Engineer, significantly impede traffic or create a hazard to public safety, the Engineer will suspend the work and order the roadway opened to full available capacity. The Contractor shall immediately cease operations affecting traffic and provide a safe travel way.

No additional compensation will be paid for suspending the work. The sole allowance for any such suspension is an extension of time as provided by Subsection 8.10.

If significant, unexpected traffic delays are recurring, the Contractor may be required to modify the work hours and the traffic management plan.

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.

(page 27 English, page I.36 Metric) Add the following paragraph after the eleventh paragraph of the Subsection:

Work is restricted to a normal 8-hour day, 5-day week, with the Prime Contractor and all Subcontractors working on the same shift. No work shall be done on Saturdays, Sundays, holidays, or the day before or after a holiday without prior approval of the Engineer.

SUBSECTION 7.09 (continued)

(page 27 English, page I.36 Metric,) Replace from the paragraphs starting with "Trenches shall not be opened…" to the end with the following:

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 an HS20 Loading with 33% 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.

At the end of each working day where trenches in areas of public travel are covered with steel plates, each edge of such plates shall either be beveled or protected by a ramp with a slope of 2-feet (600 mm) horizontally to 1-inch (25 mm) vertically. Temporary patching material for the ramps shall meet the requirements of Section 472 Hot Mix Asphalt for Miscellaneous Work. The cost of necessary patching materials, and their maintenance and removal, will be considered incidental to the item involved, with no separate payment.

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 safely sustaining an HS20 Loading with 33% impact. The cost of necessary covers or plates will be considered incidental to the item involved with no separate payment.

SUBSECTION 7.11 Traffic Officers and Railroad Flagging Service.

(page 28 English, page I.36 Metric) Replace this Subsection with the following:

The Contractor shall provide such police officers as the Engineer deems necessary for the direction and control of traffic within the site. Such officers shall wear regulation policemen's uniforms and reflectorized safety vests meeting the requirements of ANSI 107, Class 3. They may be reserve, special, or regular officers not subject to the control of the Contractor.

Compensation for the services of said police officers will be paid by the Contractor to their employers, subject to all rules and regulations, ordinances, or by-laws in effect in the city or town in which the work is being performed. The Department shall pay the same hourly rate as the municipality in which they are working pays its police for similar work on the municipality's projects as set by the municipality's collective bargaining agreement. The Department shall not pay any administrative charges charged by the municipality in association with the police costs. The Department will pay the Contractor for all police officers approved by the Department. Within two weeks from the issuance of payment by the Department for police costs, the Contractor shall submit proof that payment has been made to the police department. Failure of the Contractor to provide proof of payment within the two week period will result in the following: (a) the removal of the prior payment from the subsequent estimate; and (b) all future payments will be made on a reimbursement basis, based upon the receipt of a cancelled check.

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 flagger or flaggers or other railroad employees are required by the Chief Engineer of the railroad company and personnel are assigned by that Chief Engineer for the protection of the property and traffic of the Railroad against hazards, the cost of all such flagging services will be paid by the Contractor to their employers, subject to the rules and regulations of the railroad company. The Department will only pay the Contractor for the costs of flaggers in the same manner as described above for police officers. The Department shall not pay any administrative charges associated with the costs of flaggers charged by the railroad nor shall the Department pay charges for debit accounts if such accounts are required by the railroad.

SUBSECTION 7.13 Protection & Restoration of Property.
(page 29 English, page I.37 Metric) Add the following paragraph after the first paragraph, and capitalize "The" at the start of the second sentence of the 7th paragraph of the English book:

The Contractor shall maintain all drainage systems in the project areas to provide continual drainage of the travelways and construction area. All pipes and structures installed as part of this Contract shall be left in a clean and operable condition at the completion of the work.

(page 29 English, page I.37 Metric) Replace the last paragraph with the following:

The Contractor shall adhere to all requirements established by Occupational Safety and Health Administration and take all necessary precautions for the protection of personnel and equipment. The bidder's attention is directed to the Code of Federal Regulations Part 1926 - *Safety and Health Regulations for Construction*, Subpart CC, 1926.1408 *Power line safety (up to 350 kV)--equipment operations* which establishes the minimum clearance between the lines and any part of the crane or load. If the voltage is unknown the minimum clearance is 20 feet. If the line is known to be rated 50 KV or below the minimum clearance is 10 feet. For higher voltages consult the above referenced subsection. For protection of personnel and equipment, the Contractor should be aware of this regulation especially during paving operations using dump trucks.

SUBSECTION 7.14 Responsibility for Damage Claims.
(pages 29 English, page I.38 Metric) Replace the first paragraph with the following:

The Contractor shall indemnify, defend, and save harmless the Commonwealth, the Department, the Municipality, and all of its offices, agents, and employees from and against all claims, damages, losses, and expenses, including attorney's fees, for or on account of any injuries to persons or damages to property arising out of or in consequence of the acts of the Contractor in the performance of the work covered under the contract or failure to comply with the terms and conditions of said contract, and is caused in whole or in part by any negligent act or omission of the Contractor, any subcontractor, anyone indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by a party indemnified hereunder.

SUBSECTION 7.16 Claims of Contractor for Compensation.
(page 35 English, page I.44 Metric) Add (English) / Replace (Metric) this paragraph above the last paragraph of the Subsection:

Interest on judgments for contractor claims filed with the Superior Court of Massachusetts shall be calculated pursuant to the provisions of M.G.L. c. 231, §6 I from the date of the breach or demand. If the date of the breach or demand is not established, such interest shall be calculated from the date of the commencement of the action.

SUBSECTION 7.23 Archeological and Paleontological Discoveries.
(page 38 and 38 English, page I.47 Metric) Replace this Subsection with the following;

7.23 Discovery of Unanticipated Archaeological and Skeletal Remains.

Should any archaeological remains be encountered during any phase of construction, the Contractor shall immediately cease all construction activities in the discovery area, secure the area and notify the Engineer. The Engineer shall immediately notify the MassDOT Environmental Services Section in Boston Headquarters Office. The MassDOT Archeologist shall inspect the remains and their context in order to evaluate the discovery.

In the event a potentially significant archaeological find is encountered, as determined by the MassDOT Archaeologist, the Contractor shall carefully protect the discovery area by placing snow fencing and/or flagging (with an approximately 30-foot buffer zone) around the find(s). The MassDOT Archaeologist shall notify the Federal Highway Administration (if the project is federally funded), the Massachusetts State Archaeologist, the Massachusetts State Historic Preservation Officer/Executive Director of the Massachusetts Historical Commission and other relevant parties (the Massachusetts Commission on Indian Affairs, Tribal Historic Preservation Officers) of the discovery and serve as the liaison on all subsequent actions. Outside the protected discovery area, construction work may continue. Construction may not resume in the discovery area until the MassDOT Archaeologist has secured all necessary regulatory approvals and given the approval to continue to the Engineer.

If skeletal remains are discovered during construction, the Contractor shall immediately cease all work in the discovery area, secure and protect the area and notify the Engineer as stipulated above. The Engineer shall immediately contact the State Medical Examiner, the police and the MassDOT Archaeologist. If the skeletal remains prove to be human and more than 100 years old, as determined by the State Medical Examiner, the MassDOT Archaeologist shall consult with the Massachusetts State Archaeologist and other relevant parties pursuant to all procedures and protocols under the Massachusetts Unmarked Burial Law (M.G.L. Chapter 38, Section 6; M.G.L. Chapter 9, Section 26A and 27C; and M.G.L. Chapter 7, Section 38A) and Section 106 of the National Historic Preservation Act as amended, and its implementing regulations for emergency situations and post-review discoveries [36 CFR 800.12(b)(2) or 36 CFR 800.13(b)].

SECTION 8.00
PROSECUTION AND PROGRESS

SUBSECTION 8.01 Subletting or Assignment of Contract.
(page 38 English, page I.48 Metric) Add the following sentence to the end of the second paragraph:

The Contractor shall not withhold retainage on any subcontract.

(page 38 English, page I.48 Metric) Replace the paragraph just above the last paragraph of this subsection with the following:

(2) Chapter 30, General Laws, Section 39L Public construction work by foreign corporations; restrictions and reports.

SUBSECTION 8.03 Prosecution of Work.
(page 39 English, page I.48 Metric) Add the following to the end of the Subsection:

The contract work shall be expedited when the Engineer determines that the safety and/or the convenience of the public necessitates an earlier completion date for the performance of the work contained in the contract.

Compensation for expediting the work shall be based on the actual added cost of direct labor as applied to the overtime labor cost only. The contractor shall accept as full compensation for the actual added cost of expediting the contract work the following:

(a) The added overtime premium portion of the direct labor costs (the premium labor cost less [minus] the regular time labor cost);
(b) Plus the actual cost for payroll taxes associated with (a) above.
(c) Plus an overhead additive of 10% of the total of (a) and (b) above for related overhead.
(d) Plus any proportionate added cost for surety bond.

For work performed by a Subcontractor, the Contractor shall accept as full payment thereof an amount equal to the added cost to the Subcontractor as determined above, plus 10% of such cost.

No allowance shall be made for general superintendence as such costs shall be considered reimbursed under the overhead additive applied to direct labor. No allowance shall be made for any additional equipment, equipment operating costs, or the use of small tools and manual equipment.

SUBSECTION 8.07 Character of Workmen, Methods and Equipment.
(page 39 English, page I.49 Metric) Change the title as shown below and add the following after the second paragraph of this subsection:

8.07 Character of Workers, Methods and Equipment.

The Contractor is responsible to ensure that all personnel, including all subcontractors, working on the project are issued and are wearing all necessary personal protective safety equipment while working within the project limits. This equipment shall include, as a minimum, a hardhat and a safety vest, regardless of the type of work being performed, and shall include floatation vests for work over or around water. Hardhats shall have a minimum rating meeting ANSI Type I Class E or G and be capable of taking a 40 pound impact; vests shall be a minimum of ANSI/ISEA 107- Class 2. The Contractor shall furnish such hardhats and vests and maintain a sufficient supply of such at the work site for the Contractor's personnel assigned to the project as well as those visiting the work site. Personal protective safety equipment for Roadway Traffic Flaggers is specified in Subsection 850.41.

(pages I.50 Metric) In the second paragraph from the end of this Subsection replace "… by the Contractor is accomplishing…" with "… by the Contractor in accomplishing…".

SUBSECTION 8.10 Determination and Extension of Contract Time for Completion (Time Extensions).
(page 40 English, page I.51 Metric) Replace this subsection with the following:

A. General

It is an essential part of all contracts that contractors shall perform the Work fully, entirely and in an acceptable manner within the contract duration.

The contract duration 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, as specified in the Contract.

The contract duration has been carefully considered and has been established for reasons of importance to the Department. The contract duration will be enforced and it is understood that the Contractor accepted this concept at the time of the submission of the bid. The timing of the Notice to Proceed (NTP) has been taken into account in the determination of the contract duration and the timing of the issuance of the NTP shall not, by itself, be a reason for a time extension.

An extension of contract time will be granted only if entitlement to a time extension has been clearly demonstrated to the satisfaction of the Engineer by a documented time entitlement analysis (TEA), performed in accordance with the requirements of Subsection 8.02.

B. Requests for Additional Contract Time (Time Extensions)

In response to a request for a time extension, an extension of contract time may be granted for demonstrated delays resulting from only one, or, in the case of concurrent delays, a combination of the following causes:

1. Extra Work

Each extra work order (EWO) proposal shall include an evaluation of the impact of the EWO on contract time, expressed in calendar days. If there is no impact to the contract time as a result of the EWO, the EWO shall indicate this by stating that zero calendar days of additional time is being requested. The need for a time extension as a result of the EWO must be clearly demonstrated by a documented TEA performed by the Contractor in accordance with the requirements of Subsection 8.02. A documented preliminary TEA supporting the EWO proposal shall be submitted to the Engineer as part of the EWO proposal. Also see Subsection 4.03 – *Extra Work and Subsection* and 4.05 – *Validity of Extra Work*.

2. Department-Caused Delays

If any part of the Work is delayed or suspended by the Department, the Contractor will be granted a time extension to complete the Work or any portion of the Work only if entitlement to this time extension has been clearly demonstrated by a documented time entitlement analysis. Department-caused delays shall not include delays to or suspensions of the Work that result from the fault or negligence of the Contractor. Also see Subsection 8.05 – Claim for Delay or Suspension of the Work.

3. Increased Quantities

Increased quantities of work may be considered as the basis for a time extension only if the requirements of Subsection 4.06 - Increased or Decreased Contract Quantities are met. The time allowed for performance of the Work will be increased based on increased quantities only if entitlement to this time extension has been clearly demonstrated by a documented time entitlement analysis. A decrease in quantities shall also require a time entitlement analysis to determine if a deduction of contract time is warranted.

4. Delays Not Caused by Contractor Fault or Negligence

When delays occur due to reasonable causes beyond the control and without the fault or negligence of the Contractor, including, but not restricted to: "Acts of God"; 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, and/or freight embargoes; a time extension will be granted only if entitlement to a time extension has been clearly demonstrated by a documented time entitlement analysis.

An "Act of God" as used in this subsection is construed to mean an earthquake, flood, cyclone, hurricane, tornado, or other cataclysmic phenomenon of nature beyond the power of the Contractor to foresee and/or make preparations against. Additional consideration may be given to severe, abnormal flooding in local rivers and streams that has been reported as such by the National Weather Service. Rain, wind, snow, and/or other natural phenomena of normal intensity, based on National Weather Service 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 time extension 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 of preference ratings by the Federal Government or its agencies to defense contracts of any type.

5. Delays Caused by Public Service Corporations, Municipal Departments or Other Third Parties

If any part of the Work is delayed by public service corporations, municipal departments or other third parties, a time extension will be granted only if entitlement to a time extension has been clearly demonstrated by a documented time entitlement analysis. Also see Subsections 5.05 - *Cooperation by Contractor*, 5.06 - Adjacent Contracts and 8.04 - *Removal or Demolition of Buildings and Land Takings*.

C. Time Extension Determination

1. When the Contractor submits a request for a time extension, placing the Department on notice of a delay due to any of the causes listed in Subsection 8.10.B, it shall be submitted in writing to the Engineer within 15 calendar days after the start of the delay. No time extension will be granted if a request for a time extension is not filed within 15 calendar days after the start of the delay.

A documented preliminary TEA supporting the request for a time extension and meeting the requirements of Subsection 8.02 shall be submitted to the Engineer no later than 30 calendar days after the start of the delay. A documented final TEA shall be submitted to the Engineer no later than 15 calendar days after the end of the delay. During the time between the preliminary and final TEA, the delay shall be documented in contract progress schedules submitted in accordance with the requirements of Subsection 8.02.

2. No time extension will be granted for any delay or any suspension of the Work due to the fault of the Contractor.

3. No time extension will be granted if the request for a time extension is based on any claim that the originally established contract duration was inadequate.

4. Time extensions will only be granted for delays, including concurrent delays, to activities affecting contract milestones, the contract completion date and/or other critical path activities as demonstrated to the satisfaction of the Engineer by a detailed time entitlement analysis that clearly states the number of calendar days of extra time being requested.

5. The probable slowdown or curtailment of work during inclement weather and winter months has been taken into consideration in determining the contract duration and therefore no time extension will be granted, except as defined in Subsection 8.10.B.4.

6. Any work restriction related to weather, permit conditions, community accommodation, traffic or any other restriction specified in the Contract or reasonably expected for the particular locality and for the particular season of the year in which the Work is being prosecuted must be considered in the analysis of each individual time extension and shall not be considered, in itself, justification for an extension of time.

7. Any time entitlement analysis prepared for the purpose of requesting a time extension shall clearly indicate any proposed overtime hours or additional shifts that are incorporated in the schedule. The Engineer shall have final approval over the use of overtime hours and additional shifts and shall have the right to require that overtime hours and/or additional shifts be used to minimize the duration of time extensions if it is determined to be in best interest of the Department to do so.

D. Disputes

Any dispute regarding whether or not a time entitlement analysis demonstrates entitlement to a time extension, the number of days granted in a time extension or any other question of fact arising under this subsection shall be determined by the Engineer.

SUBSECTION 8.10 (continued)

The Contractor may dispute a determination by the Engineer by filing a claim notice within 14 calendar days after the Contractor's request for additional time has been denied or if the Contractor does not accept the number of days granted in a time extension. The Contractor's claim notice shall include a time entitlement analysis that sufficiently explains the basis of the time-related claim. Failure to submit the required time entitlement analysis with the claim notice shall result in denial of the Contractor's claim.

SUBSECTION 8.11 Failure to Complete Work on Time.

(page 42 English, page I.52 Metric) Change the first sentence of the second paragraph to read:

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 Department a designated sum per day for the entire period of overrun in accordance with the following Schedule of Liquidated Damages.

(page 42 English, page I.52 Metric) Add the following to the end of this Subsection (English). Revise the table at the bottom of the page to read as follows (Metric).

SCHEDULE OF LIQUIDATED DAMAGES	
PROJECT VALUE - DOLLARS	LIQUIDATED DAMAGES DOLLARS / DAY
0 to 100,000	$575.00
100,000 to 500,000	$850.00
500,000 to 1,000,000	$975.00
1,000,000 to 2,000,000	$1,250.00
2,000,000 to 3,000,000	$1,550.00
3,000,000 to 4,000,000	$1,800.00
4,000,000 to 5,000,000	$2,200.00
5,000,000 to 10,000,000	$2,400.00
10,000,000 to 15,000,000	$2,700.00
over 15,000,000	$3,500.00

SUBSECTION 8.13 Convenience Termination.
(page 43 English, page I.54 Metric) Replace this Subsection with the following:

If the Department 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 Department may designate.

If the Department notifies the Contractor to discontinue all work, or any part thereof, the Department shall pay and the Contractor shall accept, as full payment for all work and materials provided, a sum agreed to by the Contractor and the Department. If a sum cannot be agreed upon, the Contractor shall accept the sum of A. for the completed work, plus B. and C. for other costs, determined as follows:

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

The original contract unit prices.

B. For Construction Related Costs.

(1) The actual costs for direct labor (direct labor costs shall include the actual salary costs of laborers, equipment operators, truck drivers, steel workers and other trades persons up to and including working foremen. The costs of general superintendence shall be considered included in field and/or home office overhead.), materials (less salvage value, if any) and use of equipment (determined in accordance with Subsection 9.03 of the Standard Specifications), plus 10% of this total for overhead (the 10% additive is inclusive of both field and home office overhead); and
(2) the actual cost for Salary Related Costs such as Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits, Social Security deductions, and Employment Security Benefits; and
(3) 10% 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% of such cost.

No allowance shall be made for general superintendence and the use of small tools and manual equipment. General superintendence is that next level above the working foreman. The costs of general superintendence as well as use of small tools and manual equipment shall be considered included in field and/or home office overhead.

C. For Discontinuance Costs.

The reasonable and necessary costs of storage, transportation and other costs incurred for the preservation, protection or disposition of the discontinued work which are pre-approved by the Department to be determined as follows:
(1) the actual costs for direct labor (Direct labor costs shall include the actual salary costs of laborers, equipment operators, truck drivers, steel workers and other trades persons up to and including working foremen. The costs of general superintendence shall be considered included in field and/or home office overhead.), materials (less salvage value, if any) and use of equipment (determined in accordance with Subsection 9.03 of the Standard Specifications), plus 10% of this total for overhead (the 10% additive is inclusive of both field and home office overhead); and
(2) the actual cost for Salary Related Costs such as Workmen's Compensation and Liability Insurance, Health, Welfare and Pension benefits, Social Security deductions, and Employment Security Benefits.

No allowance shall be made for general superintendence and the use of small tools and manual equipment. General superintendence is that next level above the working foreman. The costs of general superintendence as well as use of small tools and manual equipment shall be considered included in field and/or home office overhead.

The reasonable and necessary legal costs of work discontinuance, plus an additive of 10% for overhead (the additive is inclusive of both field and home office overhead), is allowable. The legal costs for litigation and/or negotiation purposes with the Department in settlement of said discontinuances are not allowable.

Any other reasonable and necessary costs for discontinuance that are pre-approved by the Department, plus an additive of 10% for overhead (the additive is inclusive of both field and home office overhead).

When requested by the Department, the Contractor shall furnish itemized statements of the cost of the work performed and shall give the Department (and/or the Department's Auditors) access to any and all financial and/or project records and documents, relating thereto. Unless the Contractor, when requested to do so, furnishes such itemized statements and access to any and all financial and/or project records and documents, the Contractor shall not be entitled to payment for the work for which such information is sought by the Department.

SUBSECTION 8.13 (continued)

The Contractor shall not be paid and the Contractor shall not have any claim for loss of anticipated profits or for any costs or profit in addition to those stipulated above; 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 any other cause.

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

The authority of the Department 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

SUBSECTION 9.02 Scope of Payments.

(page 44 English, page I.57 Metric) Replace the first paragraph with the following:

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, and for providing all required submittals, reports, Certificates of Compliance (COCs) and any other paperwork or supporting documentation required by the plans and specifications, 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 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.

(page 44 English, page I.57 Metric) Delete the words ", or any retained percentage" from the first sentence of the second paragraph.

SUBSECTION 9.03 Payment for Extra Work.

(page 45 English, page I.57 Metric) Replace this Subsection with the following:

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) 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 subcontractor or a Public or Private Utility costs; (4) plus 10 percent of the total of (1), (2) and (3); (5) 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 subcontractor or a Public or Private Utility costs; (4) plus 10 percent of the total of (1), (2) and (3); (5) plus the estimated proportionate cost of surety bonds.

Costs incurred for traffic police, railroad flagging and permits will be reimbursed without mark-up for overhead or profit.

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, the Contractor 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 from the Contractor's records, hourly equipment cost rates for equipment owned by the Contractor may be determined by the use of rate schedules (with adjustments) supplied by EquipmentWatch Cost Recovery™ .

The Contractor shall provide to the Department, in a format prescribed by the Department, sufficient descriptive ownership and operating records and documentation for each piece of equipment subject to the extra work so that the equipment rates may be determined and adjusted as follows:

1) Hourly equipment rates shall be the FHWA rate supplied by EquipmentWatch adjusted by application of the Rate Adjustment Tables (for machine age adjustment) plus adjustments to eliminate equipment overhead (indirect ownership) plus regional adjustments (the weekly, hourly and daily rates listed in EquipmentWatch will not be used). This rate shall be defined as 'Adjusted FHWA Rate'.
2) Equipment standby rates shall be the 'Adjusted FHWA Rate' as described in (1) above, minus the operating rate and reduced by 50%. Standby rates shall not include operating rates:
   Equipment standby rate = (Adjusted FHWA Rate – Estimated Operating Rate)/2

The number of equipment hours to be paid for under the extra work or force account work shall be the number of hours that the equipment is actually used on a specific extra work or force account activity.

The current version of EquipmentWatch will be used in establishing equipment rates. The version applicable to specific extra work or force account work will be the version in effect as of the first day that work is performed on that force account work and that rate shall apply throughout the period during which the force account work is being performed.

In all cases, the Department reserves the right to utilize equipment rates based upon the contractor's actual equipment ownership costs, other equipment rate books and guides (i.e. Construction Equipment Ownership and Operating Expense Schedule, Region One published by the Army Corps of Engineer's) or hybrid rates determined to be reasonable by the Department.

(c) In those cases where a 10 percent additive for overhead and profit is to be superimposed on the equipment costs as provided in Subsections 4.04, and 9.03B, equipment cost rates determined under (a) and (b) above 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 included 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.

SUBSECTION 9.03 (continued)

(3) Reasonable hourly costs of renting equipment are allowable subject to the Contractor producing adequate 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 incidental 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 the Contractor producing adequate 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 31.105, 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.

SUBSECTION 9.04 Partial Payments.

(page 47 English, page I.59 and 60 Metric) Replace the first three paragraphs with the following:

The Engineer shall biweekly make an estimate of the total amount of the work completed from one estimate to the next. The Department may reduce payment on any or all individual pay items to account for the estimated value of documented incomplete or non-conforming work related to that pay item, including, in addition to the physical work, any submittals, Certificates of Compliance (COCs), reports or other paperwork required to support the work of the item. The Party of the First Part shall 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 of the General Laws. 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/her judgment the total value of the work completed since the last estimate amounts to less than $1,000.00.

There will be no retainage held from partial payments.

SUBSECTION 9.04 (continued)
(page 47 English) Add the following after the seventh paragraph.

Payment for structural steel and aluminum, specifically purchased and received by fabricators for incorporation into a Department project may be requested by the Contractor and included in the current estimates in an amount not to exceed 50 percent of the contract price. Certified paid invoices and material certifications must be submitted by the contractor to the Department with the request for payment. The invoices must clearly identify the Department project for which the material is intended along with the material type and quantity. When payment is made, the raw material becomes the property of the Commonwealth of Massachusetts. A document transferring ownership of the raw material to the Commonwealth shall be submitted to the Department immediately after payment is made. Such payment shall in no way release the Contractor from his responsibility for condition, protection and, in case of loss, replacement of such materials or from any liability resulting in any manner from the presence of such materials wherever they may be stored. Any material not conforming to the specifications shall be rejected in accordance with the stipulation of Subsection 6.04.

In instances where the raw material is not in the process of fabrication, the material shall be segregated from other material, designated as "Property of the Commonwealth of Massachusetts", and clearly marked to identify the project into which the material will be incorporated.

All material shall be inspected at the fabricator's plant by a representative of the Department prior to the submittal of invoices to ensure that all material has been received and is properly stored and segregated.

SUBSECTION 9.05 Final Acceptance and Final Payment.
(page 47 English, page I.59 and 60 Metric) Replace the last sentence of the second paragraph with the following:

If the Contractor has not filed valid (as determined by the Engineer) written reasons for not accepting the final estimate within three months from the date the final estimate is forwarded to the Contractor, the final estimate will be considered acceptable to the Contractor and payment of the final estimate made.

DIVISION II
CONSTRUCTION DETAILS

SECTION 101
CLEARING AND GRUBBING

SECTION 101 CLEARING AND GRUBBING
(page 53 English, page II.3 Metric) Replace this section with the following:

DESCRIPTION

101.20 General.

This work shall consist of clearing, grubbing, cutting, removal and disposal of all vegetation and debris from areas 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, etcetera, 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 before storing debris within the Right-of-Way. Any clearing operations beyond the limits set by the Engineer shall be done with the approval of the Engineer and at the Contractor's 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 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 3 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 3feet 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 as directed to provide the minimum vertical clearance including selective trimming of such trees as directed.

101.62 Tree Trimming and 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 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 the minimum vertical clearance directed by the Engineer.

B. Prosecution of Work.

(Supplementing Subsection 8.03.)

All trimming and pruning shall conform to ANSI A300 *For Tree Care Operations - Tree, Shrub, and Other Woody Plant Management - Standard Practices*.

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 arborists with the ISA Tree Worker Climber Specialist certification. 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. Injury to limbs, bark or roots of such plants shall be repaired or the plants replaced by the Contractor, at the discretion of the Engineer, 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 inch tolerance permitted and the resulting stumps or stubble

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 Disposition of Trees, Stumps and Brush.

All trees, tree stumps, including trunk base, root flare and attached root mass and brush to be cleared shall be subject to the regulations and requirements of state and local authorities governing the disposal of such materials. Trees, stumps and brush shall be chipped to 1 inch maximum chip dimension and spread to a depth not to exceed 4 inches, in a location approved by the Engineer, at no additional compensation.

The trees, stumps and brush including cuttings, shall not be stored on site for more than 24 hours unless chipped.

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 without additional compensation.

The Contractor shall be responsible for ensuring that all plant pests on site shall not be carried off site and shall be either destroyed or otherwise contained on site. Plant pests shall include invasive plants, noxious weeds, insect pests, and plant diseases (including infected plant tissue). Method of destruction or containment shall be approved by the Engineer. If invasive or contaminated material cannot be either destroyed or contained on site, contractor shall submit plans for disposal for approval by the Engineer. For current list of plant pests and applicable management procedures see the following on-line references:

Invasive Plants: http://www.massnrc.org/mipag/docs/MIPAG_FINDINGS_FINAL_042005.pdf

Plant Pests: http://www.massnrc.org/pests/factsheets.htm#commodity

COMPENSATION

101.80 Method of Measurement.

Both Clearing and 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 the 5 feet beyond the top or bottom 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 and noise barriers shall be computed on the basis of a 10 foot width multiplied by the total length 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.

Trees and stumps, regardless of size, that fall within an area to be cleared and grubbed or selectively cleared and thinned shall not be measured separately for payment.

Only trees that have a shortest diameter of at least 9 inches and less than 2 feet shall be included in Item 103. Trees Removed (Diameter Under 2 feet). Only trees that have a shortest diameter of 2 feet or more shall be included in the Item 104. Trees Removed (Diameter 2 feet and Over).

Tree trimming shall be measured along the length of the tree trimming operation. Sections along the length of the tree trimming operation where no trees are required to be trimmed for a length of 30 feet or more shall be subtracted from the total length of the tree trimming operation.

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 feet 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 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.

101.81 Basis of Payment.

Clearing and Grubbing will be paid at the contract unit price per acre and shall include the removal of all brush, trees, stumps and roots within the designated area. No separate payment will be made for any individual trees or stumps removed within the area.

Clearing will be paid at the contract unit price per acre and shall include the removal of all brush undergrowth and trees, within the designated area. No separate payment will be made for any individual trees removed within the area.

Selective Clearing and Thinning will be paid at the contract unit price per acre and shall include the removal of all trees as directed, brush, dead, dying and diseased trees, previously fallen trees, branches, uprooted stumps and other debris within the designated area. No separate payment will be made for any individual trees or stumps removed within the area.

When clearing or clearing and grubbing work is not included in the proposal as a payment item, payment for any such work will be included in the excavation or borrow items.

Individual trees to be removed will be paid for at the contract unit price per each and shall include the stump and major root systems. Only trees having a shortest diameter of 9 inches and over as defined in Subsection 101.80 shall be measured for payment.

Tree Trimming will be paid for at the contract unit price per foot.

Stumps to be removed, as defined in Subsection 101.80, will be paid at the contract unit price per each and shall include the major root system.

The contract unit price shall include the cost of all arrangements and methods required to protect from harm all existing overhead or underground installations.

No payment shall be allowed for preparation and spreading of wood chips.

101.82 Payment Items.

101.	Clearing and Grubbing	Acre
101.1	Clearing	Acre
102.	Selective Clearing and Thinning	Acre
102.1	Tree Trimming	Foot
103.	Tree Removed (Diameter Under 2 feet)	Each
104.	Tree Removed (Diameter 2 feet and Over)	Each
105.	Stump Removed	Each

SECTION 112
DEMOLITION OF BUILDINGS, STRUCTURES AND BRIDGES

SUBSECTION 112.60 Demolition of Buildings and Structures.

(page 57 English) Add the following after the second sentence of the ninth paragraph:

All materials which consist of hazardous substances such as lead paint, asbestos, petroleum products, etcetera, shall be disposed of in accordance with state and federal environmental regulations.

SUBSECTION 112.82 Payment Items.

(page 58 English, page II.9 Metric) Replace this Subsection with the following:

112.1	Demolition of Building No. _____	Lump Sum
114.1	Demolition of Superstructure of Bridge No. _____	Lump Sum
115.1	Demolition of Bridge No. _____	Lump Sum
150.	Ordinary Borrow	Cubic Yard (m^3)

SECTION 120
EXCAVATION

SUBSECTION 120.20 General.

(page 59 English, page II.10 Metric) Add the following to the end of this Subsection:

Existing concrete foundations, if not interfering with the proposed construction, may be abandoned in place with approval of the Engineer. Foundations under the roadway surface shall be removed to a depth of 3 feet (1 m) below finished grade. Foundations outside of the roadway surface shall be removed to a depth of 1 foot (300 mm) below the proposed finished grade.

SUBSECTION 120.25 Bituminous Concrete by Cold Planer.

(page 60 English, page II.11 Metric) Replace this Subsection with the following:

120.25 Hot Mix Asphalt Pavement Milling.

This work shall consist of milling and removal of existing Hot Mix Asphalt (HMA) pavement courses from the project by the Contractor. Milling shall be performed in conformity with the limits, line, grade, and typical cross-section shown on the plans. The milled material shall become the property of the Contractor.

SUBSECTION 120.26 Unclassified Excavation.
(page 60 English) Replace this Subsection with the following:

This work shall consist of all earth excavation as specified in Subsection 120.21, rock excavation as specified in Subsection 120.22 and all other excavation not provided elsewhere in the contract.

SUBSECTION 120.63 Presplitting Rock.
(page 62 English) Replace M2.02.6 with M2.01.6 in paragraph number 7.

SUBSECTION 120.66 Bituminous Concrete Excavation by Cold Planer.
(page 62 English, page II.13 Metric) Change the title of this Subsection to Hot Mix Asphalt Pavement Milling. and add the following paragraph after the first paragraph of the Subsection:

For night time milling operations the temporary illumination of the milling area shall require an approved lighting plan in accordance with the requirements of Section 850 before any milling work begins.

SUBSECTION 120.80 Method of Measurement.
SUBSECTION 120.81 Basis of Payment.
SUBSECTION 120.82 Payment Items.
(pages 63 and 64 English, pages 14 and 15 Metric) Replace Bituminous Concrete Excavation by Cold Planer with Pavement Milling at each occurrence.

SUBSECTION 120.81 Basis of Payment.
(page 64 English, page II.15 Metric) Replace the last paragraph of the Subsection with the following:

Pavement Milling will be paid for at the contract unit price per square yard and shall include temporary illumination.

SECTION 140
EXCAVATION FOR STRUCTURES

SUBSECTION 140.20 General.
(page 64 English, page II.15 Metric) Replace the Subsection with the following:

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

SUBSECTION 140.27 Test Pits for Exploration.
(page 65 English, page II.16 Metric) Add this new Subsection in numerical order.

140.27 Test Pits for Exploration.

Test pits shall be excavated where and as directed by the Engineer. The contractor shall take special care during the excavation to avoid damage to any existing structure or conduit. Hand excavation may be required to ensure no damage to surrounding utilities

SUBSECTION 140.60 General.
(page 66 English, page II.18 Metric) Replace paragraph F. Shoring and Bracing of Trenches with the following:

Shoring and bracing of trenches and other excavations shall be in accordance with all OSHA requirements.

SUBSECTION 140.63 Drainage Structures Abandoned or Removed.
(page 67 English, II.19 Metric) Replace the second paragraph with the following;

Inlets and outlets of structures to be abandoned shall be plugged with masonry. The masonry plug shall conform to the requirements of Section 270. 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.

SUBSECTION 140.80 Method of Measurement.
(page II.20 Metric) In the second full paragraph of the page, replace the word 'scope' with 'slope' in the third sentence and replace 'be1 meter' with 'be 1 meter' in the fifth sentence.

(page 68 English, page II.20 Metric) Add this new paragraph to the end of this Subsection.

Test Pit for Exploration will be measured as the actual volume removed to the limits established by the Engineer.

SUBSECTION 140.81 Basis of Payment.
(page 69 English, page II.21 Metric) Delete the last sentence of the 6th paragraph of the Subsection starting with "Test pits exclusively for the purpose…"

(page 69 English, page II.21 Metric) Add the following after the 6th paragraph:

Test Pit for Exploration shall be paid for at the contract unit price per cubic yard which price shall include excavation (including hand excavation) backfilling and compaction.

(page 69 English, II.21 Metric) Replace the last two paragraphs with the following;

Drainage Structures Abandoned and Drainage Structures Removed will be paid for at the contract unit price each. Masonry plugs shall be incidental to the work.

SUBSECTION 140.82 Payment Items.
(pages 69 and 70 English, page II.21 Metric) Replace this Subsection with the following:

140.	Bridge Excavation	Cubic Yard (m^3)
140.1	Bridge Excavation within Cofferdam	Cubic Yard (m^3)
141.	Class A Trench Excavation	Cubic Yard (m^3)
141.1	Test Pit for Exploration	Cubic Yard (m^3)
142.	Class B Trench Excavation	Cubic Yard (m^3)
143.	Channel Excavation	Cubic Yard (m^3)
144.	Class B Rock Excavation	Cubic Yard (m^3)
145.	Drainage Structure Abandon	Each
146.	Drainage Structure Removed	Each

SECTION 150
EMBANKMENT

SUBSECTION 150.40 General.

(page 73 English, page II.25 Metric) Replace this Subsection with the following:

All embankment material, 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.

The material will be classified into particular groups according to AASHTO 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
Reclaimed Pavement Borrow Material	M1.09.0
Crushed Stone	M2.01.0

Reclaimed Pavement Borrow Material meeting Subsection M1.09.0 may be substituted for Ordinary Borrow, Special Borrow or Gravel Borrow under pavement areas and sidewalks.

SUBSECTION 150.62 Embankment Construction With Materials Other Than Rock.

(page 74 English, page II.27 Metric) Replace the fourth paragraph of the Subsection with the following:

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 T 99, Method C, corrected in accordance with AASHTO T 224. If the material retained on the ¾ inch (19 mm) sieve is 30 percent or more of the total sample, this test shall not apply and the material shall be compacted to the target density. The target density shall be established by determining the number of passes of a roller required to produce a constant and uniform density, after conducting a series of tests using either AASHTO T 310, *In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)*, or AASHTO T 191, *Density of Soil In-Place by the Sand-Cone Method*. The Contractor shall, without additional compensation, employ whatever measures may be necessary to adjust the natural water content of the suitable embankment material to permit the placement and compaction as hereinbefore specified.

SUBSECTION 150.64 Backfilling for Structures and Pipes.

(page 76 English, page II.28 Metric) Replace the second paragraph under C. Pipes with the following:

Material used for backfilling to a point 2 feet (600 mm) over the pipe shall contain no stones larger than 3 inches (75 mm) in greatest dimension, except material used to backfill corrugated plastic pipe shall consist of gravel borrow meeting the requirements of M1.03, Gravel Borrow Type d to a depth of 2 feet (600 mm) over the top of pipe.

(page 76 English, page II.28 Metric) Delete the fourth paragraph under C. Pipes.

SUBSECTION 150.66 Gravel Borrow for Bridge Foundations.
(page 76 English, page II.29 Metric) Replace this Subsection with the following:

The gravel shall be placed on firm material free from standing water and thoroughly compacted in layers not exceeding 12 inches (300 mm) in depth, loose measurement, in accordance with the provisions of Subsection 150.62 to a minimum total depth of 2 feet (600 mm), except the compacted gravel as tested in the field shall be not less than 95% of the laboratory maximum density as determined by AASHTO T 180 Method D, corrected in accordance with AASHTO T 224.

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.

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.

SUBSECTION 150.68 Crushed Stone for Drainage, Revetment and/or Water Works Foundations.
(page 77 English, page II.29 Metric) Replace the entire Subsection with the following:

150.68 Crushed Stone.

Crushed stone shall meet the Division III Materials specification for the intended application as follows:

Noise Barrier.....M2.01.2
Pipe bedding M2.01.4
Revetment foundations M2.01.2

The minimum total depth of crushed stone to be placed under this item of work shall be 6 inches (150 mm). No compaction will be required for depth up to 1 foot (300 mm). For any depth over 1 foot (300 mm), the crushed stone shall be placed and compacted in layers not to exceed 6 inches (150 mm). 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.

SUBSECTION 150.82 Payment Items.
(page 78 English, page II.30 Metric) Add payment item 151.01 in numerical order and replace payment item 156. with the following:

151.01	Gravel Borrow - Type c	Cubic Yard (m^3)
156.	Crushed Stone	Ton (Mg)

SECTION 170
GRADING

SECTION 170 GRADING
(page 78 English, page II.30 Metric) Replace this Subsection with the following;

DESCRIPTION

170.20 General.

The shaping, trimming, compacting and finishing 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 conformance 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 no. 200 sieve, 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.

In areas where the contract specifies the use of gravel borrow for subbase and the existing material, after testing, is found to comply with the requirements of Subsection M1.03.0, the material shall remain in place if directed by the Engineer.

170.61 Fine Grading and Compacting.

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 square yard. Grading and finishing for the entire project will include all grading work not included under Item 170. Fine Grading and Compacting – Subgrade Area.

170.81 Basis of Payment.

Payment for the shaping and compacting of the subgrade shall be included in Item 170. Fine Grading and Compacting – 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 or existing gravel areas to remain in place will be included in the price of the other respective items of work involved.

In areas where Special Borrow 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 excavation.

In areas where Gravel Borrow material is required as stipulated in Subsection 170.60, the material shall be paid for as Gravel Borrow.

170.82 Payment Items.

150.1	Special Borrow	Cubic Yard
151.	Gravel Borrow	Cubic Yard
170.	Fine Grading and Compacting – Subgrade Areas	Square Yard

SECTION 190
BORINGS

SUBSECTION 190.21 Borings, Samples and Reports.
(page 80 English, page II.32 Metric) Replace this subsection with the following:

All Borings including Trial Borings, Auger Borings, Wellpoints, Probes and Test Pits shall require boring logs and/or records. Three copies of the final boring logs, one vellum and 2 paper copies, and 2 diskettes of the electronic files in Autocad compatible format shall be submitted to the MassDOT Geotechnical Engineer within 10 calendar days after completion of the last boring at each site. Abbreviations shall not be used on the final printed logs .

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 logs are submitted, transportation prepaid, to the MassDOT Geotechnical Engineer.

A supply of Boring Record Cards for Department projects may be obtained upon request from the MassDOT Geotechnical Engineer to be glued on both ends of each cardboard sample box.

Where Borings are specified, a legible copy of the Driller's field log shall be forwarded to the MassDOT Geotechnical Engineer the day after the Boring work at each site is completed.

The original drillers field log (copy) will be submitted to the MassDOT Geotechnical Engineer with the Driller's field description unaltered. Should the Contractor's Office Engineer or Geologist after review find it necessary to change a description it shall be done on a separate copy of the field log, dated, signed, and clipped to the original Driller's log. Copies of these logs shall be sent to the MassDOT Geotechnical Engineer no later than one day after the completion of each borehole.

SUBSECTION 190.60 General.
(page 81 English) Under A. Starting Boring, Replace the first sentence with the following:

Every boring shall start as a Drive Sample Boring, except Hollow Stem Auger, Auger, Undisturbed Sample Preparatory, and Vane Shear Test Preparatory Borings.

(page 81) Under B. Casing, Replace the first sentence with the following:

Casing shall be of a size that will permit the specified soil sample or rock core to be obtained, or groundwater observation well to be installed, or to allow for telescoping and spinning of casing.

SUBSECTION 190.61 Drive Sample Borings.
(page 82 English) Replace the 6th and 7th paragraphs, which starts "In no event...", with the following:

In no event will washed, bucketed, or bobbed samples be accepted.

Before sampling, the driller shall mark the drill rods in three successive 6 inch (150 mm) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6 inch (150 mm) increment.

During the sampling operation, the driller of the boring crew shall count and record the number of blows required to effect each 6 inch (150 mm) increment of penetration or fraction thereof for a distance of 18 (450 mm) inches using a 140 lb. weight (63.5 kg mass) free-falling 30 inches (760 mm).

The number of blows required to effect each 6 inches (150 mm) of penetration or fraction thereof for a distance of 18 inches (450 mm) shall be recorded on the field log and final log.

The first 6 inches (150 mm) shall be considered to be the seating drive. The summation of the number of blows for the second and third 6 inch (150 mm) increment of penetration shall be the penetration resistance (N).

The blow counts shall be shown on the final boring log as recorded in 6 inch (150 mm) increments or fraction thereof, if the sampler fails to penetrate the 6 inches (150 mm), with the corresponding sample depth.

SUBSECTION 190.68 Vane Shear Test.
(page 86 English, page II.39 Metric) Replace the 4th sentence of the 3rd paragraph with the following:

Equipment shall be acceptable to the Engineer and in good working order.

SECTION 201 BASINS, MANHOLES AND INLETS

(page 91 English, page II.44 Metric, SUPPLEMENT C2012-34) Replace this Section with the following:

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. 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 Drainage Structures M4.02.16
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. Basins 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.

201.61 Excavation.

Excavation shall conform to the applicable portions of Section 140.

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 settling 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 Special Provisions.

201.64 Weep Holes.

Two 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 ¼ 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 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 feet Depth) or Manholes (14 to 18 feet Depth) do not appear in the Proposal the standard unit of depth for all structures shall be 6 ½ feet.

Special manholes will be measured as complete units regardless of depth.

Frames and grates or covers will be measured by each complete unit furnished and delivered to the site.

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 include crushed stone for weep holes and installation of the frame and grate or cover .

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.

Frames and grates or covers will be paid for at the contract unit price each under the items for furnishing and delivering new frames and grates or covers.

Hoods shall be paid at the contract unit price each and shall include furnishing and installation of the hood.

201.82 Payment of Items.

201.	Catch Basin	Each
202.	Manhole	Each
202.2	Manhole (9 to 14 Foot Depth)	Each
202.3	Manhole (14 to 18 Foot 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 - MassDOT Bar Type	Each
222.1	Frame and Grate- MassDOT Cascade Type	Each
222.2	Frame and Grate - MassDOT Drop Inlet	Each
222.3	Frame and Grate (or Cover) Municipal Standard	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	Ton

*Pipe or appurtenance size will be included as part of the item number to differentiate between the sizes.

SECTION 220
ADJUSTMENT, REBUILDING AND REMODELING OF DRAINAGE STRUCTURES

SECTION 220 ADJUSTMENT, REBUILDING AND REMODELING OF DRAINAGE STRUCTURES

(page 93 English, page II.47 Metric, SUPPLEMENT C2012-35) Replace this Subsection with the following:

DESCRIPTION

220.20 General.

The work shall consist of rebuilding, removing, replacing, discarding 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 by 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 judgment 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 3 inches of hot mix asphalt.

Frames and grates (or covers) determined to be unsatisfactory for reuse shall become the property of the Contractor and shall be removed and discarded. All frames and grates or covers designated to be discarded shall be carefully removed, transported and discarded in accordance with all applicable regulations.

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/her 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.

Drainage Structure Adjusted will be measured in place by the unit each, complete and approved.

Drainage Structure Remodeled will be measured in place by the unit each, complete and approved.

Drainage Structure Changed in Type will be measured in place by the unit each, complete and approved.

Drainage Structure Rebuilt shall be measured by the average height in feet, vertically to the nearest 1/10 of a foot, from the bottom of rebuilt masonry to the bottom of the casting. The removal and resetting of the casting shall be incidental to the work.

Frame and Grate (or Cover) Removed and Discarded shall be measured by each unit of frame and grate or frame and cover removed and discarded.

The chart below summarizes the items utilized on common types of work.

Item Number	Item Description / Pay Unit	Items necessary to Build a new Drainage Structure	Items necessary to Adjust a Structure (6 inches or less)	Items necessary to Rebuild a Structure	Items necessary to do a structure Change-in Type	Items necessary to Remodel a Structure
201 / 202	Catch Basin or Manhole / Ea	✓				
222.1, 221. 222.	Frame and Grate or Cover / Ea	✓	If required	If required	✓	If required
224.*	Hood / Ea	If required	If required	If required	If required	If required
220	Drainage Structure Adjusted / Ea		✓			
220.2	Rebuild / Foot			✓		
220.3	Change-in-Type / Ea				✓	
220.5	Remodel / Ea					✓

220.81 Basis of Payment.

Drainage Structure Adjusted will be paid for at the contract unit price each.

Drainage Structure Change in Type will be paid for at the contract unit price each.

Drainage Structure Remodeled will be paid for at the contract unit price each.

Drainage Structure Rebuilt will be paid for at the contract unit price per vertical foot.

The work of removing, adjusting and resetting the casting and installation of new castings shall be incidental to the pay items for adjust, rebuild, remodel, or change in type of the structure.

Frames and grates or covers furnished and delivered to the site will be paid for under the provisions of Section 201.

Frame and Grate (or Cover) Removed and Discarded shall include all labor, equipment and transportation necessary to remove and discard the materials to the satisfaction of the Engineer.

Furnishing new hoods shall be paid for at the contract price each under the items for ___ Inch Hood.

220.82 Payment Items.

220.	Drainage Structure Adjusted	Each
220.2	Drainage Structure Rebuilt	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 - MassDOT Bar Type	Each
222.1	Frame and Grate- MassDOT Cascade Type	Each
222.2	Frame and Grate - MassDOT Drop Inlet	Each
222.3	Frame and Grate (or Cover) Municipal Standard	Each
223.2	Frame and Grate (or Cover) Removed and Discarded	Each
224.*	___ Inch Hood	Each

*Pipe or appurtenance size will be included as part of the item number to differentiate between the sizes.

SECTION 227 DRAINAGE SYSTEM SEDIMENT

(page 95 English, page II.48 Metric) Add the following Section in numerical order:

SECTION 227
DRAINAGE SYSTEM SEDIMENT

DESCRIPTION

227.10 General

The work shall consist of removal and disposal of accumulated sediment, which may contain refuse and other debris, from designated drainage systems, including: drainage structures, pipes, the gutter mouth of curb inlets, and as directed by the Engineer.

CONSTRUCTION METHODS

227.21 Regulatory Requirements

Drainage system sediment is classified as a solid waste by the DEP and must be handled and disposed in accordance with Solid Waste Management Regulations 310 CMR 19.000, as well as all other applicable DEP policies and guidance.

Sediment must arrive at the disposal facility sufficiently dry since DEP regulations prohibit landfills from accepting materials that contain free draining liquids. A permitted solid waste disposal facility may require characterization of the material prior to accepting it for disposal at the facility. The Contractor shall provide copies of all material shipping records to the Engineer.

227.23 Prosecution of Work

No casting shall be removed until immediately preceding the work and shall be replaced immediately after the cleaning of the drainage structure and/or pipes is completed. Open catch basins shall not be left unattended. The Contractor shall properly secure the grate locking device after cleaning.

The Contractor shall protect the cast iron hood of drainage structures so equipped, during the sediment removal process. Equipment used to collect drainage system sediment shall be capable of decanting free flowing liquids back into the drainage system. Conditions such as location, extraordinary shape due to conduits or public utility pipes, or off pavement work, may require hand work. Drainage system sediment shall be transported to a disposal facility in trucks that will not spill the material along the roadway. Any sediment falling on the roadway shall be removed by the Contractor at his own expense.

COMPENSATION

227.30 Method of Measurement

Sediment removed from drainage structures will be measured by the cubic yard after decanting.

Sediment removed from drainage pipes will be measured by the foot of drainage pipe, regardless of the diameter of pipe from which material is removed.

227.31 Basis of Payment

Removal and disposal of drainage structure sediment will be paid for at the contract unit price per cubic yard.

Removal and disposal of drainage pipe sediment will be paid for at the contract unit price per foot, regardless of the volume of sediment removed.

The price of these items shall include all labor, equipment, approvals, permits, testing, transportation, disposal and all other incidentals necessary to complete the work.

227.32 Payment Items

227.3	Removal of Drainage Structure Sediment	Cubic Yard
227.31	Removal of Drainage Pipe Sediment	Foot

SUBSECTION 230.40 General.

(page 95 English, page II.49 Metric) Replace "Asphalt Coated Corrugated Metal Pipe" with "Corrugated Metal Pipe", delete Asphalt Coated Corrugated Metal Pipe (Aluminum) M5.03.3, Corrugated Metal Pipe (Aluminum) M5.03.3, Cement Concrete Pipe M5.02.0, Clay Pipe M5.01.0 and add the following material designations:

Corrugated Plastic (Polyethylene) Pipe M5.03.10
Corrugated Plastic Flared Ends.....M5.03.10

SUBSECTION 230.60 General.

(page 96 English, page II.49 Metric) Replace this Subsection with the following:

Excavation and backfill shall conform to the applicable portions of Sections 140 and 150.

SUBSECTION 230.62 Pipe Joints.

(page 96 English) Delete the last sentence in the first paragraph and substitute the following:

Corrugated metal pipe and corrugated plastic (polyethylene) pipe shall be firmly joined with an approved coupling.

(page 96 English, page II.50 Metric) Replace the 4th and 5th paragraphs with the following:

Where water tight joints are required, reinforced cement concrete pipe shall be joined using flexible water tight rubber gaskets conforming to ASTM C443. Any alternative joint design must be pre-approved by the Department's Research and Materials Engineer.

SUBSECTION 230.64 Field Testing of Corrugated Plastic Pipe.

(page 96 English, page II.50 Metric) Add this new Subsection.

Installed pipe shall be tested to ensure the maximum vertical deflection of the thermoplastic pipe does not exceed five percent of its base inside diameter. The base inside diameter is defined as the specified nominal diameter minus the AASHTO allowable inside diameter tolerance of 1.5% but not more than ½ inch (12.5 mm).

A minimum of 20% of the total length of each size of Corrugated Plastic Pipe installed on the project shall be tested. Only mandrel testing shall be used for pipe sizes of 24 inches (600 mm) or less. For pipe sizes greater than 24 inches (600 mm), the Contractor shall have the option to video inspect, and (1) use a mandrel test if a deflection is noted or (2) hand measure, for pipes with a diameter greater than 36 inches (900 mm), to the requirements listed below. Runs of pipe to be tested shall be selected by the Engineer. The failure of any tested pipe shall subject all Corrugated Plastic Pipe of every size to 100% testing, at the discretion of the Engineer.

Deflection tests shall be performed by the Contractor under the direction of the Engineer not sooner than 30 days after completion of installation and compaction of backfill. The pipe shall be cleaned and inspected for offsets and obstructions prior to testing.

Mandrel Test:

- Shall be used for all pipes up to 24 inches (600 mm) nominal inside diameter
- The mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded
- The mandrel diameter shall be verified and approved by the Engineer prior to use
- Use of an unapproved mandrel will invalidate the test

SUBSECTION 230.64 (continued)

- If the mandrel fails to pass through the pipe, the pipe will be deemed to be over-deflected
- The mandrel shall be a rigid device, with odd numbered-legs (9 legs minimum) having an effective length not less than its nominal diameter
- The mandrel shall be fabricated of steel with pulling rings at each end
- The mandrel shall be stamped or engraved on some segment other than a runner indicating the nominal size, and mandrel OD

Video Inspection:

- May be used to determine if a deflection is evident in pipes with a nominal inside diameter greater than 24 inches (600 mm).
- Verification of the actual deflection limits must be accomplished using the mandrel test method or the hand measurement method
- Provide and use a mobile color video camera and light source to inspect pipes
- The video camera must be able to be moved inside the pipe barrel and be controlled remotely by the inspector
- The video camera must have a remote monitor and a recording apparatus to view and record the condition of the installed pipes
- A copy of the pipe inspection video recording, in an approved format, shall be provided to the Engineer

Hand Measurement:

- Measure manually any deflections of pipe larger than 36 inches (900 mm) nominal inside diameter.
- Must be done in the presence of the Engineer.

The minimum diameters, based on approximately 95% of base inside diameter at any point along the full length, are as follows:

Nominal Size (inches / mm)		*Allowable Deflected Diameter (inches / mm)*	
12	300	11.2	285
15	375	14.0	356
18	450	16.8	428
24	600	22.4	570
30	750	28.0	713
36	900	33.7	856
42	1050	39.4	1001
48	1200	45.1	1146
60	1500	56.5	1436

Any pipe deflected beyond acceptable limits shall be uncovered. If not damaged, as determined by the Engineer, the pipe may be reinstalled. Damaged pipe shall not be reinstalled and shall be removed from the work site. No other method or process to reduce or correct deflection shall be acceptable.

SUBSECTION 230.65 Strutting of Pipe.

(page 96 English, page II.50 Metric) Add this new Subsection:

Strutting shall be used as required to ensure the integrity of the pipe and all costs associated are incidental to the item.

SUBSECTION 230.80 Method of Measurement.
(page 97 English, page II.50 Metric) Replace the third paragraph with the following:

Pipe bends for Corrugated Metal pipe shall be in accordance with the standard drawings and the length of pipe sections containing bends shall be measured along the centerline and shall be paid for as straight sections of pipe.

(page 97 English, page II.51 Metric) Add the following paragraph to the end of this Subsection.

Corrugated Plastic Pipe includes testing and all other incidentals necessary to complete the work. All costs incurred by the Contractor attributable to testing and corrective action, including any delays, shall be borne by the Contractor at no cost to the Department.

SUBSECTION 230.81 Basis of Payment.
(page 97 English, page II.51 Metric) Add the following to the first paragraph:

Corrugated plastic pipe shall include gravel borrow type d backfill material.

(page 97 English, page II.51 Metric) Replace the first sentence of the 4th paragraph with the following:

Trench excavation and backfill for trenches 5 feet (1.5 m) or less in depth for pipe arches, pipe culverts, pipe drains, pipe sewers, and structural plate pipe arches shall be included in the various pipe items.

SUBSECTION 230.82 Payment Items.
*(page 97 English) Delete payment items 233., 235., *231.-, *231.6. and *231.7-.; add payment items *252.- and *252.1 - as shown below; and amend items *230, *230.7-, *231, *231.7-, *232, *234.- to read as follows:*

*230.	-Inch Corrugated Metal Pipe __Gage	Foot
*230.7-	-Inch Corrugated Metal Pipe End Section	Each
*232.	___ x ___ Inch ACCM Pipe-Arch ___ Gage	Foot
*234.-	-Inch Drainage Pipe-Option	Foot
*252.-	-Inch Corrugated Plastic (Polyethylene) Pipe	Foot
*252.1-	-Inch Corrugated Plastic Pipe Flared End	Each

(page II.51 Metric) Delete payment items 233. and 256.*, 231.-*, 231.6*.and *231.7-*; change pay items 241.1* to 245.1* to 242.*; change micrometer to micron in all locations; add payment item 252.1* as shown below, and replace existing payment items 230.*, 230.7*, and 232.* with the following:*

230.*	_ Millimeter Corrugated Metal Pipe _ Microns	Meter
230.7*	_ Millimeter Corrugated Metal Pipe End Section	Each
232.*	_ x _ ACCM Pipe-Arch _ Microns	Meter
252.1*-	_ Millimeter Corrugated Plastic Pipe Flared End	Each

SECTION 260
SUBDRAINS

SUBSECTIONS 260.20, 260.40, and 260.61
(page 100 English, page II.54 Metric) Replace these Subsections with the following:

260.20 General.

This work shall consist of constructing subdrains, using pipe, filter fabric 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.

260.40 General.

Materials shall meet the requirements specified in the following subsection of Division III, Materials:

Perforated Corrugated Metal Pipe M5.03.1
Porous Concrete Pipe M5.03.11
Crushed Stone..... M2.01.5
Slot Perforated Corrugated Plastic Pipe M5.03.9
Geotextile Fabric for Subsurface Drainage M9.50.0

260.61 Laying Pipe.

Before any pipe is installed filter fabric shall be placed along the sides and bottom of the trench. The overlap between any adjoining pieces of fabric shall be at least two feet (600 mm). Perforated subdrain pipe shall be laid with the perforations facing up.

SUBSECTIONS 260.81 and 260.82
(page 101 English, page II.55 Metric) Replace these Subsections with the following:

260.81 Basis of Payment.

Payment for the above work at the contract price per foot will include excavation, pipe, filter fabric, crushed stone and installation complete in place and satisfactory to the Engineer.

Trench excavation greater than 5 feet (1.5 m) in depth 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.

English:

*261.-	-Inch Perforated Corrugated Metal Pipe ...Gage (Subdrain)	Foot
*265.-	-Inch Pipe Subdrain - Option	Foot
*266.-	-Inch Porous Concrete Pipe (Subdrain)	Foot
*269.-	-Inch Slot-Perforated Corrugated Plastic Pipe (Subdrain)	Foot
142.	Class B Trench Excavation	Cubic Yard
144.	Class B Rock Excavation	Cubic Yard

Metric:

261.*	-Millimeter Perforated Corrugated Metal Pipe _Microns (Subdrain)	Meter
265.*	-Millimeter Pipe Subdrain - Option	Meter
266.*	-Millimeter Porous Concrete Pipe (Subdrain)	Meter
269.*	-Millimeter Slot-Perforated Corrugated Plastic Pipe (Subdrain)	Meter
142.	Class B Trench Excavation	Cubic Meter
144.	Class B Rock Excavation	Cubic Meter

* Pipe size will be added to the item number and description.

SECTION 270
PIPES REMOVED AND RELAID OR STACKED

SUBSECTION 270.20 General.
(page 101 English, page II.55 Metric) Replace this Subsection with the following:

This work shall consist of removing present pipes, plugging the ends 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.

SUBSECTION 270.62 Stacking.
(page 102 English, page II.56 Metric) Change the existing Subsection number to 270.63 and add new subsection 270.62 in numerical order as follows:

270.62 Masonry Plugs for Pipe Ends.

Masonry plugs shall consist of bricks and mortar to form a watertight seal at the end of the pipe being plugged. The thickness of the plug shall at least be equal to the inside diameter of the pipe being plugged.

SUBSECTION 270.63 Backfilling Trenches.
(page 102 English, page II.56 Metric) Change the Subsection number 270.64.

SUBSECTION 270.80 Method of Measurement.
(page 102 English, page II.56 Metric): Add the following paragraph after the first paragraph:

Masonry plugs for pipe ends shall be measured in place by the cross sectional area of the inside of the pipe being plugged.

SUBSECTION 270.81 Basis of Payment.
(page 102 English, page II.565 Metric) Add the following paragraph after the first paragraph:

Masonry plugs will be paid for at the contract unit price per square yard complete in place.

(page 102 English, page II.56 Metric) Replace the existing third paragraph with the following:

Field Stone Masonry in Cement Mortar and 3000 psi, 1.5 in., 470 (20 MPa - 40 mm - 280 kg) Cement Concrete will be paid for at the contract unit price per cubic yard.

SUBSECTION 270.82 Payment Items.
(page 102 English, page II.57 Metric) Delete the word Masonry in the description for item 903 and add the following payment item in numerical order:

227.4	Masonry Plug	Square Foot (m^2)

SECTION 280
WATERWAYS

SUBSECTION 280.40 General.
(page 103 English) Delete Half Circle ACCMP Pipe M5.04.1

SUBSECTION 280.63 Half Circle ACCM Pipe.
(page 103 English) Delete this entire Subsection.

SUBSECTION 280.80 Method of Measurement.
(page 103 English) Delete the last paragraph.

SUBSECTION 280.81 Basis of Payment.
(page 104 English) Delete the second paragraph.

SUBSECTION 280.82 Payment Items.
*(page 104 English) Delete payment item *279. Half Circle ACCM Pipe (Waterway) Linear Foot.*

SECTION 301
WATER SYSTEMS

SUBSECTION 301.40 General.
(page 105 English, page II.59 Metric) Delete Cast Iron for Water Systems ,M5.05.1.

SUBSECTION 301.60 General.
(page 107 English, page II.61 Metric) Delete paragraphs I. and J. and renumber headings K. through P. to I. through N. respectively.

SUBSECTION 301.81 Basis of Payment.
(page 109 English, page II.63 Metric) Change Item 308. to Item 309. in the first sentence of the second paragraph.

(page 109 English, page II.63 Metric) Add the following paragraph after the 6th paragraph of the subsection:

The prices shall also include all disinfection and testing of the water pipeline system.

SUBSECTION 301.82 Payment Items.
(page 109 English, page II.64 Metric) Delete pay items 300. Cast Iron Water Pipe (Rubber Gasket), 304.* Cast Iron Water Pipe (Cement Lined), and 308. Cast Iron Fittings for Water Pipe. Delete Cast Iron from the descriptions of pay items 313.* and 315.*.*

SECTION 401
GRAVEL SUB-BASE

SUBSECTION 401.40 General.
(page 111 English) Add the following material:

Processed Gravel.....M1.03.1

SUBSECTION 401.60 Gravel Sub-base.
(page 111 English) Revise the wording within the parentheses of the first sentence to (conforming to M1.03.0 Type a or b, or M1.03.1).

SUBSECTION 401.82 Payment Items.
(page 112 English) Add the following:

152.	Processed Gravel	Cubic Yard (m^3)

SECTION 402
DENSE GRADED CRUSHED STONE FOR SUB-BASE

SUBSECTION 402.82 Payment Items.
(page 113 English) Add the following:

402.1	Dense Graded Crushed Stone for Sub-base	Ton (Mg)

SECTION 403
RECLAIMED BASE COURSE

SECTION 403 RECLAIMED BASE COURSE
(page 113 English, page II.67 Metric) Replace the existing Section with the following:

SECTION 403
RECLAIMED PAVEMENT FOR BASE COURSE AND/OR SUB-BASE

DESCRIPTION

403.20 General.

The work shall consist of producing a stabilized base course and/or sub-base through the recycling of the existing pavement structure and a specified depth of acceptable sub-base material. This combination of pavement and sub-base material is to be uniformly crushed, pulverized and blended, then spread, graded, and compacted to the lines and grades shown on the plans or established by the Engineer.

MATERIALS

403.40 General.

All reclaimed material shall conform to the requirements of Subsection M1.09.0 of Division III, Materials.

Aggregate for Crushed Stone for Blending, used to correct gradation deficiencies, shall conform to the requirements of Subsections M2.01.0 to M2.01.6 of Division III, Materials.

Aggregate for Dense Graded Crushed Stone for Sub-Base shall conform to the requirements of Subsection M2.01.7 of Division III, Materials.

403.41 Sampling and Pretesting.

The Department will take and analyze test pits to the depth to be recycled and provide the following information in the bid proposal for each:

1. The location of the test pit.
2. The depth of existing asphalt pavement material to be recycled.
3. The aggregate gradation of the underlying material to be recycled.

The information supplied is intended to be an indication of the existing conditions and in no way releases the Contractor from the responsibility of fulfilling the requirements of this specification.

Any gradation deficiencies in the existing materials, as indicated by the test pits, shall be corrected by blending the appropriate aggregate size(s) into the mixture.

CONSTRUCTION METHODS

403.60 General.

Reclaiming operations shall not be permitted when the existing pavement or sub-base contains frost, when the sub-base is excessively wet as determined by the Engineer, nor when the air or surface temperature is below 40°F.

Reclaiming operations shall not commence before April 15 and shall terminate on or before October 15.

Prior to the start of reclaiming operations, the Contractor shall locate and protect existing drainage and utility structures and underground pipes, culverts, conduits and other appurtenances. The limit of each sequence of the reclamation process shall be 1 mile (1.7 km) full width or as directed by the Engineer in order that the placing of pavement structure, up to the binder course, will be completed before beginning the next sequence of roadway reclamation work.

403.61 Equipment.

The recycling equipment shall have a positive depth control to ensure a uniform depth of processing. This equipment shall have the ability to process the complete design depth specified into a homogeneous mass. It shall also be capable of crushing all oversize material encountered except ledge, or boulders larger than 8 inches (200 mm) in diameter.

A minimum of 14 calendar days prior to the proposed start of work, the Contractor shall submit in writing to the Engineer for approval, a description of the specific equipment and construction methods to be used in performing the work. The Contractor will be required to demonstrate to the Engineer the ability of the work crew and equipment to produce reclaimed material conforming to specifications at a rate of production consistent with the time allowed under the Contract. A test section shall be constructed approximately 500 feet (150 m) long and one lane wide and be located within the project limits at a location determined by the Engineer. The forward speed and processing direction (e.g. up cutting vs. down cutting) of the recycling equipment shall be recorded during construction of the test section. Representative samples of the reclaimed material shall be taken from this test section for analysis by the Engineer. Full scale production will not be allowed to commence until the Engineer has reviewed the test results and gives written approval of the equipment and construction methods used in the construction of the test strip.

Failure to meet gradation requirements or an insufficient production rate may be considered cause for rejection of the equipment, the construction methods, or both. The Contractor must then submit, in writing, the proposed changes in equipment and/or construction methods and either construct another test section or reconstruct the original section, as determined by the Engineer. This procedure may be repeated until acceptable results are obtained, at no additional compensation.

Failure to meet gradation requirements due to improper equipment or construction methods, shall not constitute a reason for any additional compensation for the import and blending of any aggregate to meet the deficiencies.

Approval of equipment includes the speed and processing direction it was operated at during construction of the test section. Therefore, the same operating speed and processing direction must be maintained during normal production. Changes in the equipment's operating speed and/or processing direction may only be made with the Engineer's written approval.

At least one vibratory roller shall be used on each reclaimed surface, and shall have a compacting width of not less than 5 feet (1.5 m). Each roller shall have a gross weight of not less than 15 tons (14.6 Mg).

Approved equipment shall be maintained in satisfactory working condition at all times.

403.62 Structure Lowering and Raising.

All work shall be done in accordance with the applicable provisions of Section 220.

All drainage, utility, and municipality structures are to be referenced and lowered to a minimum depth 6 inches (150 mm) below the bottom of the proposed reclaimed base course. Lowered structures shall be covered with steel plates conforming to the requirements specified in Subsection 7.09. The voids remaining after the structures have been lowered are to be filled with a suitable material as determined by the Engineer. The Contractor will be responsible for the coordination with the respective utility companies for the lowering and raising of privately owned structures and gate boxes. The reclaiming operation shall not begin until all structures and boxes are lowered.

It shall be the Contractor's responsibility to maintain drainage functioning properly in the areas under construction up to the time when the final system is put into use. All structures lowered will be raised to the binder grade elevation upon placement of the binder course material for that section. Adjustment of the castings to final grade will not be allowed until the Engineer approves the placement of hot mix asphalt top course material throughout the project.

Any drainage structure found to be deteriorated below the plated depth shall be rebuilt from the bottom of the deterioration to the plated depth.

403.63 Reclaiming Operations.

Prior to the start of reclamation, the existing pavement shall be swept with a power sweeper to remove all trash, sand, dirt, organic matter, and other undesirable material, to the satisfaction of the Engineer.

Also, the existing pavement shall be sawcut full depth within the areas where the adjacent surface is to be protected (curb, side streets, etc.) as shown on the plans and/or as directed by the Engineer.

The Contractor shall reclaim only that area of pavement that can be processed and compacted by the end of the same working day, at which time it must be opened to traffic, with the Engineer's approval. In any section, reclamation work shall be done on one-half the road width at a time. One-way traffic will be allowed only during working hours with traffic police present. Two-way traffic shall be maintained at all other times. Suitable ramping shall be in place at the beginning and end of each work zone to allow for smooth and safe travel. This shall be considered incidental to the work for this item. The required density shall be maintained until the hot mix asphalt pavement has been placed. Any imperfections discovered prior to the placement of hot mix asphalt shall be repaired, as directed by the Engineer, at no additional compensation.

The total thickness of the pavement structure and uppermost portion of the sub-base layer shall be recycled to the design depth specified on the typical sections. The Engineer shall perform a sieve analysis of the reclaimed material for every 5,000 square yards (4,200 m^2) of material processed or as often as conditions may require as determined by the Engineer. Test results shall be made available to the Contractor. If conditions warrant, the Engineer may stop work until the required test results become available. If the Engineer directs, due to grading deficiencies in the existing materials as indicated by the test pits, the appropriate crushed stone aggregate sizes shall be blended with the recycled material to produce a uniform mixture meeting the gradation requirements. Additionally, if the Engineer directs, dense graded crushed stone shall be added for volume purposes.

Any required modifications to the remaining sub-base such as, but not limited to, cuts, fills, and grade realignment shall be made. Existing unsuitable material shall be removed to the lines and grades established by the Engineer and replaced with a suitable material, as determined by the Engineer. Existing surplus reclaimed material shall be used, when available, at no additional compensation.

All unsuitable material and/or excess reclaimed material shall become the property of the Contractor to be properly disposed of outside the project limits.

403.64 Compaction and Dust Control.

The reclaimed material shall be rolled, compacted and fine graded to the specified cross section(s) and/or grades as shown or as established by the Engineer.

The reclaimed base course shall be tested for compaction and smoothness and accuracy of grade in accordance with the applicable provisions of Subsection 401.60. The required density shall be measured by a Nuclear Density Gauge supplied by the Department. If any portions are found to be unacceptable by the Engineer, such portions shall be reprocessed, regraded, and recompacted until the required smoothness and accuracy are obtained.

At the end of each days progress, the Contractor shall apply Calcium Chloride in accordance with the applicable provisions of Section 440. Water for roadway dust control shall be applied as directed.

A grader, roller, and water wagon shall be maintained on the project site during the reclamation process. The Contractor shall submit to the Engineer, in writing, a 24 hour availability telephone number for any emergency maintenance dictated by the weather conditions or as determined by the Engineer, for repair, compaction, and dust control.

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 will be made for surface structures. The lowering and the plating of gates and structures will be considered incidental to this Item and no additional compensation will be allowed.

Structures raised from the plated depth to an intermediate depth of approximately 8 inches (200 mm) below finished grade, as determined by the Engineer, shall be plated and shall be measured by the unit each as a Drainage Structure Remodeled.

Structures adjusted from the intermediate depth to finished grade shall be measured by the unit each as a Drainage Structure Adjusted.

Structures rebuilt shall be measured by the average height in feet and tenths of feet from the bottom of the deterioration to the plated depth. Structures damaged below the plated depth, due to the Contractors negligence, shall be measured and deducted from the depth measurement. Raising the structure from the plated depth will be measured as stated above for a remodeled unit.

403.81 Basis of Payment.

The accepted quantity of reclamation as measured above shall be paid for at the contract unit price bid per square yard. This unit price shall include all compensation for crushing, pulverizing, blending, spreading, grading, sawcutting the existing asphalt pavement at the direction of the Engineer, compacting, test section construction, blending with aggregate, moving the processed material to allow for modifications to the remaining sub-base and/or subgrade, moving reclaimed material from one location to another within the project and any incurred costs resulting from the Contractor's decision to process off site.

The unit price bid shall also include compensation for all costs associated with the removal of the castings and the referencing, lowering, and plating of the structures. It shall also include full compensation for all labor, tools, equipment, materials, and all incidental work necessary to complete the work as specified.

Removal and disposal of unsuitable material, surplus reclaimed material, or any sub-base/subgrade material necessary for grade changes shall be paid for at the contract unit price per cubic yard for Item 120.1, Unclassified Excavation.

Special borrow required to be placed under the reclaimed material shall be paid for at the contract unit price per cubic yard for Item 150.1, Special Borrow.

Grading and compacting the sub-base and/or subgrade resulting from the removal of unsuitable material shall be paid for at the contract unit price per square yard (m^2) for Item 170., Fine Grading and Compacting.

Adjustment of drainage structures shall be paid for at the contract unit price each for Item 220., Drainage Structure Adjusted.

Rebuilding of drainage structures shall be paid for vertically at the contract unit price per foot (m) for Item 220.2, Drainage Structure Rebuilt.

Raising of lowered structures shall be paid for at the contract unit price each for Item 220.5 Drainage Structure Remodeled.

Aggregate for providing added volume shall be paid for at the contract unit price per ton (Mg) or Item 402.1, Dense Graded Crushed Stone for Sub-base.

Aggregate to correct gradation deficiencies shall be paid for at the contract unit price per ton (Mg) for Item 403.1, Crushed Stone for Blending.

Calcium Chloride for dust control shall be paid for at the contract unit price per pound (kg) for Item 440., Calcium Chloride for Roadway Dust Control.

Water for dust control shall be paid for at the contract unit price per 1,000 gallons (m^3) for Item 443., Water for Roadway Dust Control.

403.82 Payment Items.

120.1	Unclassified Excavation	Cubic Yard (m^3)
150.1	Special Borrow	Cubic Yard (m^3)
170.	Fine Grading and Compacting	Square Yard (m^2)
220.	Drainage Structure Adjusted	Each
220.2	Drainage Structure Rebuilt	Feet (m)
220.5	Drainage Structure Remodeled	Each
402.1	Dense Graded Crushed Stone for Sub-base	Ton (Mg)
403.	Reclaimed Pavement for Base Course and/or Sub-base	Square Yard (m^2)
403.1	Crushed Stone for Blending	Ton (Mg)
440.	Calcium Chloride for Roadway Dust Control	Pound (kg)
443.	Water for Roadway Dust Control	M. Gallons (m^3)

SECTION 404
RECLAIMED PAVEMENT BORROW MATERIAL

SECTION 404 RECLAIMED PAVEMENT BORROW MATERIAL

(page 114 English, page II.71 Metric) Add (English) the following Section / Replace this Section with the following (Metric):

DESCRIPTION

404.20 General.

Reclaimed pavement borrow material shall be used for base course and sub-base areas. The material shall be pre-mixed and placed on the sub-grade or sub-base in close conformity with the lines and grades established by the Engineer.

MATERIALS

404.40 General.

Material shall meet the requirements of Subsection M1.09.0 of Division III, Materials.

CONSTRUCTION METHODS

404.60 General.

The reclaimed pavement borrow material shall be spread and compacted in layers not exceeding 8 inches (200 mm) in depth, compacted measurement, except the last layer of reclaimed pavement borrow material (conforming to M1.09.0) will be 4 inches (100 mm) in depth compacted measurement. The specified density of the Reclaimed Pavement Borrow Material shall be maintained by determining the number of passes of a roller that 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. The Reclaimed Pavement Borrow Material shall be placed to the tolerance as stipulated in Section 401, Gravel Sub-base.

COMPENSATION

404.80 Method of Measurement.

Reclaimed Pavement Borrow Material shall be measured in place, to the limits specified on the plans or as directed by the Engineer, with no percentage added.

404.81 Basis of Payment.

Reclaimed Pavement Borrow Material will be paid for at the contract unit price per cubic yard complete in place.

404.82 Payment Items.

404.5	Reclaimed Pavement Borrow Material	Cubic Yard (m^3)

SECTION 405
GRAVEL BASE COURSE

SECTION 405. GRAVEL BASE COURSE
(page 114 English, page II.72 Metric) Delete this entire Section.

SECTION 420
HOT MIX ASPHALT BASE COURSE

SECTION 420 HOT MIX ASPHALT BASE COURSE
(page 115 English, page II.73 Metric) Delete this entire Section.

SECTION 430
CEMENT CONCRETE BASE COURSE

SUBSECTION 430.63 Joints.
(page 117 English) 460.63 should read 430.63. In the second paragraph M8.14.0 should read M9.14.0.

SECTION 450 HOT MIX ASPHALT PAVEMENT
(page 117 English) Add this new Section.

SECTION 450
HOT MIX ASPHALT PAVEMENT

DESCRIPTION

450.10 General.

This work shall consist of producing and placing Hot Mix Asphalt (HMA) pavement. The HMA pavement shall be constructed 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 as shown on the plans. Each HMA pavement course placed shall be comprised of one of the mixture types listed in Table 450.1.

Table 450.1 - HMA Pavement Courses & Mixture Types

Pavement Course	Mixture Type	Mixture Designation
Friction Course	• Open-Graded Friction Course - 9.5 - Polymer • Open-Graded Friction Course - 9.5 - Asphalt Rubber	OGFC-P OGFC-AR
Surface Course	• SUPERPAVE Surface Course - 4.75 • SUPERPAVE Surface Course - 4.75 - Polymer • SUPERPAVE Surface Course - 9.5 • SUPERPAVE Surface Course - 9.5 - Polymer • SUPERPAVE Surface Course - 12.5 • SUPERPAVE Surface Course - 12.5 - Polymer • SUPERPAVE Surface Course - 19.0 • SUPERPAVE Surface Course - 19.0 - Polymer • Asphalt Rubber Gap Graded - 12.5	SSC - 4.75 SSC - 4.75 - P SSC - 9.5 SSC - 9.5 - P SSC - 12.5 SSC - 12.5 - P SSC - 19.0 SSC - 19.0 - P ARGG - 12.5
Intermediate Course	• SUPERPAVE Intermediate Course - 12.5 • SUPERPAVE Intermediate Course - 12.5 - Polymer • SUPERPAVE Intermediate Course - 19.0 • SUPERPAVE Intermediate Course - 19.0 - Polymer	SIC - 12.5 SIC - 12.5 - P SIC - 19.0 SIC - 19.0 - P
Base Course	• SUPERPAVE Base Course - 25.0 • SUPERPAVE Base Course - 37.5	SBC - 25.0 SBC - 37.5

Table 450.1 - HMA Pavement Courses & Mixture Types (Continued)

Pavement Course	Mixture Type	Mixture Designation
Leveling Course	• SUPERPAVE Leveling Course - 4.75 • SUPERPAVE Leveling Course - 9.5 • SUPERPAVE Leveling Course -12.5	SLC - 4.75 SLC - 9.5 SLC - 12.5
Bridge Surface Course	• SUPERPAVE Bridge Surface Course - 9.5 • SUPERPAVE Bridge Surface Course - 9.5 - Polymer • SUPERPAVE Bridge Surface Course - 12.5 • SUPERPAVE Bridge Surface Course - 12.5 - Polymer	SSC-B - 9.5 SSC-B - 9.5 - P SSC-B - 12.5 SSC-B - 12.5 - P
Bridge Protective Course	• SUPERPAVE Bridge Protective Course - 9.5 • SUPERPAVE Bridge Protective Course - 9.5 - Polymer • SUPERPAVE Bridge Protective Course - 12.5 • SUPERPAVE Bridge Protective Course - 12.5 - Polymer	SPC-B - 9.5 SPC-B - 9.5 - P SPC-B - 12.5 SPC-B - 12.5 - P

450.20 Quality Assurance.

A. Quality Assurance Responsibilities.

This is a Quality Assurance Specification wherein the Contractor is responsible for controlling the quality of materials and workmanship and the Department is responsible for accepting the completed work based on the measured quality. Quality Assurance is simply defined as "making sure the Quality of a product is what it should be."

The core elements of Quality Assurance include: Contractor Quality Control (QC), Department Acceptance, Department Independent Assurance (IA), Dispute Resolution, Qualified Laboratories, and Qualified Personnel. Although Quality Assurance utilizes test results to control production and determine acceptance of the HMA, inspection remains as an important element in controlling the process and accepting the product.

The Contractor is responsible for providing an appropriate Quality Control system to ensure that all materials and workmanship meet the required quality levels for each specified Quality Characteristic. The Contractor will perform all required Quality Control inspection, sampling, and testing in accordance with these specifications and the Contractor's Quality Control Plan.

The Department will monitor the adequacy of the Contractor's QC activities and will perform Acceptance inspection, sampling, and testing. The Department's Acceptance information will be utilized in the acceptance determination for each Lot of material produced and placed.

Independent Assurance is the responsibility of the Department's Research & Materials Section (RMS). The function of IA testing is to periodically provide an unbiased and independent evaluation of the sampling and testing procedures used in the acceptance decision. Contractor QC and Department Acceptance testing procedures and equipment will be evaluated by IA personnel using one or more of the following: observation, calibration checks, split sample comparison, or proficiency samples (homogeneous samples distributed and tested by two or more laboratories). QC and Acceptance testing personnel are evaluated by observation and split samples or proficiency samples.

B. Hot Mix Asphalt Lots & Sublots.

The quality of each HMA pavement course of the same mixture type produced and placed will be inspected, tested, and evaluated on the basis of Lots and Sublots. A Lot is defined as "an isolated quantity of material from a single source which is assumed to be produced or placed by the same controlled process".

The Lot size and corresponding unit of measure is a function of the individual Quality Characteristic evaluated. Lot sizes for Quality Characteristics subject to Department Acceptance are as shown in Table 450.2.

Changes in the target values, material sources, or JMF for an HMA mixture type will constitute a change in Lot, requiring the establishment of a new Lot. All Lots will be properly identified for accurate evaluation and reporting of HMA quality.

Table 450.2 - HMA Lot Sizes

Quality Characteristic	Lot Size & Unit of Measure
PG Asphalt Binder Grading	Total Tons of HMA from all JMFs using the same PGAB Grade (from same PGAB Supplier), produced by a single plant and placed within same construction season.
PG Asphalt Binder Content	Total quantity of an HMA mixture type with the same JMF for the same individual pavement course, produced by a single plant using the same source of materials and placed at a uniform plan thickness within the same construction season, not to exceed 18,000 tons. (See Table 450.3).
Volumetrics – Air Voids	
In-place Density	Total quantity of an HMA mixture type with the same JMF for the same individual pavement course, produced by a single plant using the same source of materials and placed at a uniform plan thickness within the same construction season, not to exceed 18,000 tons. (See Table 450.3).
Thickness	
Ride Quality (IRI)	Total length (miles) of individual wheel paths (in all travel lanes and ramps) of in-place HMA with same JMF for same individual pavement course, produced by a single plant and placed within same construction season, and which is located within the same posted speed limit range as defined in Tables 450.19a, 450.19b, and 450.19c.

C. HMA Quality Assurance Requirements.

These Specifications establish three categories under which Hot Mix Asphalt Lots will be produced, placed, evaluated and accepted. Table 450.3 below defines each of the Lot categories and outlines the required Quality Assurance activities of the Contractor and the Department. The division of the Lot categories is based on the total estimated contract quantity of each individual HMA mixture type per each project location. For contracts containing multiple Hot Mix Asphalt items, it is possible to have work performed under more than one HMA Lot category.

(1) Determination of Lot Size and Lot Category

When the total contract quantity of an HMA mixture type is < 2,100 tons, it shall be classified as a Minor Lot (Category C Lot).

When the total contract quantity of an HMA mixture type is ≥ 2,100 tons, but < 7,500 tons, it shall be classified as a Small Lot (Category B Lot).

When the total contract quantity of an HMA mixture type is ≥ 7,500 tons, but ≤ 15,000 tons, it shall be classified as a Large Lot (Category A Lot).

When the total contract quantity of an HMA mixture type is > 15,000 tons, each 15,000 tons will represent a Category A Lot. If the quantity remaining after all 15,000 ton Category A Lots is ≤ 3,000 tons, it shall be added to the final Lot providing a final Lot quantity not to exceed 18,000 tons. If the quantity remaining after all 15,000 ton Category A Lots is > 3,000 tons, it shall constitute a separate Category A Lot.

If a Category A Lot extends into the subsequent year, the Lot will be ended and a new Lot will be established for the next year. The Lot category for the subsequent year shall be categorized based on the remaining tonnage to be placed as designated above.

Category A and B Lots shall not be divided to produce multiple smaller category Lots without the prior approval of the District Quality Engineer and RMS.

(2) Determination of Sublot Size

Each HMA Lot will be divided into Sublots. The size of each HMA Sublot shall be as listed in Table 450.11 and Table 450.17. If the quantity of HMA at the end of a Lot is equal to or greater than one half of a full Sublot, then such quantity shall be identified and evaluated as a separate Sublot. If the HMA quantity at the end of a Lot is less than one half of a full Sublot, then such quantity shall be combined with the previous full Sublot quantity and shall be identified and evaluated as the final Sublot.

Table 450.3 - HMA Lot Categories & Quality Assurance Requirements

Quality Assurance Requirements	Category A (Large Lot)	Category B (Small Lot)	Category C (Minor Lot)
Total Quantity for individual Lot of HMA:	≥ 7,500 tons, but ≤ 15,000 tons (See Note 1)	≥ 2,100 tons, but < 7,500 tons	< 2,100 tons
QC Plan Required:	YES	YES	(See Notes 2 and 3)
Contractor QC Inspection Required:	YES (Subsection 450.64)	YES (Subsection 450.64)	YES (Subsection 450.64)
Contractor QC Testing Required:	YES (Subsection 450.65)	YES (Subsection 450.65)	YES (Subsection 450.65)
Control Strip Required:	YES	NO	NO
Control Charts Required:	YES	NO	NO
Quality Level Analysis Required:	YES	YES	NO
MassDOT Acceptance Inspection Performed:	Minimum 25% of Sublots (Subsection 450.73)	Minimum 50% of Sublots), But Minimum 3 Sublots (Subsection 450.73)	100% of Sublots (Subsection 450.73)
MassDOT Acceptance Testing Performed:	Minimum 25% of Sublots (Subsection 450.74)	Minimum 50% of Sublots), But Minimum 3 Sublots (Subsection 450.74)	100% of Sublots (Subsection 450.74)
QC Test Results included in MassDOT Acceptance Determination:	YES (If Validated)	YES (If Validated)	NO
Pay Adjustment Applied:	YES (Subsection 450.92)	YES (Subsection 450.92)	NO

Note 1: Category A Lots shall not exceed 18,000 tons as specified in Subsection 450.20C(1)

Note 2: If all HMA Lots fall under Category C then a QC Plan is not required. However, if any Lots on the project fall under Category A or Category B, then any Category C Lots must be addressed in the QC Plan.

Note 3: If a QC Plan is not required, it is still the responsibility of the Contractor to provide to the Engineer any information that is designated as "Per QC Plan" as found in this specification.

MATERIALS

450.30 General.

Materials shall meet the requirements in the following Subsections of Division III, Materials and as otherwise specified herein:

Performance Graded Asphalt Binder.....M3.01.0
Warm Mix Asphalt.....M3.01.4
Asphalt Anti-Stripping Additive.....M3.01.5
Asphalt Release Agents.....M3.01.6
Asphalt Emulsion for Tack Coat.....M3.03.0
Hot Poured Joint Sealer.....M3.05.0
Hot Mix Asphalt.....M3.11.0
Aggregate.....M3.11.2
Hot Mix Asphalt Mixture Design.....M3.11.4
Verification of Laboratory Trial Mix Formula.....M3.11.5
Hot Mix Asphalt Production Facility.....M3.11.7
Contractor Quality Control Laboratory.....M3.12.1
Department Acceptance Laboratory.....M3.12.2

450.32 Hot Mix Asphalt Mix Design.

HMA mixtures shall be composed of the following: Mineral aggregate, mineral filler (if required), Performance Graded Asphalt Binder (PGAB), and as permitted, recycled materials. The Contractor shall be responsible for development of an HMA Laboratory Trial Mix Formula (LTMF) for each HMA mixture type specified for the contract in accordance with the requirements of Subsection 450.30.

CONSTRUCTION PROCEDURES

450.40 General.

Prior to the start of any work activity addressed in Subsections 450.43 thru 450.52 below, a Construction Quality Meeting shall be held to review the Contractor's Quality Control system. The Contractor shall present and discuss with the Engineer in sufficient detail the specific Quality Control information and activities contained in each section of their QC Plan as outlined in Subsection 450.61. The meeting is intended to ensure that the Contractor has an adequate Quality Control system in place and that the Contractor's personnel are fully knowledgeable of the roles and activities for which they are responsible to achieve the specified level of quality. Contractor personnel required to attend the Construction Quality Meeting include the Construction QC Manager and all Superintendents. The Contractor shall provide a copy of the approved QC Plan for each Contractor and Department attendee of the meeting.

450.41 Control of Grade and Cross-Section.

The Contractor will provide a longitudinal and transverse reference system, with a maximum spacing of 100 ft, for the purpose of locating and documenting sampling and testing locations and related uses. It is the Contractor's responsibility to clearly mark this reference system in the field. Work related to this reference system is incidental and will be included as part of the Contractor's Quality Control system. The Department shall provide information tying in the Contractor's reference system to the State Mile Marker System.

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 course of the pavement.

Under normal conditions, where more than one course of HMA is to be constructed, the use of the string line for grade control may be eliminated or discontinued after the construction of the initial course of HMA. For resurfacing projects, where only one course of HMA is to be constructed, the use of the string line for grade control may be eliminated. The use of approved automation may then be substituted for the string line where lines and grades are found to be satisfactory by the Engineer.

450.42 Weather Limitations.

HMA shall only be placed on dry, unfrozen surfaces and only when the temperature requirements contained in Table 450.4 below are met. If the temperature requirements contained in Table 450.4 are not met at any point throughout the paving shift, HMA placement shall cease, except as determined and directed in writing by the Engineer depending upon the necessity and emergency of attendant conditions, and weather conditions.

The Contractor may continue HMA placement when overtaken by sudden rain, but only with material which is in transit from the HMA production facility at the time, and then only when the temperature of the HMA mixture is within the temperature limits specified and when the existing surface on the roadway is free of standing moisture. The Engineer is not obligated to accept any material that was not already in transit prior to the onset of rain and the Contractor shall suspend operations for the day when the requirements of this specification cannot be met.

The construction of HMA 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. Only in extreme cases will the placement of Surface Courses be permitted between November 15 and April 1. Regardless of any temperature requirements, OGFC mixtures shall not be placed after October 31 or before May 1 without the written permission of the Engineer.

Table 450.4 - Temperature Limitations for HMA Placement

HMA Pavement Course	**Lift Thickness** (Inches)	**Minimum Air Temperature** (°F)	**Minimum Surface Temperature** (°F)
Friction Course	1	50	55
Surface Course	< 1¾	45	50
Surface Course	≥ 1¾	35[(1)]	40
Intermediate Course	All	35[(1)]	40
Base Course	All	35[(1)]	40
Leveling Course	As Specified	45	50

When the air temperature falls below 50°F, extra precautions shall be taken in drying the aggregates, controlling the temperatures of the materials, and in placing and compacting the mixtures.

The Contractor shall supply the Engineer with two (2) approved dial type thermometers with a temperature range of -50° to 500°F and two (2) infrared pistol thermometer for each paving machine in operation on the project. The infrared pistol thermometers shall read in Fahrenheit and conform to the following requirements:

- Portable and battery operated
- LCD Display to nearest 1°F
- Temperature operating range of 0° to 750°F
- Accuracy of ± 2%
- Repeatability of +/- 5°F
- Emissivity preset at 0.95

The thermometers will remain the property of the Contractor upon completion of the project.

450.43 Preparation of Underlying Surface.

HMA mixtures shall be placed only upon properly prepared surfaces that are clean from foreign materials. The underlying surface shall be prepared in accordance with the requirements below, prior to the placement of HMA pavement courses.

A. Subbase or Reclaimed Base.

Prior to the placement of HMA Base Course mixtures, the Contractor shall inspect the prepared subbase or reclaimed base material to ensure that it is in conformance with the required grade, cross-section, and in-place density. Subbase or reclaimed base material that is not in accordance with the plans or specifications shall be reworked or replaced to meet the applicable requirements of Sections 401, 402, or 403 before the start of HMA placement. The compacted subbase or reclaimed base shall not be frozen or have standing water when placing HMA.

B. Milling Existing HMA Pavement.

When specified on the plans, existing HMA pavement courses shall be milled and removed from the project by the Contractor. Milling shall be performed in conformity with the limits, line, grade, and typical cross-section shown on the plans and in accordance with the applicable milling specification required by the contract. All Quality Control activities for milling shall be addressed in the Contractor's HMA QC Plan. The Contractor shall adjust equipment speed and milling depth for Quality Control of the milled surface and to ensure the smoothest possible surface for paving. Adjustments to milling depth shall be approved by the Engineer and shall be used for consideration of the HMA pavement thickness measurements. Whenever the milling operations are being conducted between the hours of sunset and sunrise, the Contractor shall provide mobile lighting system(s) in accordance with Subsection 450.47C.

C. Patching Existing Pavement Courses.

Areas of existing HMA pavement courses that are significantly distressed or unsound shall be removed and replaced with patches using new Hot Mix Asphalt. The location and limits of patching will be as identified in the plans or as directed by the Engineer.

Each existing pavement course determined to be unsound shall be removed to the full depth of the pavement course within a rectangular area. For each patch location equal to or greater than 50 square feet in area (and having a minimum dimension of 4 feet) where the existing pavement courses are removed down to subbase, the subbase shall be compacted by mechanical means to not less than 95% of the maximum dry density of the subbase material as determined by AASHTO T 99 Method C at optimum moisture content. Each edge of the patch area shall be sawcut or otherwise neatly cut by mechanical means to provide a clean and sound vertical face. The vertical face of each edge shall be thoroughly coated with a hot poured rubberized asphalt sealant meeting the requirements of Subsection 450.30 immediately prior to placing the HMA patching mixture.

Delaminated areas of existing pavement courses resulting from pavement milling shall be cut back neatly by mechanical means to the limits of any unsound material. After removing all unsound material, the underlying pavement surface within the patch limits shall receive a thorough tack coat at a rate of application in accordance with Subsection 450.43G(2) prior to placing the HMA patching mixture.

HMA patching mixture shall be the same mixture type as the existing pavement course being patched or as specified on the plans or as directed by the Engineer. The lift thickness of the patching mixture shall not exceed four times the nominal maximum aggregate size of the mixture. The patching mixture will be placed by hand or by mechanical means and shall match the thickness, grade, and cross-slope of the surrounding pavement. The HMA patching mixture shall be compacted using a steel wheel roller. For patch areas not large enough to permit use of a roller, compaction shall be accomplished using a mechanical tamper capable of achieving the required in-place density. The Contractor shall test the in-place density of each patched area using a calibrated density gauge and record the test data for each patched area on NETTCP Test Report Forms. The in-place density of the HMA patching mixture shall be not less than 90% of the maximum theoretical density of the mixture as determined by AASHTO T 209 (Method A).

D. Leveling Courses.

HMA Leveling Courses shall only be used when specified in the Contract. The HMA mixture used for a Leveling Course shall be as specified in the Contract and shall conform to the relevant materials requirements of this specification.

E. Preparation of Curbs, Edging, and Utilities.

All curbs or edging shall be installed or reset to the line and grade established on the plans. The surface elevation of all catch basin frames and grates, manholes, utility valve boxes, or other utility structures located in the pavement shall uniformly match the grade and cross-slope of the final pavement riding surface. Adjustment of all curbs, edging, and utilities shall be completed prior to the placement of the HMA Surface Course. When OGFC is specified to be placed over the Surface Course, all curbs, edging, and utilities shall be adjusted prior to placement of the HMA Surface Course mixture. Hand placement of HMA along curbs and edging or around utilities after placement and compaction of the Surface Course shall not be permitted.

F. Sweeping Underlying Surface.

The Contractor shall provide a mechanical sweeper equipped with a water tank, spray assembly to control dust, a pick-up broom, a dual gutter broom, and a dirt hopper. The sweeper shall be capable of removing millings and loose debris from the underlying surface.

Prior to opening a milled area to traffic, all milled pavement surfaces shall be thoroughly swept in accordance with the applicable milling specification required by the contract to remove all remaining millings and dust. All pavement surfaces shall be swept clean, free of dust, fines, and slurry immediately prior to application of the tack coat. Any new HMA pavement course that has been open to traffic, or that was placed 30 days prior to placement of the subsequent pavement course, shall also be swept immediately prior to application of the tack coat.

G. Asphalt Emulsion for Tack Coat.

A tack coat of asphalt emulsion, meeting the requirements of Subsection 450.30 shall be uniformly applied to existing or new pavement surfaces prior to placing pavement courses as specified below. The existing surface shall be swept clean of all foreign matter and loose material using a mechanical sweeper and shall be dry before the tack coat is applied.

(1) Tack Distributor System.

A pressure distributor shall be used to apply the tack coat. The tack distributor system shall be equipped with the following to control and monitor the application:

- System for heating the asphalt emulsion uniformly to specified temperature.
- Thermometer for measuring the asphalt emulsion temperature.
- Adjustable full circulation spray bar.
- Positive controls including tachometer, pressure gauge, and volume measuring device.

At least once every 12 months the application rate of the tack distributor system shall be calibrated by the Contractor using the appropriate spray bar nozzle size(s). The calibration shall be in the transverse and longitudinal directions following ASTM D2995. The calibration shall address the spray bar height, nozzle angle, spray bar pressure, thermometers, and strapping stick. Documentation of the annual calibration shall be kept with the tack distributor system and shall be provided to the Engineer when requested.

The use of tack wagons/trailers shall only be allowed for patching under Item 451 or when the Engineer agrees that the area is inaccessible to the distributor. Regardless of application method the tack application rates shall meet the requirements below. The use of gravity distributors is not allowed.

(2) Tack Application Requirements.

The tack coat material shall be applied by a pressure distributor. All nozzles on the distributor shall be open and functioning. All nozzles shall be turned at the same angle to the spray bar. The nozzles shall be offset at an angle from the spray bar to prevent the fan from one nozzle from interfering with the fan from another. Proper nozzle angle shall be as determined by the manufacturer of the distributor spray bar. The spray bar shall be adjusted so that it is at the proper height above the pavement surface to provide a triple overlap spray for a uniform coverage of the pavement surface. A triple lap application requires that the nozzle spray patterns overlap one another such that every portion of the pavement receives spray from exactly three nozzles. Tack coat application rates for specific surface conditions shall be in accordance with the following:

- On a new HMA surface, not opened to traffic, the emulsion application rate shall equal 0.06 to 0.08 gal/yd^2
- On an existing tight smooth pavement the emulsion application rate shall equal 0.06 to 0.08 gal/yd^2
- On a milled surface the emulsion application rate shall equal 0.07 to 0.09 gal/yd^2
- On cement concrete base course the emulsion application rate shall be equal to spray application for adjacent surface
- On new HMA patches the emulsion application rate shall equal 0.06 to 0.09 gal/yd^2

Specified application rates are based on a 57/43 residual to water ratio. The residual amount of tack is defined as the remaining asphalt after the tack coat has set and all water has evaporated. The application rate of the tack coat emulsion shall be set at a rate that achieves the specified residual amount. Tack coat shall be applied to cover a minimum of 95% of the pavement surface.

In addition to the requirements above, all vertical surfaces of curbs, edging, utilities, and drainage structures that will be abutted by new pavement shall receive a thorough tack coat application immediately prior to placing each HMA pavement course.

(3) Tack Inspection.

The asphalt emulsion temperature and application rate shall be periodically measured and properly recorded by the Contractor on NETTCP Inspection Report Forms. If the temperature or application rate is determined to not be in conformance with the specification requirements above, the Contractor shall make appropriate adjustments to the tack application operations.

450.44 Zero Tolerance for Use of Petroleum Products as Release Agents.

MassDOT has a zero tolerance for the use of petroleum products (e.g. diesel, kerosene, etc.) as a release or cleaning agent in the manufacture, loading, transporting, and placement of HMA materials. The Contractor's Quality Control Manager shall ensure the conformance of this requirement. Equipment to be used for transferring, hauling, or placing HMA materials shall be inspected by QC personnel per the approved QC Plan and will ensure that no petroleum products are used. Contaminated equipment shall not be used most especially haul units. Haul units and truck companies with repeated violations will not be used to haul HMA materials for MassDOT projects. Any violations of this policy shall be reported to the Engineer and subject to the following actions:

A. Haul Unit Violations During Loading at the Plant and Transportation to the Project.

Haul units identified by the Contractor to have contaminated beds during initial inspection prior to loading will not be used during that day's placement operations. If a haul unit is found to violate this policy after the initial inspection, the Engineer shall issue a Deficiency Report (DR) and the haul unit and driver shall be suspended from the project until a written corrective action is proposed and approved by the Engineer.

If a haul unit is found to be contaminated with an unapproved release agent after it has been loaded, the HMA shall be rejected by the Engineer. The Engineer shall issue a DR and the haul unit and driver shall be suspended from the project until a written corrective action is proposed and approved by the Engineer.

B. Field Equipment Violations.

All equipment used for the placement and compaction of HMA shall not be treated with an unapproved release agent. This includes the paver, material transfer vehicle, rollers, plate compactors, and tools.

Any use of an unapproved release agent will result in the termination of placement operations and the removal of contaminated materials. The Engineer shall issue a DR and paving operations will not be allowed to resume until a written corrective action is submitted and approved by the Engineer.

C. Repeated Violations.

If a Contractor or any of their Subcontractors is found to repeatedly violate this policy it may result in further actions taken by the Engineer including filing a report with the Department of Environmental Protection.

450.45 Hot Mix Asphalt Production.

HMA production shall conform to the requirements of Subsection 450.30.

450.46 Hot Mix Asphalt Transportation and Delivery.

A. Haul Unit Equipment.

The trucks used to transport HMA to the field placement site shall have tight, clean, smooth metal beds. When necessary to maintain the required HMA temperature, trucks shall be equipped with insulated beds. The truck beds shall be evenly and lightly coated with an approved release agent found on the MassDOT Qualified Construction Materials List to prevent HMA mixture adherence. Truck beds shall be kept free of kerosene, gasoline, fuel oil, solvents, or other materials that could adversely affect the HMA mixture in accordance with Subsection 450.44. Excess lubricant shall not be allowed to accumulate in low spots in the body. The Contractor shall employ sufficient procedures and QC inspection to ensure that all truck beds are free of contaminants, residual HMA, or excess release agent.

B. HMA Protection During Transport.

The HMA shall be transported from the plant to the field placement site in trucks previously cleaned of all foreign materials. During transportation of the HMA from the plant to the placement equipment at the site, each load shall be fully covered at all times, without exception, with canvas or other suitable material of sufficient size and thickness, which is tightly secured to furnish complete protection. Mesh tarps will not be allowed. The HMA shall not be transported such a distance that temperature segregation of the mixture takes place or that excessive crusting is formed on the surface, bottom or sides of the HMA.

C. Coordination and Inspection of HMA Delivery.

The dispatching of trucks from the plant shall be continuously coordinated to ensure that all of the HMA mixture planned to be delivered to the field placement site may be placed and compacted before the end of the scheduled work day. During paving operations, the Contractor shall provide for ongoing two-way radio or cellular phone communication between the field placement site and the HMA plant.

The target temperature and allowable range of the HMA when delivered at the field placement site will be established in the Contractor's Quality Control Plan. The Contractor shall measure the temperature of the HMA, either from the trucks prior to discharge or from the paver hopper, using an infrared pistol type thermometer at the minimum frequency indicated in the approved QC Plan. All QC temperature measurement results of the delivered HMA mixture shall be recorded on NETTCP Inspection Report Forms. The Contractor shall also visually inspect the delivered HMA for crusting or material (physical) segregation. The Contractor shall reject any loads of HMA with material which is crusted, segregated, or which is not within the delivery temperature range established in the Contractor's Quality Control Plan.

450.47 Hot Mix Asphalt Placement.

A. Material Transfer Vehicles.

For projects on all controlled access highways with HMA Category A Lots, a Material Transfer Vehicle (MTV) will be required. An MTV shall also be required for all pavement courses requiring Ride Quality testing (IRI). The MTV shall be used to place each pavement course, with the exception of base and leveling courses, on the mainline of the traveled way including all travel lanes, auxiliary lanes, and collector/distributor (C/D) lanes.

(1) MTV Equipment Requirements.

The MTV shall be self-propelled and capable of remixing and transferring the HMA mixture to the paver so that the HMA mat behind the paver has a uniform homogeneous temperature and appearance. The MTV shall be equipped with the following:

(a) A truck unloading system, capable of maintaining the planned paving production rate, which shall receive HMA from the trucks and independently deliver the mixture from the trucks to the paver.

(b) A paver hopper insert with a minimum capacity of 14 tons shall be installed in the hopper of conventional paving equipment. The paver hopper insert shall be marked to identify the point at which the insert is 50% full.

(c) An internal storage bin with a minimum capacity of 25 tons of mixture and a remixing system in the bottom of the storage bin to continuously blend the mixture as it discharges to a conveyor system; or a dual pugmill system located in the paver hopper insert with two full length longitudinally mounted counter-rotating screw augers to continuously blend and feed the mixture through the paver to the screed.

(2) MTV Operations.

The Contractor shall ensure that the MTV is loaded continuously to keep the paver moving. The volume of HMA in the paver hopper insert shall remain above the 25% capacity mark during all paving operations. In the event the MTV malfunctions during HMA placement operations, the Contractor shall continue placement of material until such time there is sufficient HMA placed to maintain traffic in a safe manner. The Contractor may continue placement of HMA until any additional mixture in transit has been placed. Paving Operations may resume only after the MTV has been repaired and is fully operational.

The MTV shall operate in the adjacent lane and not travel on the tack coat when the Engineer and Construction QC Manager determine that the project conditions and safety allow. In these instances, only the paver will be allowed on the tack coat.

(3) Bridge Loading Restrictions.

The MTV shall be subject to all bridge load restrictions. The Contractor shall verify the sufficiency of the current bridge ratings with the Engineer. In the event that the MTV exceeds the maximum allowable bridge load, the MTV shall be empty when crossing the bridge and shall be moved across without any other Contractor vehicles or equipment being on the bridge. The MTV shall be moved across the bridge in a travel lane and shall not be moved across the bridge on the shoulder. The MTV shall be moved at a speed no greater than five (5) miles per hour without any acceleration or deceleration.

B. Pavers.

Each HMA pavement course shall be placed with one or more pavers at the specified grade, cross-slope, and lift thicknesses.

(1) Paver Equipment Requirements.

Each paver shall be a self-contained, power propelled unit and shall produce a finished surface of smooth and uniform texture without segregating, tearing, shoving or gouging the HMA. The pavers shall be equipped with the following:

(a) A receiving hopper having sufficient capacity to ensure a uniform and continuous placement operation.

(b) Automatic feed controls, which are properly adjusted to maintain a uniform depth of material ahead of the screed.

(c) Automatic screed controls with sensors capable of sensing the transverse slope of the screed, and providing the automatic signals that operate the screed to maintain grade and transverse slope.

(d) An adjustable vibratory screed with full-width screw augers and heated for the full width of the screed.

(e) Capable of spreading and finishing HMA pavement courses in widths at least 12 inches more than the width of one travel lane.

(f) Capable of being operated at forward speeds to satisfactorily place the HMA.

(g) For nighttime paving operations, lighting fixtures shall be adjustable and tilt toward the work area. Illumination shall be provided at the guide line, the auger area, and for the full width of the screed, including fifteen (15) feet immediately behind the screed where manual raking operations are taking place. Care shall be taken in the placement of these floodlights to avoid aiming of the lights into oncoming traffic. The number of lighting fixtures shall meet the following requirements:

a. Single width pavers (≤ 12 feet) shall have three (3) fixtures illuminating the screed area and two (2) fixtures for the auger and guide line area.

b. Double width pavers (> 12 feet) shall have six (6) fixtures illuminating the screed area and two (2) fixtures for the auger and guide line area.

(2) Paver Operations.

The Contractor shall ensure that the paver is loaded continuously to keep the placement operation moving. The volume of HMA in the paver receiving hopper shall remain above the paver tunnel during all paving operations. Proper practices shall be utilized to ensure that HMA is not dumped or spilled onto the prepared underlying surface in front of the paver by trucks unloading into the receiving hopper. Any material that falls in front of the paver shall be removed before the paver passes over it. The screed vibrator shall be operated at all times.

When the use of an MTV is required the paving operations shall be coordinated in such a manner as to allow the paver to operate at a consistent speed without stopping. If the Construction QC Manager or the Engineer determines that the paver excessively changes speed or stops, then stoppage of the paving operation may be required until such time the Contractor is able to correct the deficiency.

C. Mobile Lighting for Milling and Paving Equipment.

Whenever milling or paving operations are being conducted between the hours of sunset and sunrise, the Contractor shall provide mobile lighting system(s) attached to each piece of mobile milling and paving equipment, including milling machines, mechanical sweepers, material transfer devices, paver machines, and rollers, but shall not include trucks used to transport materials and/or personnel to the work zone or other vehicles that are continually moving in and out of the work zone.

Mobile lighting systems attached to milling and paving equipment shall be in addition to work zone lighting requirements specified in Section 850.

Lighting attached to each machine shall be capable of providing a minimum of 1 foot-candle measured 60 feet in front of and behind the equipment (1 foot candle is defined as1 lumen/ft^2). Lighting measurements shall be per Section 850. Light fixtures shall be balloon-style or otherwise diffused to minimize glare. Flood lights without diffusers shall not be permitted.

No part of the mobile lighting system shall exceed a height 13 feet above the pavement except in areas with constrained vertical clearances where the height may further be limited by the Engineer.

Existing street or highway lighting shall not eliminate the requirement for the Contractor to provide lighting.

D. HMA Placement Inspection.

The HMA shall be free of identifiable material (physical) segregation or temperature related segregation. The HMA placed shall be a homogeneous mixture that is of uniform temperature. The Contractor shall inspect the mixture in the paver receiving hopper for material (physical) segregation. The Contractor will also inspect the uncompacted HMA mat behind the paver for longitudinal streaks, end-of-load segregation or other irregularities.

The Contractor shall also measure the temperature differential in the uncompacted mat behind the paver. Each HMA pavement course behind the paver shall be divided into longitudinal Sublots of 500 feet. The mat temperature differential of the uncompacted HMA shall be measured at a minimum of one location in each Sublot along a straight transverse line behind the paver at a minimum frequency of once per Sublot. The transverse line for mat temperature measurement shall be established at a distance within 10 feet behind the paver screed. Temperature measurements shall be obtained by the Contractor using an infrared pistol thermometer at two (2) foot intervals along the transverse line across the width of the mat and recorded on NETTCP Inspection Report Forms. The difference between the highest and lowest temperature measurement shall not exceed 20°F.

If the maximum mat temperature differential is exceeded, or if material segregation or irregularities in the HMA mat behind the paver are noted, the Contractor shall review the production, transportation, and placement operations and take corrective action. The Contractor shall make every effort to prevent or correct any irregularities in the HMA, such as changing pavers or using different and additional equipment. The Contractor's Quality Control Plan shall fully outline procedures for inspecting the HMA mat during placement, identifying and troubleshooting material segregation or temperature related segregation, and implementing corrective action.

450.48 Hot Mix Asphalt Compaction.

A. Compaction Equipment Requirements.

The Contractor shall employ compaction equipment as outlined in the approved Quality Control Plan. Equipment used for compaction of HMA Base Courses, Intermediate Courses and Surface Courses may include steel wheeled rollers, vibratory rollers, oscillation rollers, or pneumatic-tired (rubber tired) rollers as determined appropriate by the Contractor for the particular mixture type being placed. The number and type of rollers used for breakdown, intermediate, and finish rolling shall be sufficient to achieve the target in-place density and specified course thickness.

For nighttime paving operations, each roller shall be equipped with floodlights on both the front and back. Two floodlights (one wide beam and one narrow beam) shall be aimed towards the front and two floodlights (one wide beam and one narrow beam) shall be aimed towards the back. All floodlights shall be securely mounted to minimize vibrations during roller operations. Floodlights shall be mounted above the top platform surface of the roller but less than fifteen (15) feet above ground level. Mounting height and placement shall be designed to allow the operator to run the roller without blocking the lighting beams onto the roadway.

B. Compaction Operations.

The rollers shall not crush the aggregate in the HMA mixture and shall be capable of reversing without shoving or tearing the mixture. Rollers shall not be permitted to stop on the mat except to reverse direction. Rollers may also stop on the mat to refill water when the Construction QC Manager and Engineer determine that the project conditions and safety do not allow for removing the roller from the pavement mat. In these instances the Contractor shall ensure that the pavement is sufficiently cool to prevent the roller from leaving mat deficiencies. The Contractor shall outline in the Quality Control Plan the proposed rolling sequence for each HMA pavement course to be placed. For HMA Category A Lots, the initial rolling pattern for each pavement course will be confirmed or adjusted during placement of the Control Strip in accordance with the requirements of Subsection 450.51B. As the Lot placement progresses during the construction season, the rolling pattern shall be adjusted as necessary to achieve the specified HMA in-place density. The rolling pattern shall be noted in the Quality Control Daily Diary. If there is a major change to the rolling pattern, such as the addition or subtraction of a roller and the subsequent individual pavement mat quality characteristic test results fall below the Specification Limits, then a new Control Strip shall be performed.

C. Compaction of Open-Graded Friction Course.

Rubber tire rollers will not be permitted on Open Graded Friction Course (OGFC) mixtures. Vibratory and oscillatory rollers shall be operated in static mode. Initial rolling of OGFC should be accomplished with the breakdown roller within a short distance of the paver. Any subsequent rolling shall be accomplished without over-rolling the mixture. Breakdown and intermediate rolling of OGFC shall be completed before the material has cooled to 195°F.

D. Inspection & Testing of Compacted HMA.

The compacted HMA pavement course shall be free of mat deficiencies listed below and shall meet the requirements for in-place density, thickness, and ride quality specified in Subsection 450.65F. The Contractor shall inspect each Sublot of HMA throughout the compaction operation and shall further inspect the in-place HMA after Sublot completion and identify any areas of visible material (physical) segregation. The Contractor shall reject any in-place Sublot of HMA which is determined to be segregated through procedures established in the Quality Control Plan. The Contractor will also test each Sublot for in-place density, thickness, and ride quality as specified in Subsection 450.65F. Mat deficiencies include, but are not limited to:

- Material (physical) segregation
- Wavy surface
- Tearing of the mat
- Non-uniform mat texture
- Screed marks
- Poor pre-compaction
- Poor mix compaction
- Poor Joints
- Transverse (check) cracking
- Mat shoving under roller
- Bleeding or fat spots in the mat
- Roller marks

450.49 Hot Mix Asphalt Joints.

The Contractor shall plan the sequence of HMA placement to minimize transverse and longitudinal joints in each pavement course. Paving operations should employ long pulls or tandem pavers, whenever practicable, to reduce the number and length of joints. Finished joint surfaces, including joints in the roadway and bridge joints, shall be uniform and true to the required grade and cross-slope without deviations exceeding 0.25 inches, both transversely and parallel to the joint, when measured with a 10 foot standard straightedge.

A. Transverse Joints.

Where the start or end of a new HMA pavement course meets existing HMA pavement, the existing pavement shall be sawcut to form a transverse butt joint for the full depth of all new pavement courses. The sawcut shall follow a straight line and provide a clean and sound vertical face. Material at any intermediate transverse joint resulting from suspension of placement of a new HMA pavement course shall also be sawcut and removed to provide a clean vertical face before continuing placement of the pavement course.

When traffic is to be carried over any transverse joint before completion of an HMA pavement course, the Contractor shall provide a temporary tapered joint with a maximum 12:1 slope. The HMA mixture forming the taper shall be placed on heavy wrapping paper or other suitable material to serve as a bond breaker. The temporary tapered joint shall be sawcut to reveal the full depth of the pavement course and form a transverse butt joint with a clean vertical face. The temporary tapered joint material shall be completely removed before resuming placement of the HMA pavement course.

Prior to the start of HMA placement at each transverse joint, the vertical joint face shall be thoroughly coated with a hot poured rubberized asphalt sealant meeting the requirements of Subsection 450.30. The asphalt sealant temperature and application rate for each pavement course shall be established in the Contractor's Quality Control Plan and shall follow the Manufacturer's recommendation. No reheating of the joint face shall be permitted. Equipment used to apply the hot poured rubberized asphalt sealant shall be capable of maintaining the sealant at the established temperature and application rate sufficient to uniformly coat the vertical joint face without runoff or accumulation of the asphalt sealant.

B. Longitudinal Joints.

All longitudinal joints in HMA Surface Courses shall be located on the roadway centerline or on a lane line or edge line of the traveled way. The longitudinal joints in each pavement course below the Surface Course shall be successively offset from the joint in the Surface Course by no more than twelve (12) inches and no less than six (6) inches. Joints shall be straight and parallel to the lane line of the roadway.

(1) Vertical Joints.

When an HMA pavement course is placed using single paver pulls, the Contractor shall employ suitable equipment to confine the longitudinal edge of the HMA mixture to establish an edge that is near vertical. For all HMA Surface Course mixtures placed, when the Contractor's placement operations do not provide a confined and near vertical edge, the longitudinal edge of the Surface Course shall be sawcut full depth and removed to provide a clean vertical face before placement of the adjacent course of HMA.

All longitudinal joint edges of HMA Surface Courses, regardless of whether the joint edge is required to be sawcut, shall be treated prior to placing the adjacent pull of HMA. The vertical joint shall be coated with a hot poured rubberized asphalt sealant meeting the requirements of Subsection 450.30. The asphalt sealant shall be applied at a sufficient temperature and application rate for each pavement course sufficient to uniformly coat the vertical joint face without runoff or accumulation of the sealant. The asphalt sealant temperature and application rate shall be established in the Contractor's Quality Control Plan and shall follow the manufacturer's recommendation. No reheating of the joint shall be permitted.

When placing an HMA Surface Course with pavers in tandem, the use of the hot poured rubberized asphalt sealant will be omitted, provided the temperature of the mixture at the longitudinal joint does not fall below 200ºF prior to the placement of the adjacent mat.

When the longitudinal edge of any HMA pavement course is placed against an adjoining edge such as existing pavement, curb, gutter, drainage or utility structure, or any metal surface, a tack coat shall be uniformly applied to the entire vertical joint surface in accordance with Subsection 450.43 prior to placement of the HMA.

(2) Wedge Joints.

The Contractor may use a longitudinal wedge joint when placing HMA pavement courses at a thickness of 1.25 inches to 3.75 inches as shown in Figure 1 below. In instances where the joint will not be subjected to traffic prior to the adjacent pass being placed the maximum thickness may be increased to 5 inches.

When a wedge joint is proposed for use, the joint detail shall be included in the Contractor's QC Plan. The wedge joint shall include a notched vertical edge with a minimum depth equal to the nominal maximum aggregate size (NMAS) at the top and bottom of the wedge. The sloped surface of the wedge joint shall not exceed a 6:1 slope. The width of the wedge shall not exceed 6 times the pavement depth. The Contractor shall use a commercially manufactured wedge joint attachment to the paver, or other attachment approved by the Engineer, to form the wedge joint.

Hot poured rubberized asphalt sealant shall not be applied to wedge joints. A tack coat shall be applied to the entire surface of the wedge joint in accordance with Subsection 450.43 prior to placement of the adjacent pull of HMA.

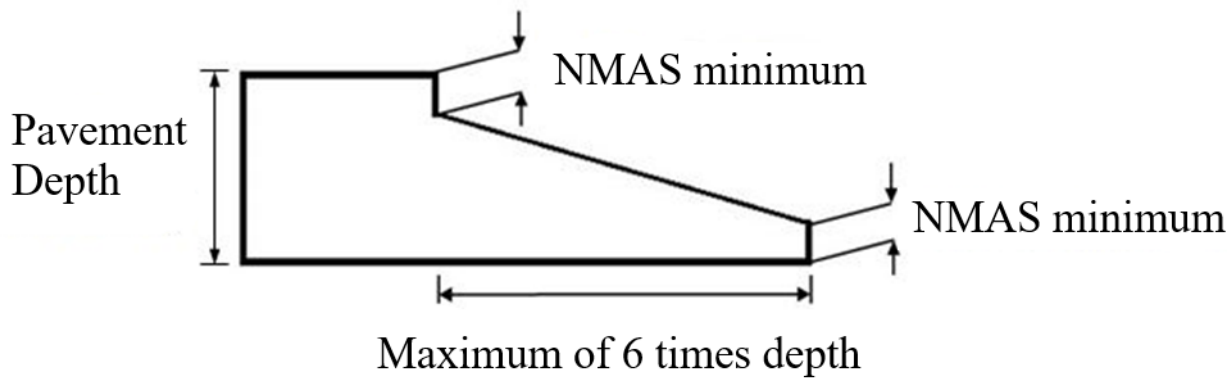

Figure 1 - Notched Wedge Joint

C. Inspection & Testing of HMA Joints.

The hot poured rubberized asphalt sealant temperature and application rate shall be measured and properly recorded by the Contractor on NETTCP Inspection Report Forms a minimum of once per transverse joint and once per 1,000 feet of longitudinal joint. If the temperature or application rate is determined to not be in conformance with the requirements established in the Contractor's Quality Control Plan, the Contractor shall make appropriate adjustments to the asphalt sealant application operations.

The placement and compaction of HMA at each transverse joint or longitudinal joint shall provide a tight bond between the existing pavement and the new pavement course. The Contractor shall visually inspect each transverse joint and longitudinal joint throughout the placement and compaction operations and shall further inspect the joints after Sublot completion and identify any bumps, depressions, openings, or other visible defects. The Contractor shall reject any in-place Sublot of HMA which is determined to have defective joints through procedures established in the Quality Control Plan.

Finished joint surfaces, including joints in the roadway and bridge joints, shall be uniform and true to the required grade and cross-slope without deviations exceeding 0.25 inches, both transversely and parallel to the joint, when measured with a 10 foot standard straightedge. The in-place density of the completed HMA pavement course, within 1 foot of either side of the finished joint, shall be not less than 90% of the maximum theoretical density of the mixture as determined by AASHTO T 209 (Method A). The Contractor will measure the surface smoothness and test the in-place density of each transverse joint and longitudinal joint of each Sublot of HMA as specified in Subsection 450.65F. All joint inspection and testing data shall be recorded on NETTCP Inspection Report Forms and Test Report Forms.

450.50 HMA Pavement on Bridges.

A. Bridge Course Mixture Requirements.

HMA pavement courses for bridge decks shall consist of a Bridge Protective Course, placed first, followed by a Bridge Surface Course. The maximum amount of RAP used in HMA pavement courses for bridge decks shall not exceed 15%. All Bridge Protective Course mixtures shall be treated with an approved anti-stripping compound as specified under Subsection 450.30. The addition of anti-strip incorporated in the HMA mixture shall be in accordance with the anti-strip Manufacturer's recommendation.

The Bridge Protective Course and Bridge Surface Course shall be placed only after all curbing and edging, when included in the work, are in place. The Bridge Protective Course shall be placed within 24 hours after the membrane waterproofing has been placed. No vehicular traffic shall be permitted over any bare membrane waterproofing except as provided for under Subsection 965. Equipment used for placement and compaction of the Bridge Protective Course and Bridge Surface Course shall be sufficient to place the HMA mixture at the required grade, cross-slope, thickness, and in-place density without damaging the underlying membrane waterproofing. Rollers will not be allowed to use the vibratory function when compacting the mat. Rollers operated in oscillatory mode may be permitted.

B. Inspection & Testing of Bridge Course Mixtures.

The Contractor shall inspect and test each Sublot of Bridge Protective Course HMA mixture and Bridge Surface Course HMA mixture in accordance with the requirements for mixture temperature, mat temperature, segregation, and joint quality as specified in Subsections 450.43 through 450.52. QC sampling and testing of each Sublot shall be performed for all HMA loose mix Quality Characteristics specified in Subsection 450.65F. The in-place density of the Bridge Protective Course and Bridge Surface Course shall be randomly tested using a calibrated density gauge and the test data recorded on NETTCP Test Report Forms. The in-place density of the Bridge Protective Course and Bridge Surface Course shall be not less than 90% of the maximum theoretical density of the mixture as determined by AASHTO T 209 Method A and tested per AASHTOT 343 or T 355. Cores shall only be allowed for Dispute Resolution. When the HMA Bridge Surface Course is placed in conjunction with mainline pavement, QC testing for ride quality shall be performed as specified in Subsection 450.65F(11).

450.51 HMA Mix Design Verification and Control Strip Requirements.

For all pavement courses with HMA Lots falling under Lot Category A (Large Lots), the HMA mix design Verification and Control Strip procedures outlined below shall apply.

A. Laboratory Verification of HMA Mix Design.

The Contractor shall develop and submit a Laboratory Trial Mix Formula (LTMF) for each HMA mixture type, which is to be proposed as a Job Mix Formula, a minimum of sixty (60) days prior to the start of HMA production in accordance with the requirements of Subsection 450.30 and MassDOT's Asphalt Mix Design approval process. The Contractor shall not proceed to HMA production for the Control Strip as outlined below until the LTMF is verified by the Department.

B. HMA Control Strip.

For all HMA pavement courses with Lots falling under Category A (Large Lots), with the exception of Leveling Courses, the Contractor shall produce and place a Control Strip Lot on the first day of HMA production.

The Control Strip will be used to verify that the HMA can be produced per the LTMF, to establish compaction patterns, and to verify that the equipment and processes for lay-down and compaction are capable of providing the HMA pavement course in conformance with these specifications. The Control Strip Lot shall be placed in the same manner planned for the full production Lot. This shall include paving with the same equipment and personnel, at the same speed, and using the same number of rollers as will be used during full production. If the paving operation is significantly changed after the Control Strip then the Engineer may require that another Control Strip be performed.

The Control Strip Lot shall consist of a minimum of 600 tons of HMA, but not more than 1,800 tons. Each Control Strip will be divided into three (3) equal Sublots. The Contractor and the Department will both perform inspection, sampling, and testing on the Control Strip and evaluate the corresponding data as outlined below.

The Engineer may waive the requirement for a Control Strip in its entirety or for evaluation of the plant production Quality Characteristics, if all of the following requirements are met:

- The Contractor has placed a passing (i.e. Verified) Control Strip in the same calendar year.
- The Verified Control Strip was for an HMA pavement course with the same LTMF produced by the same HMA plant.
- The Verified Control Strip was for a pavement course with the same lift thickness (± 15%).
- The Contractor's most recent Category A Lot represented by the Verified Control Strip has a Quality Level of 90 PWL or better (for each Quality Characteristic) in the same calendar year.

(1) Control Strip Inspection.

The Contractor's QC personnel shall perform inspection of each Control Strip Sublot at both the HMA production facility and at the site of HMA field placement. The specific items to be inspected for the Control Strip shall include the four primary inspection components (Equipment, Materials, Environmental Conditions, Workmanship) in accordance with the requirements of Table 450.8, Table 450.9, and as specified in the Contractor's approved QC Plan. The Department will also inspect each Control Strip Sublot for the inspection components of Materials and Workmanship.

(2) Control Strip Sampling and Testing.

The Contractor and the Department shall independently sample and test the Control Strip Lot for the Quality Characteristics identified in Table 450.5. The Contractor and the Department shall independently sample and test each Sublot produced and placed. Each Contractor QC sample and each Agency Acceptance sample shall be randomly obtained from each Sublot in accordance with Subsection 450.65A and the prescribed sampling protocols for each Quality Characteristic as outlined in Subsection 450.65F. Split samples shall be retained for each Sublot by both the Contractor and the Department in accordance with Subsection 450.65D.

(3) Evaluation of Control Strip Inspection Data.

The Contractor and the Department shall each evaluate their respective Control Strip inspection data against the requirements for Materials and Workmanship specified in Subsection 450.43 thru Subsection 450.52.

(4) Evaluation of Control Strip Sampling and Testing Data.

The Contractor and the Department shall each evaluate their respective individual Sublot test results against the Control Strip Quality Limits in Table 450.5. The Contractor and the Department shall also evaluate the Control Strip Lot Quality Level (PWL) using the Specification Limits in Table 450.5 for those Quality Characteristics subject to Quality Level Analysis. The Contractor's QC test data shall be subject to Validation against the Agency's Acceptance test data in accordance with Subsection 450.77 and, if Validated, shall be combined with the Acceptance test data to determine the Lot Quality. The Control Strip Lot Quality Level must be 70 PWL or greater.

Table 450.5 - Control Strip Quality Limits

Quality Characteristic	Target	Specification Limits		Engineering Limits		Acceptance Limit
		LSL	USL	LEL	UEL	
PG Asphalt Binder Grading	Per Binder Grade specified	N/A	N/A	Per AASHTO M 320	Per AASHTO M 320	N/A
PG Asphalt Binder Content	Per LTMF	Target - 0.3 %	Target + 0.3 %	Target - 0.4 %	Target + 0.4 %	≥ 70 PWL
Volumetrics: Air Voids	4 %	2.7 %	5.3 %	2 %	6 %	≥ 70 PWL
Combined Gradation: Passing #4 (4.75mm) and Larger Sieves	Per LTMF	N/A	N/A	Target - 7%	Target + 7%	N/A
Combined Gradation: Passing #8 (2.36mm) Sieve	Per LTMF	N/A	N/A	Target - 5%	Target + 5%	N/A
Combined Gradation: Passing #16 (1.18mm) to #50 (300um) Sieve	Per LTMF	N/A	N/A	Target - 4%	Target + 4%	N/A
Combined Gradation: Passing #100 (150um) Sieve	Per LTMF	N/A	N/A	Target - 3%	Target + 3%	N/A
Combined Gradation: Passing #200 (75um) Sieve	Per LTMF	N/A	N/A	Target - 1.5%	Target + 1.5%	N/A
In-Place HMA Mat Density (Cores)	95 % of G_{mm}	92.5 % of G_{mm}	97.5 % of G_{mm}	91.5 % of G_{mm}	98.5 % of G_{mm}	≥ 70 PWL
Thickness[(1)]: (All Courses 1 inch or greater)	Per Plans	- 20 % of Target Thickness	+ 20 % of Target Thickness	- 30 % of Target Thickness	+ 30 % of Target Thickness	≥ 70 PWL
Ride Quality[(1)]: Posted Speed Limit ≥ 55 mph	50 in/mile	N/A	70 in/mile	N/A	80 in/mile	≥ 70 PWL
Ride Quality[(1)]: Posted Speed Limit ≥ 40 mph, but < 55 mph	70 in/mile	N/A	100 in/mile	N/A	110 in/mile	>70 PWL

(1) To be evaluated for applicable pavement courses subject to testing per Subsection 450.65F. The Quality Limits for Ride in Table 450.5 shall only apply to Control Strips for the final pavement course (HMA Surface Course or Friction Course). For pavement courses below the final pavement course that are subject to Ride Quality testing, the Mean IRI for the Control Strip Sublots shall be less than or equal to the Maximum Mean IRI values in Table 450.13.

(5) Verification of Control Strip Lot and LTMF.

In order for a Control Strip Lot and corresponding LTMF to be Verified, the following criteria must be met:

a) All Attributes inspected for each Sublot must meet the specification requirements in Table 450.16.

b) All individual Sublot test results for the Quality Characteristics tested on the Control Strip must be within the Engineering Limits in Table 450.5.

c) If the evaluation of all inspection data and testing data for the Control Strip indicates that the individual Sublots are in conformance with the requirements outlined in Subsection 450.51B paragraphs (3) and (4) above and the Lot Quality for each applicable Quality Characteristic in Table 450.5 is ≥ 70 PWL, the Control Strip Lot and LTMF shall be declared "Verified". In such event, the LTMF shall become the Job Mix Formula (JMF) for the Lot and the Contractor may proceed with production and placement of the first HMA Lot.

d) If the Control Strip is not Verified, the Contractor shall reassess the LTMF, the production process, and the placement process to determine the apparent cause(s) of non-conformance. The Contractor must submit proposed adjustment(s) to the LTMF and/or the production process and/or placement process. If adjustments to the LTMF are "major" (as defined in Table 1 of AASHTO R 42), the Contractor will be required to submit a new LTMF for laboratory verification by the Engineer per the requirements of Subsection 450.51A. If proposed adjustment(s) are accepted by the Engineer, the Contractor may proceed with a subsequent Control Strip.

   i. If a 2nd or any subsequent Control Strip does not pass all of the inspection and testing requirements, the Contractor must submit proposed adjustment(s) to the LTMF and/or the production process and/or placement process,

   ii. If the computed PWL for any Quality Characteristic, with the exception of thickness, is < 60 PWL, the Control Strip Lot will be determined rejected and shall be removed. If the mean thickness of the Lot is greater than the target, it may remain in place, but payment will be based upon the HMA tonnage calculated at the target thickness.

   iii. For any Control Strip that is not Verified, the Contractor shall prepare a Corrective Action Plan for the nonconforming Control Strip Lot. The corrective method(s) proposed by the Contractor shall be subject to the approval of the Department and shall be performed at the Contractor's expense.

   iv. When a Control Strip is not Verified, all subsequent Control Strips shall be tested for all applicable Quality Characteristics. For these subsequent Control Strips, no waivers will be allowed for evaluation of either plant production or field Quality Characteristics.

(6) Acceptance and Payment of Control Strips

(a) 1st and 2nd Control Strip

For each Control Strip Lot that has been Verified, payment shall be determined for each individual Quality Characteristic in accordance with the pay adjustment provisions of Subsection 450.92.

   i. If the Lot Quality Level for an individual Quality Characteristic is 90 PWL, payment for the Quality Characteristic shall be 100% of the Contractor's bid price for the pay item quantity placed on the Control Strip.

   ii. If the Lot Quality Level for an individual Quality Characteristic is > 90 PWL, payment for the Quality Characteristic shall be an incentive amount determined in accordance with Subsection 450.92.

   iii. If the Lot Quality Level for an individual Quality Characteristic is ≥ 60 PWL, but < 90 PWL, payment for the Quality Characteristic shall be a disincentive amount determined in accordance with Subsection 450.92.

   iv. If the computed Quality Level for an individual Quality Characteristic is < 60 PWL, the Control Strip Lot will be determined rejected and removed in accordance with Subsection 450.51B(5) and shall receive no payment.

(b) 3rd Control Strip

If a 3rd Control Strip Lot is placed and is Verified, payment shall be limited to a maximum of 75% of the Contractor's bid price for the entire pay item quantity placed on the Control Strip, regardless of the actual calculated Quality Level for the Lot.

If a 3rd Control Strip Lot is placed and is not Verified, payment shall be limited to a maximum of 70% of the Contractor's bid price for the entire pay item quantity placed on the Control Strip, regardless of the actual calculated Quality Level for the Lot.

If the computed Quality Level for an individual Quality Characteristic is < 60 PWL, the Control Strip Lot will be determined rejected and removed in accordance with Subsection 450.51B(5) and shall receive no payment.

(c) 4th or Subsequent Control Strip

If a 4th or subsequent Control Strip Lot is placed and is Verified, payment shall be limited to a maximum of 65% of the Contractor's bid price for the entire pay item quantity placed on the Control Strip, regardless of the actual calculated Quality Level for the Lot.

If a 4th or subsequent Control Strip Lot is placed and is not Verified, payment shall be limited to a maximum of 60% of the Contractor's bid price for the entire pay item quantity placed on the Control Strip, regardless of the actual calculated Quality Level for the Lot.

If the computed Quality Level for an individual Quality Characteristic is < 60 PWL, the Control Strip Lot will be determined rejected and removed in accordance with Subsection 450.51B(5) and shall receive no payment.

450.52 Opening to Traffic.

No vehicular traffic or loads shall be permitted on the newly completed HMA pavement until adequate stability has been attained and the material has cooled sufficiently to a temperature of 140° F or less as indicated by an infrared thermometer. The Contractor shall clearly outline, in the Quality Control Plan, the specific criteria related to opening new pavement to traffic. The final determination to open the pavement to traffic shall be made by the Engineer and the Construction QC Manager.

HMA cores shall be obtained by the Contractor for all Sublots placed each day in accordance with the approved Quality Control Plan prior to opening to traffic. At the discretion of the Engineer, based on climactic or other conditions, obtaining of cores may be delayed for a period up to, but not to exceed, 48 hours.

In the event of force majeure resulting from direction by the Engineer, the Contractor shall document the event and may submit a claim in accordance with current Department procedures. In such event, the Engineer and Construction QC Manager will determine if the affected Sublots must be isolated from the relevant HMA Lot and the HMA quality be evaluated as a separate Lot.

CONTRACTOR QUALITY CONTROL

450.60 General.

The Contractor shall provide a Quality Control (QC) system and, when required, a Quality Control Plan, adequate to ensure that all materials and workmanship meet the required quality levels for each specified Quality Characteristic. The Contractor shall provide qualified QC personnel and QC laboratory facilities and perform Quality Control inspection, sampling, testing, data analysis, corrective action (when necessary), and documentation as outlined further below.

450.61 Contractor Quality Control Plan.

For projects with HMA Category A Lots (Large Lot) or Category B Lots (Small Lot), the Contractor shall provide and maintain a detailed Quality Control Plan, hereinafter referred to as the "QC Plan". If all HMA Lots fall under Lot Category C (Minor Lot) then a QC Plan is not required. However, if any Lots on the project fall under Lot Category A or Category B, then any Category C Lots must be addressed in the QC Plan. The QC Plan should sufficiently document the QC processes of all Contractor parties (i.e. Prime Contractor, Subcontractors, Producers) performing work required under this specification. The QC Plan is not intended to be a generic document, but rather must be project specific. If a QC Plan is not required, it is still the responsibility of the Contractor to provide to the Engineer any information that is designated as "Per QC Plan" as found in this specification.

A. QC Plan Submittal Requirements.

At the pre-construction conference, the Contractor shall be prepared to discuss the Quality Control Plan. Information to be discussed shall include the proposed QC Plan submittal date, QC organization, and sources of materials. The Contractor shall submit one (1) hard copy and one (1) electronic copy of the QC Plan to the Engineer for approval not less than thirty (30) days prior to the start of any work activities related to HMA pavement construction (including preparation of underlying surface) addressed in Subsections 450.43 thru 450.52. The Contractor shall not start work on the subject work items without an approved QC Plan.

B. QC Plan Format and Contents.

The QC Plan shall be structured to follow the format and section headings outlined in the MassDOT Model QC Plan. The pages of the QC Plan shall be sequentially numbered. The QC Plan shall address, in sufficient detail, the specific information requested under each section and subsection contained in the MassDOT Model QC Plan.

C. QC Plan Approval and Modifications.

Approval of the QC Plan will be based on the inclusion of the required information. Revisions to the QC Plan may be required prior to approval for any part of the QC Plan that is determined by the Department to be insufficient. Approval of the QC Plan does not imply any warranty by the Engineer that the QC Plan will result in completed work that complies with the specifications. It remains the responsibility of the Contractor to demonstrate such compliance. The Contractor may modify the QC Plan as work progresses when circumstances necessitate changes in Quality Control personnel, laboratories, or procedures. In such case, the Contractor shall submit an amended QC Plan to the Department for approval a minimum of three calendar days prior to the proposed changes being implemented.

450.62 Quality Control Personnel Requirements.

The Contractor's Quality Control organization shall, at a minimum, consist of the personnel outlined below that meet the described minimum qualifications. Every effort should be made to maintain consistency in the Quality Control organization, however substitution of qualified personnel shall be allowed. When circumstances necessitate substitution of QC personnel not originally listed in the approved QC Plan, the Contractor shall submit an amended QC Plan for approval in accordance with Subsection 450.61C.

A. Construction Quality Control Manager.

The Contractor's Quality Control system and QC Plan shall be administered by a qualified project assigned Construction Quality Control Manager (QC Manager). The QC Manager must be a full-time employee of the Contractor or a Quality Control consultant engaged by the Contractor. The QC Manager (or their assistant in the QC Manager's absence) shall have full authority to institute any and all actions necessary for the successful implementation of this specification and the QC Plan. The QC Manager (or their assistant in the QC Manager's absence) shall be available to communicate with the Engineer at all times.

Principal responsibilities of the QC Manager shall include preparation and submittal of the Contractor's QC Plan, managing the activities of all QC personnel, communicating on quality issues within the Contractor's organization, and ensuring that all requirements outlined in the approved QC Plan are met.

The QC Manager shall be certified by the NETTCP as a Quality Assurance Technologist. For projects having only HMA Category C Lots, the Contractor may submit alternate qualifications for the QC Manager acceptable to the Department.

B. Production Facility Quality Control Technician(s).

All Contractor Quality Control sampling, testing, and inspection conducted at the HMA production facility shall be performed by qualified Production Facility Quality Control Technicians (Plant QCTs). The Contractor shall provide a sufficient number of Plant QCTs to adequately implement the minimum Quality Control requirements contained in this specification and as outlined in the approved QC Plan. A minimum of one (1) qualified Plant QCT shall be present at each production facility location. HMA will not be accepted by the Department unless the Plant QCT is physically present at the plant during production and correctly performs the required Quality Control inspection, testing and documentation.

All Plant QCTs shall be certified as a HMA Plant Technician by the NETTCP.

C. Laboratory Quality Control Technician(s).

Any QC testing that is performed at off-site laboratories (i.e. other than at the production facility or field site) shall be performed by qualified Laboratory Quality Control Technicians (Laboratory QCTs). The Contractor shall provide a sufficient number of Laboratory QCTs to adequately implement the minimum Quality Control requirements contained in this specification and as outlined in the approved QC Plan.

All Laboratory QCTs shall be certified as a HMA Plant Technician by the NETTCP.

D. Field Quality Control Technician(s).

All Contractor Quality Control sampling, testing, and inspection conducted at the HMA field placement site shall be performed by qualified Field Quality Control Technicians (Field QCTs). The Contractor shall provide a sufficient number of Field QCTs to adequately implement the minimum Quality Control requirements contained in this specification and as outlined in the approved QC Plan. A minimum of one (1) qualified Field QCT will be present at each field placement site. HMA will not be accepted by the Department unless the Field QCTs is physically present at the site during pre-placement and placement operations and correctly performs the required Quality Control inspection, testing and documentation.

All Field QCTs shall be certified as a HMA Paving Inspector as certified by the NETTCP.

450.63 Quality Control Laboratory Facility Requirements.

All Contractor Quality Control testing shall be performed in laboratories qualified through the NETTCP Laboratory Qualification Program (LQP) or accredited through the AASHTO Accreditation Program (AAP). The Quality Control laboratory shall conform to Subsection 450.30.

450.64 Quality Control Inspection.

The Contractor shall perform Quality Control inspection of all work items addressed under this specification. Inspection activities during HMA production and placement may be performed by qualified Production personnel (e.g. Skilled Laborers, Foremen, and Superintendents). However, the Contractor's QC personnel shall have overall responsibility for QC inspection. The Contractor shall not rely on the results of Department Acceptance inspection for Quality Control purposes. The Engineer shall be provided the opportunity to monitor and witness all QC inspection.

Quality Control inspection activities must address the following four primary components:

- Equipment
- Materials
- Environmental Conditions
- Workmanship

The minimum frequency of Quality Control inspection activity shall be in accordance with the requirements below and as outlined in the approved QC Plan. The results and findings of QC inspection shall be documented on NETTCP Inspection Report Forms (IRFs).

A. QC Inspection for Preparation of Underlying Surface.

The Contractor's personnel will perform Quality Control inspection during preparation of the underlying surface in accordance with the requirements of Subsection 450.43. The minimum items to be inspected shall be as outlined in Table 450.6 and Table 450.7. The Contractor shall identify in the QC Plan the specific inspection activities necessary to ensure the quality of the work, including any additional inspection activities not specifically listed in Table 450.6 and Table 450.7.

Table 450.6 - Minimum QC Inspection of HMA Patching Operations

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC Plan	Per QC Plan	Per QC Plan	Per QC Plan
Materials	Aggregates & PG Binder (Correct Type)	Per QC Plan	HMA Production Facility	Visual Check & Manufacturer COC
	HMA Mixture (Correct Type)	Per QC Plan	From Haul Vehicle at Patching Site	Visual Check & Delivery Ticket
	Rubberized Asphalt Sealant (Correct Type)	Per QC Plan	Per QC Plan	Check Manufacturer COC
	Temperature of HMA Mix	4 per Day(1)	From Haul Vehicle at Patching Site	Check Measurement
Environmental Conditions	Underlying Surface Soundness & Moisture	Per QC Plan	Underlying Surface	Visual Check
	Temperature of Air & Underlying Surface	1 per Day(2)	At Patching Site	Check Measurement
Workmanship	Sawcut Limit Vertical Face	Per QC Plan	Sawcut Limits	Visual Check
	Rubberized Asphalt Sealant Application Rate	Per QC Plan	Sawcut Limits	Check Measurement
	HMA Lift Thickness	Per QC Plan	HMA Lift	Check Measurement
	Cross-Slope & Profile	Per QC Plan	Compacted HMA	Check Measurement

(1) The initial temperature measurements will be taken from haul vehicles on the first or second load.

(2) At a minimum, the temperature measurements of the air and underlying surface shall be obtained prior to starting the HMA patching placement.

Table 450.7 - Minimum QC Inspection of Tack Coat Operations

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC Plan	Per QC Plan	Per QC Plan	Per QC Plan
Materials	Asphalt Emulsion (Correct Type)	Per QC Plan	Per QC Plan	Check Manufacturer COC
	Asphalt Emulsion Temperature	(See Note 1)	From Tack Distributor System	Check Measurement
Environmental Conditions	Underlying Surface Cleanliness & Moisture	Per QC Plan	Underlying Surface	Visual Check
	Temperature of Air & Underlying Surface	1 per Day(2)	At Paving Site	Check Measurement
Workmanship	Asphalt Emulsion Application Rate	(See Note 1)	From Tack Distributor System	Check Measurement

(1) The Asphalt Emulsion Temperature and Application Rate shall be checked as follows:
- After application of the first 1,000 lane-feet per HMA pavement course.
- After application of the next 1,500 lane-feet per HMA pavement course.
- After application of the next 2,500 lane-feet per HMA pavement course.
- Thereafter, a minimum of once per 5,000 lane-feet each day.

(2) As a minimum, the temperature measurements of the air and underlying surface shall be obtained prior to starting the tack coat placement.

B. QC Inspection for Production & Placement of HMA Lots.

The Contractor's QC personnel will perform Quality Control inspection at both the HMA production facility and at the site of HMA field placement to ensure that the production and placement processes are providing work conforming to the contract requirements. The minimum items to be inspected for each HMA Lot shall be in accordance with the requirements of Subsection 450.43 thru Subsection 450.52 and as outlined in Table 450.8 and Table 450.9. The Contractor shall identify in the QC Plan the specific inspection activities necessary to ensure the quality of the work, including any additional inspection activities not specifically listed in Table 450.8 and Table 450.9.

(1) Wheel Path Deviations.

A wheel path is defined as three (3) feet from and parallel to each longitudinal edge of a travel lane. Each wheel path for all HMA pavement course Lots shall be inspected for Wheel Path Deviations (high points or low points). All Transverse joints, Bridge joints, and structures that are within three (3) feet of a wheel path shall be inspected for Wheel Path Deviations.

Inspection shall be performed using a 10-foot standard straightedge in the longitudinal direction on each wheel path. The Sublot size and minimum frequency of QC inspection for Wheel Path Deviations shall be as specified in Table 450.9, and in the approved Contractor Quality Control Plan. Each random inspection location shall be established by determining a randomly selected distance along the wheel path in accordance with Subsection 450.65A. Additional selective QC inspection for Wheel Path Deviations within each Sublot of compacted HMA pavement courses shall be as determined necessary by the Field QCT and as specified in the Contractor's approved QC Plan.

The variation from the edge of the 10-foot straightedge to the top of the wheel path surface between any two contact points in the wheel path shall not exceed 0.25 inches. The Contractor shall correct any location in a pavement course wheel path not meeting this requirement. The corrective method(s) proposed by the Contractor shall be subject to the approval of the Department and shall be performed at the Contractor's expense. The Contractor shall re-inspect any Sublots where corrections are made and provide the Department with a copy of the inspection data for the corrected Sublots.

Table 450.8 - Minimum QC Inspection at HMA Production Facility

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC Plan	Per QC Plan	Per QC Plan	Per QC Plan
Materials	PG Binder (Correct Type)	Per QC Plan	HMA Production Facility	Visual Check & Manufacturer COC
	Aggregates (Correct Type)	Per QC Plan	HMA Production Facility	Visual Check
	RAP	Per QC Plan	HMA Production Facility	Visual Check
	MAS	Per QC Plan	HMA Production Facility	Visual Check & Manufacturer COC
	Release Agent	Per QC Plan	Haul Vehicle Bed at Plant	Check QCML & Visual Check & Manufacturer COC
	Temperature of HMA Mix at Plant	4 per Day(1)	From Haul Vehicle at Plant	Check Measurement
Environmental Conditions	Stockpile Moisture	Per QC Plan	HMA Production Facility	Visual Check
	Air Temperature & Precipitation Forecast	1 per Day(2)	HMA Production Facility	Check Measurement
Workmanship	Uncoated Mixture	Per QC Plan	HMA Production Facility	Visual Check
	Excess Blue Smoke or Moisture	Per QC Plan	HMA Production Facility	Visual Check
	Burnt Mix	Per QC Plan	HMA Production Facility	Visual Check
	Physical Segregation	Per QC Plan	HMA Production Facility	Visual Check

(1) The initial temperature measurements shall be taken from the first or second load.

(2) As a minimum, the air temperature measurements and precipitation forecast shall obtained prior to starting the HMA Plant operation.

Table 450.9 - Minimum QC Inspection at HMA Placement Location

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Equipment	As specified in QC Plan	Per QC Plan	Per QC Plan	Per QC Plan
Materials	Rubberized Asphalt Sealant (Correct Type)	Per QC Plan	Per QC Plan	Check Manufacturer COC
	Temperature of Delivered HMA Mix	4 per Day(1)	From Haul Vehicle or Paver Hopper	Check Measurement
Environmental Conditions	Underlying Surface Soundness & Moisture	Per QC Plan	Underlying Surface	Visual Check
	Temperature of Air & Underlying Surface	1 per Day(2)	At Paving Site	Check Measurement
Workmanship	Joint Location & Alignment	Per QC Plan	Per QC Plan	Visual Check
	Sawcut Joint Vertical Face	Per QC Plan	Joint Vertical Face	Visual Check
	Rubberized Asphalt Sealant Application Rate	Once per 1,000 ft per joint	Joint Vertical Face	Check Measurement
	Temperature Differential in HMA Mat	Once per 500 ft per pavement course	HMA Mat Behind Paver	Per Subsection 450.45C
	Physical Segregation	Per QC Plan	HMA Mat Behind Paver & Compacted HMA	Visual Check
	HMA Lift Thickness	Per QC Plan	HMA Lift	Check Measurement
	Cross-Slope	Per QC Plan	Compacted HMA	Check Measurement
	Joint Tightness	Per QC Plan	Compacted HMA	Visual Check
	Joint Surface Deviations	Once per 500 ft per joint	At Finished Joint	10 foot standard straightedge
	Wheel Path Deviations	Once per 2,000 ft per Wheel Path	Wheel Path	10 foot standard straightedge

(1) The initial temperature measurements will be taken from the first or second load.

(2) As a minimum, the temperature measurements of the air and underlying surface shall be obtained prior to starting the HMA placement.

450.65 Quality Control Sampling and Testing Requirements.

The Contractor's QC personnel will perform Quality Control sampling and testing at both the HMA production facility and at the site of HMA field placement to ensure that the production and placement processes are providing work conforming to the contract requirements. The Engineer will not sample or test for Quality Control or assist in controlling the Contractor's operations. All QC sampling and testing shall be in accordance with the current AASHTO, ASTM, NETTCP, or Department procedures specified in Table 450.10 and Table 450.11. When a test method has been updated or superseded, the superseding specification shall be used. If a test method has been removed from circulation with no replacement then that test method shall be used until otherwise noted. The Contractor shall furnish approved containers for all material samples. The Engineer shall be provided the opportunity to monitor and witness all QC sampling and testing.

A. Random Sampling.

The Contractor's Quality Control system shall utilize stratified random sampling of each Lot produced and placed to assure that all material within the Lot has an equal probability of being selected for testing. The Contractor's qualified QC personnel shall obtain random QC samples at the minimum frequencies specified in Table 450.10 and Table 450.11. In all cases, application of the specified QC sampling frequencies shall result in a minimum of one random sample per Sublot.

Random sample locations shall be determined using the random number tables and procedures contained in ASTM D3665 or an electronic random number generator, as presented by the NETTCP. The determination of all random sample locations shall be documented on NETTCP Standard Test Report Form D3665RNG. The Contractor will provide the Engineer with the random QC sampling locations selected and documented for each Sublot prior to production and placement of the relevant Sublots.

B. Selective Sampling.

The Contractor's Quality Control system will also utilize selective sampling (i.e. non-random samples), as needed, to provide supplemental information to assist in maintaining all production and placement processes in control. The Contractor's qualified QC personnel shall obtain selective QC samples from any Sublot as determined necessary and in accordance with the guidelines established in the approved QC Plan. Selective QC core samples shall not be obtained within a ten (10) foot radius of a Department random Acceptance sample. Selective QC samples shall not be used as a basis to dispute Department Acceptance test results.

C. QC Sample Identification System.

The Contractor shall establish a reliable system for the identification of all QC samples obtained. All PG Asphalt Binder samples, HMA loose mixture samples, and core samples shall be correctly labeled with the following minimum information:

(a) Contract No.
(b) Date of Sample.
(c) Bid Item Number
(d) Mixture Type.
(e) Mixture ID Number
(f) Lot & Sublot No.
(g) Sample No.
(h) Sample Type (i.e. Random or Selective).
(i) Sample Location (e.g. Station & Offset).

All QC sampling data for Ride Quality and Wheel Path Deviations will be identified by the Contractor as directed by the Engineer. The Contractor's system and procedures for identification of QC samples shall be outlined in the approved QC Plan.

D. Retention of Split Samples.

The Contractor's qualified QC personnel shall obtain all material samples (PGAB samples, HMA loose mix samples, and cores) for QC testing. The Contractor will retain split samples from each PGAB sample and HMA loose mix sample. If requested, these split samples will be provided to the Engineer. The Contractor shall retain the original core samples after testing to serve as "split samples" and protect them from damage. All split samples shall be properly labeled and stored for a period of thirty (30) days, or until tested. These split samples (PGAB samples, HMA loose mix samples, and cores) will only be utilized if necessary, in the Dispute Resolution process. The retained split samples may be discarded prior to the required thirty (30) days when agreed upon by the Contractor and the Department.

E. Quality Control Testing of Prepared Underlying Surface.

The Contractor's QC personnel will perform Quality Control testing during preparation of the underlying surface. All QC testing shall be in accordance with the current AASHTO, ASTM, NETTCP, or Department procedures specified in Table 450.10. The Engineer shall be provided the opportunity to monitor and witness all QC testing.

Table 450.10 - Minimum QC Sampling & Testing of Prepared Underlying Surface

Quality Characteristic	Test Method(s)	Sublot Size	Minimum Test Frequency	Point of Sampling	Sampling Method
HMA Patching Mixture: PG Asphalt Binder Content	AASHTO T 308	150 tons	1 per Sublot	From Haul Vehicle at Plant	Random AASHTO T 168
HMA Patching Mixture: Combined Agg. Gradation	AASHTO T 30	150 tons	1 per Sublot	From Haul Vehicle at Plant	Random AASHTO T 168
HMA Patching Mixture: Maximum Theo. Specific Gravity	AASHTO T 209 (Method A)	150 tons	1 per Sublot	From Haul Vehicle at Plant	Random AASHTO T 168
HMA Patching Mixture: In-place Density	AASHTO T 343 or T 355	100 sq. ft per each Patch Area	1 per Sublot	From Compacted HMA Patch	Random AASHTO T 343 or T 355

F. Quality Control Testing of HMA Lots.

The Contractor's QC personnel will perform Quality Control testing at both the HMA production facility and at the site of HMA field placement to ensure that the production and placement processes are providing work conforming to the contract requirements. The Engineer shall be provided the opportunity to monitor and witness all QC testing of HMA. All QC testing of HMA Lots shall be in accordance with the current AASHTO, ASTM, NETTCP, or Department test methods specified in Table 450.11 and the procedures outlined below.

Table 450.11 - Minimum Quality Control Sampling & Testing of HMA Lots

Quality Characteristic	Test Method(s)	Sublot Size	Minimum Test Frequency	Point of Sampling	Sampling Method
PG Asphalt Binder Grading	AASHTO M 320	Per Supplier QC Plan or 24,000 tons of HMA per Subsection 450.65F[(1)]	See Subsection 450.65F(1)	See Subsection 450.65F(1)	Random AASHTO R66
RAP Asphalt Binder Content	AASHTO T 308	Per QC Plan	Per QC Plan	At HMA Plant Per QC Plan	Random AASHTO T 2
RAP Gradation	AASHTO T 30	Per QC Plan	Per QC Plan	At HMA Plant Per QC Plan	Random AASHTO T 2
Aggregate Gradation	AASHTO T 27	Per QC Plan	Per QC Plan	At HMA Plant Per QC Plan	Random AASHTO T 2
PG Asphalt Binder Content	AASHTO T 308	600 tons	1 per Sublot[(1)]	From Haul Vehicle at Plant	Random AASHTO T 168 and R 47
Combined Aggregate Gradation	AASHTO T 30	600 tons	1 per Sublot[(1)]	From Haul Vehicle at Plant	Random AASHTO T 168 and R 47
Maximum Theo. Specific Gravity	AASHTO T 209 (Method A)	600 tons	1 per Sublot[(1)]	From Haul Vehicle at Plant	Random AASHTO T 168 and R 47
Bulk Specific Gravity	AASHTO T 166 (Method A)	600 tons	1 per Sublot[(1)]	From Haul Vehicle at Plant	Random AASHTO T 168 and R 47
Volumetrics: Air Voids, VMA, VFA	AASHTO T 312 and R 35	600 tons	1 per Sublot[(1)]	From Haul Vehicle at Plant	Random AASHTO T 168 and R 47
In-place HMA Mat Density (Density Gauge)	AASHTO T 343 or T 355	150 tons	1 per Sublot[(1)]	From Compacted HMA Course	Selective & Random AASHTO T 343 or T 355
In-place HMA Mat Density (Cores)	AASHTO T 269	600 tons	1 per Sublot[(1)]	From Compacted HMA Course	Random AASHTO R 67
Thickness	ASTM D3549	600 tons	1 per Sublot[(1)]	From Compacted HMA	Random AASHTO R 67
Transverse Joint Density	AASHTO T 343 or T 355	Each Joint	1 per Sublot[(1)]	At Finished Joint	Random AASHTO T 343 or T 355
Longitudinal Joint Density	AASHTO T 343 or T 355	500 feet per Joint	1 per Sublot[(1)]	At Finished Joint	Random AASHTO T 343 or T 355
Ride Quality (IRI)	AASHTO R 54 Per Subsection 450.65F(11)	0.1 miles per each Wheel Path	3 Runs per Sublot	Each Pavement Course Per Subsection 450.65F(11)	Random Per Subsection 450.65F(11)

(1) In the event that the total daily HMA production is less than one Sublot, a minimum of one random QC sample shall be obtained for the day's production.

(1) PG Asphalt Binder Grading.

QC testing of PG Asphalt Binder shall be performed by the PGAB Supplier in accordance with AASHTO R 26 and the Supplier's approved PGAB Quality Control Plan. The Contractor shall submit to the Engineer the Supplier's Certificate of Compliance (COC) along with copies of the Certificate of Analysis (COA) showing the certified AASHTO M 320 test results for each Supplier Lot of PGAB from which the HMA Producer's PGAB was obtained. A copy of the COA and a copy of all Bill of Ladings for the Lot of PGAB being used shall be kept in the Contractor's QC laboratory.

If the Contractor adds to or modifies the PGAB at the HMA production facility through blending or introduction of an asphalt binder additive or modifier, the Contractor (i.e. HMA Producer) shall assume responsibility as the PGAB Supplier per AASHTO R 26. In such case, the Contractor shall obtain and test a minimum of one random sample of the modified PGAB for each 24,000 ton HMA Sublot, as defined in Table 450.11, to determine conformance with AASHTO M 320.

A minimum of two (2) 1-quart containers of PGAB shall be obtained for each PGAB sample in accordance with AASHTO R 66. All QC samples shall be split prior to testing and the un-tested portion of the sample shall be retained for a minimum of thirty (30) days.

For HMA Category A Lots incorporating greater than 25% RAP by weight of the mix in the job-mix formula, the Contractor shall perform full asphalt binder grade testing on a minimum of one random sample from the Control Strip and from each Sublot as specified in Table 450.11 during HMA Lot production. The QC testing shall follow the procedures for developing a blending chart as provided in AASHTO M 323 Appendices X1 to X3. The PG Asphalt Binder Grade test results, as depicted by the blending chart, shall conform to the specified PGAB grade for the HMA pavement course mixture.

(2) Aggregate Gradation.

The virgin aggregates utilized in each HMA Lot shall be tested for Gradation in accordance with AASHTO T 27. The Sublot size and minimum frequency of QC testing for Aggregate Gradation shall be as specified in the Contractor's approved QC Plan. Aggregate samples shall be obtained at the HMA plant from aggregate bins or stockpiles in accordance with AASHTO T 2.

(3) PG Asphalt Binder Content.

Each HMA Lot produced and placed shall be tested for PG Asphalt Binder Content in accordance with AASHTO T 308. The Sublot size and minimum frequency of QC testing for PG Asphalt Binder Content shall be as specified in Table 450.11. Each material sample for PG Asphalt Binder Content shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(4) Combined Aggregate Gradation.

Each HMA Lot produced and placed shall be tested for Combined Aggregate Gradation in accordance with AASHTO T 30. The Sublot size and minimum frequency of QC testing for Combined Aggregate Gradation shall be as specified in Table 450.11. Each material sample for Combined Aggregate Gradation shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

The QC test results of Combined Aggregate Gradation must be plotted on Control Charts with Action Limits. Minimum Action Limits are provided in Table 450.12, however, the Action Limits to be used for each HMA Lot shall be as specified in the Contractor's approved QC Plan. If the QC test results for an individual Sublot fall outside of the established Action Limits, the Contractor shall evaluate the HMA production process and determine any adjustments necessary to bring the Combined Aggregate Gradation back within the Action Limits. If the subsequent Sublot test result falls outside of the Action Limits, the Contractor shall suspend Lot production until it can be demonstrated that the HMA mixture can be produced within the Action Limits. The Contractor's QC personnel shall document all action(s) taken to bring the HMA production process into control.

Table 450.12 - Minimum Action limits for Combined Aggregate Gradation

Sieve Size	Action Limit
Passing No. 4 Sieve and larger sieve sizes	JMF Target +/-6 percent
Passing No. 8 sieves	JMF Target +/-5 percent
Passing No. 16 to No. 50 sieves (inclusive)	JMF Target +/-3 percent
Passing No. 100 sieve	JMF Target +/-2 percent
Passing No. 200 sieve	JMF Target +/-1 percent

(5) Maximum Theoretical Specific Gravity.

Each HMA Lot produced and placed shall be tested for Maximum Theoretical Specific Gravity in accordance with AASHTO T 209 Method A. The Sublot size and minimum frequency of QC testing for Maximum Theoretical Specific Gravity shall be as specified in Table 450.11. Each material sample for Maximum Theoretical Specific Gravity shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(6) Bulk Specific Gravity.

Each HMA Lot produced and placed shall be tested for Bulk Specific Gravity in accordance with AASHTO T 166 (Method A). The Sublot size and minimum frequency of QC testing for Bulk Specific Gravity shall be as specified in Table 450.11. Each material sample for Bulk Specific Gravity shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(7) Volumetrics (Air Voids, VMA, VFA).

Each HMA Lot produced and placed shall be tested for Volumetrics (Air Voids, VMA, VFA) in accordance with AASHTO T 312 and R 35. The requirement for Volumetric testing of laboratory compacted specimens applies to all HMA mixtures designed by the Superpave volumetric method. The Sublot size and minimum frequency of QC testing for Volumetrics shall be as specified in Table 450.11. Each material sample for Volumetrics shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(8) In-place HMA Mat Density.

Each HMA Lot produced and placed shall be tested for In-place Density using a density gauge or cores as specified below. The requirement for In-Place Density testing applies to all pavement courses, with the exception of Open Graded Friction Courses and Leveling Courses. The Sublot size and minimum frequency of random QC testing for In-place Density by either density gauge or core shall be as specified in Table 450.11.

(a) Testing In-Place Density by Density Gauge. Initial QC testing of In-Place Density during compaction of HMA pavement courses shall be performed selectively (or randomly when determined appropriate by QC personnel) using a density gauge in accordance with AASHTO T 343 or T 355. QC testing of In-Place Density for all HMA Bridge Protective Courses and Bridge Surface Courses shall be performed randomly using a density gauge. Each random sampling and testing location for HMA bridge courses shall be established by determining a randomly selected tonnage and corresponding approximate longitudinal distance within the Sublot, along with a randomly selected offset distance in accordance with Subsection 450.65A. Additional selective QC sampling and testing within each Sublot of compacted HMA Bridge Protective Courses or Bridge Surface Courses shall be as determined necessary by the Contractor's QC personnel and as specified in the Contractor's approved QC Plan.

The density gauge shall be calibrated at least once every twelve (12) months in accordance with the applicable test method and Manufacturer's recommendations. Calibration certificates shall be kept with the gauge and a copy shall be provided to the Engineer upon request. This calibration does not include calibration of the gauge to the specific HMA pavement placed.

(b) Testing In-Place Density by Cores. Final QC testing of In-Place Density of all applicable HMA pavement courses shall be performed using 6-inch diameter cores in accordance with AASHTO T 269. Cores shall not be obtained from Bridge Protective Courses and Bridge Surface Courses. In-Place Density shall be determined from each core by comparing the Bulk Specific Gravity of the core to the average Maximum Theoretical Specific Gravity for all HMA mixture Sublots produced for the pavement course on the same day's production. Each core location shall be established by determining a randomly selected tonnage and corresponding approximate longitudinal distance within the Sublot, along with a randomly selected offset distance in accordance with Subsection 450.65A. If the randomly determined sampling location coincides with one of the following conditions, the sampling location shall be relocated immediately beyond the boundary distance as indicated below for the specific condition:

1. Within one (1) foot from an edge of pavement course to be left unconfined upon project completion.
2. Within one (1) foot of any longitudinal joint or transverse joint.
3. Within three (3) feet of any drainage structure.
4. For shoulders less than or equal to three (3) feet, the shoulder width shall be excluded from random sampling.

Core samples shall be obtained in accordance with AASHTO R 67 prior to opening the pavement course to traffic. To protect the integrity of the core, when the target lift thickness is less than 1.50 inches, the Contractor shall drill so that the sampled core is comprised of at least the lift to be tested as well as the lift immediately below. At the discretion of the Engineer, based on climactic or other conditions, sampling of cores may be delayed for a period up to, but not to exceed, 48 hours. All cores shall be protected against damage and tested within 24 hours after they have been obtained. The Contractor shall fill all core holes, whether from QC sampling or Department Acceptance sampling, with fresh HMA mixture from the same Lot. The filled core holes shall be thoroughly compacted as outlined in the Contractor's approved QC Plan.

(9) Thickness.

Each HMA pavement course specified to be placed at a compacted thickness of one (1) inch or greater shall be tested for Thickness using cores, with the exception of the following courses:

1. Open Graded Friction Course.
2. Bridge Surface Course.
3. Bridge Protective Course.
4. Leveling Course.
5. In the absence of a Leveling Course, the first pavement course placed over existing pavement. A milled surface is not considered an existing pavement. HMA placed on top of a milled surface shall be subject to thickness testing unless it is one of the previous four (4) courses listed above, or if the milling operation, approved by the Engineer, caused the pavement thickness to vary.

The aforementioned pavement courses are exempt only from determination of Thickness using cores and the corresponding statistical evaluation of Lot quality. The Contractor is still responsible for ensuring the minimum required thickness of these pavement courses using an appropriate sampling and testing protocol as outlined in the Contractor's approved QC Plan. If the mean thickness of the Lot is greater than the target, it may remain in place, but payment will be based upon the HMA tonnage calculated at the target thickness.

All sampling and testing for Thickness of the applicable pavement courses using cores shall be in accordance with AASHTO R 67 and ASTM D3549, respectively. The Sublot size and minimum frequency of random QC testing for Thickness shall be as specified in Table 450.11.

(10) Joint Density.

Each transverse joint and longitudinal joint formed during placement of a pavement course shall be tested for Joint Density using a density gauge in accordance with AASHTO T 343 or T 355. The requirement for Joint Density testing applies to all pavement courses, with the exception of Open Graded Friction Courses and Leveling Courses. The Sublot size and minimum frequency of random QC testing for Joint Density shall be as specified in Table 450.11.

Each random sampling and testing location shall be established by determining a randomly selected distance along the joint, along with a randomly selected offset distance within one (1) foot of either side of the finished joint, in accordance with Subsection 450.65A. Additional selective QC sampling and testing of Joint Density within each Sublot of compacted HMA pavement courses or Bridge Protective Surface Courses shall be as determined necessary by the Field QCT and as specified in the Contractor's approved QC Plan.

(11) Ride Quality.

The finished surface of the pavement shall be uniform in appearance, free from irregularities in contour and texture and shall present a smooth riding surface. Ride Quality testing shall be performed for Quality Control on a periodic basis during construction of the HMA pavement courses specified below. QC testing shall be performed for HMA Category A Lots, at a minimum, within 48 hours after each 8 lane-miles of an individual pavement course have been placed. QC testing of HMA Category B Lots shall be performed, at a minimum, every other paving day. In addition, the Contractor shall perform QC testing of the entire final pavement course placed upon completion.

(a) Pavement Courses Subject to Ride Quality Testing. For projects having a posted speed equal to or greater than 40 mph with HMA Lots falling under Lot Category A (Large Lots) or Category B (Small Lots), QC testing shall be performed with an inertial profiler to determine the Ride Quality of the following pavement courses:

- Friction Course
- Surface Course
- Intermediate Course (lift immediately beneath Surface Course only)
- Leveling Course (when placed immediately beneath Surface Course)
- Bridge Surface Course (when asphaltic bridge joints are used and when placed on the same contract with the mainline Surface Course)

At a minimum, the finished surface of these pavement courses will be tested for all mainline travel lanes, auxiliary lanes, ramps, and side road travel lanes. The Contractor may also elect to perform Ride Quality testing of the pavement courses beneath the courses indicated above in order to provide adequate Quality Control.

(b) Pavement Courses Excluded from Ride Quality Testing. The following pavement courses and surfaces are specifically excluded from Ride Quality testing:

1. All exposed concrete bridge decks and any Bridge Surface Course without asphaltic bridge joints (including fifteen (15) feet before the approach joint and fifteen (15) feet after the departure joint).
2. Mainline pavement courses less than one half (½) mile in total length (excluding bridge lengths).
3. Side road pavement courses less than one Sublot (0.1 mile) in total length.
4. Single resurfacing pavement courses placed in one lift at a total plan (compacted) thickness less than 1.50 inches when not placed over a milled surface.
5. Pavement courses on horizontal curves having a centerline radius of curvature of 500 feet or less, including the length of pavement within the super-elevation transition of such curves.
6. Pavement courses for shoulders.
7. Pavement segments with manholes or catch basins in the travel lane (the Ride Quality testing data for such pavement segments shall be excluded, including fifteen (15) feet before and after these manholes or catch basins).

(c) Inertial Profiler Equipment Requirements. All inertial profilers used for Contractor QC testing shall conform to the equipment specifications contained in AASHTO M 328. The inertial profiler shall be equipped with a system of transducers (height sensor, accelerometer, distance sensor) to measure the longitudinal pavement profile. An automated triggering system shall be provided that detects a reference mark to start, stop, and event mark the data collection process. The profiler equipment shall include an onboard computer system capable of storing all profile measurement data, calculating the real time International Roughness Index (IRI) per ASTM E1926 (independent of speed), and displaying profile plots.

(d) Certification and Correlation of Inertial Profilers. All inertial profilers used for Contractor QC testing must be certified for precision and accuracy in accordance with the requirements of AASHTO R 56. In addition, all Contractor QC profilers must be correlated against the Department's reference profiling device in accordance with the Department's correlation procedures. The certification and correlation of all profilers shall be conducted at MassDOT's designated Profiler Correlation Center. The certification and initial correlation of the Contractor's inertial profiler shall be completed prior to the start of Ride Quality testing on the project. After the initial correlation is successfully completed, the same inertial profiler can be used on any Department project without re-correlation for the remainder of the construction season. Equipment that does not pass the Department's correlation procedure shall not be used. The Contractor's use of inertial profiler equipment that has not been successfully correlated is sufficient grounds for withholding payment for QC testing of Ride Quality. The Contractor's inertial profiler equipment may be required to undergo re-correlation at any time during the construction season if significant variations are found within the Contractor's QC test data or between the QC test data and the Department's Acceptance test data.

(e) Ride Quality Testing Procedures. Ride Quality testing shall be performed in accordance with the procedures outlined in AASHTO R 57, as clarified or amended herein.

The Ride Quality will be measured for each wheel path [a wheel path is defined as three (3) feet from and parallel to each longitudinal edge of the lane to be measured]. Each wheel path will be divided into 0.1 mile Sublots starting at the project limits in the direction of traffic. Partial Sublots may result at either end of the project or as a result of interruptions of the continuous pavement surface (i.e. bridge approaches, railroad crossing, cessation of daily paving operations, etc.).

Just prior to testing, the Contractor shall sweep the pavement and remove all foreign objects or materials on the pavement course surface. Testing will begin fifteen (15) feet after the transverse approach joint and end fifteen (15) feet before the transverse departure joint. A minimum of three (3) and up to a maximum of five (5) test runs will be performed on each wheel path. The final test result for each Sublot will be the average of the three best test runs.

(f) Data Format and Reporting Requirements. All Ride Quality QC testing data shall be collected and saved in electronic format in an ASCII data file. A copy of the raw data file shall be provided to the Engineer on site immediately following testing of completed Sublots. A longitudinal profile shall be determined for all Sublots tested and an average IRI value shall be determined and reported for each Sublot (i.e. each 0.1 mile segment of each wheel path). The Contractor shall summarize the results for all Sublots, by corresponding Ride Quality Lot, in an electronic spreadsheet file (MS Excel) consistent with the format of the Department's QA Spreadsheets. The summary spreadsheet of QC testing data shall be submitted to the Department, electronically and in hardcopy, within two days after the testing is completed.

(g) Ride Quality Monitoring & Corrective Action. The Contractor shall evaluate and monitor the test data for each pavement course requiring Ride Quality testing for conformance with the applicable Quality Limits specified in Tables 450.19a, 450.19b, or 450.19c. If the running Quality Level for all Sublots placed and tested falls below the Suspension Quality Level (70 PWL), the Contractor shall suspend further placement of the corresponding pavement course and evaluate the Sublots placed for appropriate corrective action. If the running Mean IRI of all Sublots placed and tested for the pavement course immediately below the final course is greater than the Action Limits specified in Table 450.13, corrective action will be required prior to placement of the final pavement course.

When Ride Quality correction is required, the Contractor shall use one or more of the following corrective methods:

1. Removal and replacement of the entire pavement course.
2. Partial depth removal of the pavement course by milling and placement of new pavement course(s) of the same mixture type.
3. Overlaying (not patching) with the specified pavement course.
4. Diamond grinding or use of other surface profiling devices.

The corrective method(s) chosen by the Contractor shall be subject to the approval of the Department and shall be performed at the Contractor's expense. The Contractor shall retest any Sublots where corrections are made and provide the Department with a copy of the raw data file, the profile plot, and the IRI summary spreadsheet data for the corrected Sublots.

Table 450.13 - Action Limits for Pavement Course Below Final Pavement Course

Posted Speed Limit(1)	Target IRI	Maximum Running Mean IRI of All Sublots Tested
≥ 55 mph	60 in/mile	≤ 85 in/mile
≥ 40 mph, but < 55 mph	80 in/mile	≤ 105 in/mile
< 40 mph	Not subject to Ride Quality testing	N/A

(1) Note that projects with posted speed limits that fall into more than one of the Posted Speed Limit ranges above will be divided into multiple Lots and evaluated separately.

450.66 Quality Control Documentation and Data Evaluation.

A. QC Inspection Documentation & Evaluation.

The Contractor shall document all QC inspection activity for each HMA Lot Category (Category A, B, or C) produced and placed. All inspection results shall be recorded within 24 hours of inspection on current NETTCP standard Inspection Report Forms (IRFs). The QC Manager shall evaluate inspection results in a timely manner to confirm that production and placement processes are in control. The Contractor shall submit hard copies of all IRFs to the Engineer at the completion of each Lot.

B. QC Sampling and Testing Documentation & Data Analysis.

The Contractor shall document all QC sampling and testing data for each HMA Lot Category (Category A, B, or C) produced and placed. All sampling and testing data shall be recorded within 24 hours of sampling and testing on current NETTCP standard Test Report Forms (TRFs). The QC Manager shall evaluate sampling and testing results in a timely manner, as further outlined below, to confirm that production and placement processes are in control. All QC testing data shall be entered into the Department's QA Data Spreadsheets via the MassDOT QA SharePoint site (massdotqa.com) within two (2) days after completion of testing. The Contractor shall submit hard copies of all TRFs to the Engineer at the completion of each Lot.

(1) Control Charts.

For each HMA Category A Lot produced and placed, the Contractor shall use Control Charts as part of the QC system to assist in identifying assignable causes affecting the HMA production and placement processes. Control Charts shall be prepared for the Quality Characteristics subject to QC sampling and testing listed in Table 450.11. As a minimum, the Contractor shall plot all QC test results of each Lot on Control Charts for individual Sublot measurements or test values (Run Charts). It is also recommended practice for the Contractor to use Control Charts that plot Subgroups of data (e.g. X-Bar Charts, R Charts). The Contractor shall submit examples of the Control Charts to be used in the QC Plan. As a minimum, the Control Charts shall identify the Contract number, the Payment Item number, the Lot number, the Quality Characteristic, the Control Chart Target, the Upper and Lower Control Chart Limits, and Sublot or Subgroup numbers.

All Control Charts should be updated within 24 hours after the corresponding testing is completed and documented. Quality Control personnel should use the Control Chart data to monitor and adjust the production and placement processes or suspend operations as determined necessary. Control Charts for Quality Characteristics related to HMA production should be maintained at the HMA production facility. Control Charts for Quality Characteristics related to HMA field placement should be maintained at the project field site. Current Control Charts shall be posted in an accessible location. The Engineer shall be provided access to all Control Charts as part of the Department's monitoring of Contractor QC activity.

(2) Evaluation of Individual Sublot QC Test Results.

The Contractor shall evaluate the individual QC test results for each HMA Lot Category (Category A, B, or C) produced and placed. Each random QC test result shall be evaluated against the applicable Quality Limits within 24 hours of testing. Each Sublot test value shall be within the applicable Engineering Limits specified in Tables 450.19a, 450.19b, or 450.19c.

If the evaluation of the QC testing data indicates that an individual Sublot is not in conformance with the applicable Engineering Limits, the Contractor shall follow the requirements of Subsection 450.67.

(3) Evaluation of Lot Quality Level.

For HMA Category A Lots and Category B Lots, the Contractor shall use all random QC test results to continuously evaluate the running quality level and determine the percent within limits (PWL) for each Lot during production and placement. The PWL shall be determined through Quality Level Analysis (QLA) for each of the applicable Quality Characteristics listed in Tables 450.19a, 450.19b, or 450.19c using the corresponding Specification Limits therein. The Contractor shall perform a running QLA using random QC data only after a minimum of five (5) Sublots have been tested and shall plot the cumulative PWL after each five (5) Sublot interval. The Engineer shall be provided access to all records documenting the running QLA for each Lot as part of the Department's monitoring of Contractor QC activity.

If the running QLA shows the PWL falling below the Acceptable Quality Level (AQL) of 90 PWL, the Contractor shall initiate appropriate adjustments to the production or placement process or initiate corrective action in accordance with procedures outlined in the approved QC Plan. If the PWL falls below the Suspension Quality Level (SQL) of 70 PWL, the Contractor shall suspend production and placement of the Lot prior to any subsequent Sublots being placed. The Contractor shall prepare a plan of corrective action for any nonconforming Lot, as further outlined below.

a) If the corrective action requires a significant adjustment to the JMF or the production or placement process, a new Lot will be established. If any of the JMF target values are changed, creating a new DMF according to AASHTO R 42, then a new Lot will be established. For Category A Lots, a Control Strip will be required upon the establishment of a new Lot. After resuming production and placement, the PWL for the new Lot must be back at or above the AQL of 90 PWL once the Lot PWL can be calculated.
b) If the corrective action does not require a new Lot to be established, then the PWL must return to 70 or above within three (3) Sublots.
c) If the Lot PWL falls below 70 for more than six (6) Sublots, then any material that is placed from the time that the PWL falls below 70 to when the PWL returns to 70 or above will be determined rejected and removed and shall receive no payment.

450.67 Corrective Action.

As part of the Contractor's Quality Control system, the Contractor shall implement corrective action for any part of a Lot that is determined by inspection or testing to not be in conformance with the quality requirements specified in this specification. If the results of QC inspection identify nonconforming material or workmanship within one or more Sublots, or if the evaluation of the QC testing data indicates that any Sublot is not in conformance with the applicable Quality Limits for the particular HMA Lot Category, the Contractor shall isolate the Sublot(s) and perform additional inspection or testing to further assess the quality of the Sublot. Selective inspection or testing should be used to determine the limits of non-conformance. If a Sublot test result is outside of the Engineering Limits, the QC Manager and the Engineer will further assess the Sublot quality to determine whether the material in the Sublot can remain in place in accordance with Subsection 450.77A(2).

Based on the results of additional inspection or testing, the Contractor shall prepare a plan of corrective action for the nonconforming Sublot(s). The Corrective action plan shall be submitted to and approved by the Engineer prior to initiating corrective action. All corrective action shall be performed at the Contractor's expense.

450.68 Quality Control Records System.

A. Quality Control Daily Diary.

The QC Manager should maintain a Quality Control Daily Diary (QC Daily Diary) to document all major activities or actions related to the Contractor's QC system. The QC Daily Diary serves as a summary record of key actions taken by QC personnel each day. Recommended Information which should be recorded in the QC Daily Diary includes:

- The day's weather or environmental conditions.
- A summary of production or placement activities completed.
- Any non-conforming material or workmanship identified.
- Any corrective actions recommended or taken by QC personnel.
- Discussions held with other Contractor personnel or Department personnel.
- Visitors to the production facility or field placement operation.

B. Quality Control Record Books.

The Contractor shall maintain one or more ringed binders referred to as "Quality Control Record Books" (QC Record Books) to store all required QC documents. Separate QC Record Books shall be kept at each HMA production facility and at the project field site. Either a separate QC Record Book shall be established for each HMA pavement course or the data for each pavement course may be included in a single QC Record Book provided the data is separated according to pavement course. QC data for each pavement course shall be organized into separate sections by Quality Characteristic and by Lot number.

QC documents to be stored in the QC Record Book(s) include:

- A signed copy of the current approved QC Plan.
- The original signed copies of all completed Inspection Report Forms.
- The original signed copies of all completed Random Sampling location forms.
- The original signed copies of all completed Test Report Forms.
- A current copy or printout of all Control Charts.
- A current copy or printout of all running QLA performed.
- Current summaries of all individual QC test results to date (by Lot & Sublot).
- Summary sheets of material quantities produced or placed (by Lot & Sublot).

Each required record shall be inserted into the corresponding QC Record Book within 24 hours after the document has been completed. All QC Record Books shall be maintained in a suitable location. The Engineer shall be provided access to all QC Record Books as part of the Department's monitoring of Contractor QC activity.

In addition to entering all QC test results to the QA Data Spreadsheets, QC personnel shall also upload, to the MassDOT QA SharePoint site, all QC Inspection Report Forms and Test Report Forms for each day of production within two (2) days after completion of testing and inspection. QC personnel shall also track the daily tonnage of HMA which leaves the production facility and the quantity that is actually placed on the project site.

C. Quality Control Records Retention.

All Contractor QC records identified above shall be retained for a minimum of seven (7) years. The records shall be protected from damage or alteration. When requested by any State or Federal Agency for audit or similar purposes, the Contractor shall provide complete access to all QC records.

D. Failure to Provide Quality Control Records

The Contractor shall provide the Engineer with requested QC records within 48 hours of the request. Failure to provide the documentation in the required timeframe will result in the removal of all Validated QC test results from the Analysis of the Lot Quality Level as specified in Subsection 450.77 and no incentive will be paid for any of the Quality Characteristics.

DEPARTMENT ACCEPTANCE

450.70 General.

The Department is responsible for performing all Acceptance activities and making the final acceptance determination for each HMA Lot produced and placed. The Department's Acceptance system will include monitoring the Contractor's QC activity and performing Acceptance inspection, sampling and testing in order to determine the Quality and corresponding payment for each Lot. These activities will be performed for each HMA Lot Category (Lot Category A, B, and C) as outlined further below.

450.71 Acceptance System Approach.

A. Acceptance of Category A Lots.

The Engineer's Acceptance determination for each HMA Category A Lot will be based on an evaluation of the Department's Acceptance inspection information and testing data. The Engineer will perform Acceptance sampling and testing on a minimum of 25% and a maximum of 100% of the Sublots produced and placed. Contractor QC test data will be included in the Department's Acceptance determination for each Category A Lot provided the following requirements are met:

- Split Sample Correlation testing requirements are satisfied.
- The Contractor provides adequate Quality Control per the approved QC Plan.
- All QC test results included are from random samples.
- The QC test results are Validated against the Department's Acceptance test results.

B. Acceptance of Category B Lots.

The Engineer's Acceptance determination for each HMA Category B Lot will also be based on an evaluation of the Department's Acceptance inspection information and Acceptance testing data. The Engineer will perform Acceptance sampling and testing on a minimum of 50% and a maximum of 100% of the Sublots produced and placed, but not less than three (3) Sublots. Contractor QC test data will be included in the Department's Acceptance determination for each Category B Lot provided the requirements outlined in paragraph A above are satisfied.

C. Acceptance of Category C Lots.

For all HMA Category C Lots, the Engineer's Acceptance determination will be based only on the Department's Acceptance inspection information and Acceptance testing data. The Engineer will perform Acceptance sampling and testing on 100% of the Sublots produced and placed. Contractor QC test data will not be included in the Department's Acceptance determination for Category C Lots.

450.72 Department Monitoring of Contractor Quality Control.

The Department will monitor the Contractor's Quality Control system to confirm that QC activities are being performed for each Lot in compliance with this specification and the approved QC Plan. Department monitoring of the Contractor's QC system is not intended to evaluate the quality of the work. The Engineer will not perform the QC responsibilities of the Contractor or provide constant direction to the Contractor on how to perform Quality Control. The Engineer's monitoring of QC activity will include the following:

- Periodic visual observation of QC inspection, sampling, and testing.
- Reviewing QC documentation and records.
- Providing feedback based on monitoring findings.

When deficiencies in the Contractor's QC system are identified and documented by the Engineer, the Contractor shall take immediate action to address the deficiencies. Deficiencies related to HMA Quality Characteristics where a Quality Level Analysis is performed shall not be considered under this subsection. If the material in an HMA Lot where deficiencies in the Contractor's QC System were identified is removed and replaced, and the replacement HMA complies with the Specification requirements, the actions listed below will not apply. If the Contractor fails to acknowledge the deficiency and take appropriate action, the Contractor shall suspend production and placement of the corresponding Lot(s). Failure by the Contractor to comply with the Quality Control Requirements in either this specification or the approved QC Plan will result in the following actions:

- 1st Incident: A Non-conformance Report (NCR) will be issued by the District Quality Engineer. A follow-up Construction Quality Meeting will be held in accordance with Subsection 450.40.
- 2nd Incident: An NCR will be issued by the District Quality Engineer and work shall be immediately suspended until compliance with the specification and approved QC Plan is established. The Engineer shall issue a Deficiency Report (DR) with a deduction of 1% of the awarded contract Bid Price amount for all tonnage placed for the HMA Lot(s) where the violations were documented. Work shall not resume until a follow-up Construction Quality Meeting is held in accordance with Subsection 450.40.
- 3rd Incident: An NCR will be issued by the District Quality Engineer and work shall be immediately suspended until compliance with the specification and approved QC Plan is established. The Engineer shall issue a Deficiency Report (DR) with a deduction of 2% of the awarded contract Bid Price amount for all tonnage placed for the HMA Lot(s) where the violations were documented. The deduction will be in addition to the deduction amount from the second incident. Work shall not resume until a follow-up Construction Quality Meeting is held in accordance with Subsection 450.40.
- 4th and Subsequent Incidents: An NCR will be issued by the District Quality Engineer and work shall be immediately suspended until compliance with the specification and approved QC Plan is established. The Engineer shall issue a Deficiency Report (DR) with a deduction of 3% of the awarded contract Bid Price amount for all tonnage placed for the HMA Lot(s) where the violations were documented. The deduction will be in addition to the deduction amount from the previous incidents. An additional deduction of 1% of the awarded contract Bid Price amount for all tonnage placed for the HMA Lot(s) where the violations were documented will be added for each additional occurrence beyond the 4th. Work shall not resume until a follow-up Construction Quality Meeting is held in accordance with Subsection 450.40. The Contractor may also be required to replace the Construction QC Manager.

Failures in the Contractor QC system shall result in taking the actions listed above as well as any corrective action to the HMA pavement deemed necessary by the Engineer.

450.73 Acceptance Inspection.

The Engineer will perform Acceptance inspection of all work items addressed under this specification to ensure that all materials and completed work are in conformance with the contract requirements. Acceptance inspection is intended to visually assess the quality of each HMA Lot produced and placed and will address only the inspection components of Materials and Workmanship in support of the Department's final acceptance determination.

All Acceptance inspection activity by the Department will be performed independent of the Contractor's QC inspection at both the HMA production facility and at the site of HMA field placement. The Engineer will document the results and findings of Acceptance inspection on NETTCP Inspection Report Forms (IRFs). The Engineer will furnish a copy of all Department Acceptance inspection results to the Contractor within five (5) days following the inspection.

A. Acceptance Inspection of Prepared Underlying Surface.

The Department will perform Acceptance inspection of the prepared underlying surface prior to placement of HMA. The items to be inspected and minimum frequency of inspection will be in accordance with the requirements outlined in Table 450.14 and Table 450.15.

Table 450.14 - Department Acceptance Inspection of HMA Patching

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Materials	Mixture Type & PG Binder Grade (Correct Type)	1 per Day	HMA Production Facility	Visual Check & Manufacturer COC
	Rubberized Asphalt Sealant (Correct Type)	1 per Day	At Paving Site	Check Manufacturer COC
Workmanship	Sawcut Limit Vertical Face	25% of Patched Areas	Sawcut Limits	Visual Check
	Rubberized Asphalt Sealant Application Rate	25% of Patched Areas	Sawcut Limits	Visual Check & Check Measurement
	Cross-Slope & Profile	25% of Patched Areas	Compacted HMA	Check Measurement

Table 450.15 - Department Acceptance Inspection of Tack Coat

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Materials	Asphalt Emulsion (Correct Type)	1 per Day	At Paving Site	Check Manufacturer COC
Workmanship	Asphalt Emulsion Application Rate	Once per 5,000 lane-feet	Tacked Surface & Tack Distributor System	Visual Check & Check Measurement

B. Acceptance Inspection of HMA Lots.

The Department will perform Acceptance inspection at both the HMA production facility and at the site of HMA field placement. For purposes of Acceptance inspection, the total quantity of each HMA pavement course produced and placed during the same construction season will constitute a Lot. Each in-place HMA Lot will be divided into 500 lane-feet Sublots. The items to be inspected and minimum frequency of inspection will be in accordance with the requirements outlined in Table 450.16.

(1) Wheel Path Deviations.

Each HMA Lot produced and placed will be inspected by the Engineer for Wheel Path Deviations (high points or low points) using a 10 foot standard straightedge in accordance with the procedures outlined in Subsection 450.64B. Acceptance inspection for Wheel Path Deviations applies to all pavement courses (including Bridge Protective Courses and Bridge Surface Courses). The finished surface of each required pavement course will be inspected for all mainline travel lanes, auxiliary lanes, ramps, and side road travel lanes. The Sublot size and minimum frequency of Acceptance inspection for Wheel Path Deviations will be as specified in Table 450.16.

Table 450.16 - Department Acceptance Inspection of HMA Lots

Inspection Component	Inspection Attribute	Minimum Inspection Frequency	Point of Inspection	Inspection Method
Materials	HMA Mixture Type, Aggregates & PG Binder (Correct Type)	1 per Day	HMA Production Facility	Visual Check & Manufacturer COC
	Rubberized Asphalt Sealant (Correct Type)	1 per Day	At Paving Site	Check Manufacturer COC
Workmanship	Joint Location & Alignment	50% of Sublots, Once per Joint	At Finished Joint	Visual Check
	Sawcut Joint Vertical Face	50% of Sublots, Once per Joint	Joint Vertical Face	Visual Check
	Rubberized Asphalt Sealant Application Rate	50% of Sublots, Once per Joint	Joint Vertical Face	Visual Check & Check Measurement
	Physical Segregation	50% of Sublots, Once per Lane	Compacted HMA	Visual Check
	Cross-Slope	50% of Sublots, Once per Lane	Compacted HMA	Check Measurement
	Joint Tightness	50% of Sublots, Once per Joint	Compacted HMA	Visual Check
	Joint Surface Deviations	50% of Sublots, Once per Joint	At Finished Joint	10 foot standard straightedge
	Wheel Path Deviations	50% of Sublots, per Wheel Path	Wheel Path	10 foot standard straightedge

450.74 Acceptance Sampling & Testing.

A. Random Sampling.

The Department will utilize stratified random sampling to determine the overall quality of each HMA Lot produced and placed. Random Acceptance sample locations will be determined by the Engineer in accordance with ASTM D 3665 or by electronic random number generator, as presented by NETTCP. All random Acceptance sample locations will be documented on the most current version of MassDOT Test Report Form RMS100.

The Contractor shall furnish the Engineer with approved containers for all Acceptance samples. The Engineer will obtain all random Acceptance samples independent of the Contractor's QC samples at the frequencies outlined below.

(1) Sampling HMA Category A Lots.

The Engineer will obtain Acceptance samples from a minimum of 25% and a maximum of 100% of all Sublots in each HMA Category A Lot for all Quality Characteristics specified in Table 450.17, other than PG Asphalt Binder Grading and Ride Quality. Acceptance samples for PG Asphalt Binder Grading and Ride Quality will be obtained from each Sublot as defined in Table 450.17.

(2) Sampling HMA Category B Lots.

The Engineer will obtain Acceptance samples from a minimum of 50% and a maximum of 100% of all Sublots, but not less than three (3) Sublots, in each HMA Category B Lot for all Quality Characteristics specified in Table 450.17, other than PG Asphalt Binder Grading and Ride Quality. Acceptance samples for PG Asphalt Binder Grading and Ride Quality will be obtained from each Sublot as defined in Table 450.17.

(3) Sampling HMA Category C Lots.

The Engineer will obtain Acceptance samples from 100% of all Sublots in each HMA Category C Lot for all Quality Characteristics specified in Table 450.17, other than Ride Quality. Acceptance sampling and testing for Ride Quality will not be performed on Category C Lots.

B. Selective Sampling.

The Department will utilize selective sampling (i.e. non-random samples) as needed to provide supplemental information to assist in quantifying the quality of apparent nonconforming material. The test results of selective Acceptance samples will not be combined with random Acceptance sample data in the determination of Lot acceptance using Quality Level Analysis as outlined in Subsection 450.78.

C. Contractor Assistance in Obtaining Acceptance Samples.

The Engineer will obtain all material samples for Acceptance testing by the Department. When requested by the Department, the Contractor shall assist the Engineer in obtaining Acceptance samples in accordance with the following requirements:

- The Acceptance sample location and time will be randomly selected by the Engineer and provided to the Contractor immediately prior to sampling.
- The Contractor's qualified QC personnel will only provide the physical labor to assist the Engineer in obtaining the Acceptance sample.
- The Engineer will be present to direct and monitor the taking of the sample.
- The Engineer will take immediate possession of the Acceptance sample.

Contractor assistance may be requested in obtaining Acceptance samples (random or selective) for PG Asphalt Binder Grading and for In-Place Density and Thickness (HMA cores). The Contractor shall provide adequate traffic control for the Department to obtain cores, regardless of whether the Contractor assists the Engineer in obtaining the Acceptance core samples.

D. Acceptance Sample Identification System.

The Department will use a standard system for the identification of all Acceptance samples. All PG Asphalt Binder samples, HMA loose mixture samples, and core samples will be labeled by the Engineer with the minimum information indicated under Subsection 450.65C. Acceptance sampling data for Ride Quality and Wheel Path Deviations will be identified by the Engineer in accordance with the Department's Standard Operating Procedure (SOP) CSD QA-6.

E. Retention of Split Samples.

Qualified Department personnel will obtain all material samples (PGAB samples, HMA loose mix samples, and cores) for Acceptance testing. The Department will retain Acceptance split samples from each PGAB sample and HMA loose mix sample and provide a split sample to the Contractor if requested. The Department will retain the original core samples after testing to serve as "split samples" and protect them from damage. All split samples will be stored by the Department for a period of (30) days, or until tested. These split samples will be utilized if necessary, in the Dispute Resolution process. The retained split samples may be discarded prior to the required thirty (30) days when agreed upon by the Contractor and the Department.

F. Acceptance Testing of HMA Lots.

The Department will perform Acceptance testing using the random samples obtained in accordance with Subsection 450.74A from the HMA production facility and at the site of HMA field placement. The specific Quality Characteristics subject to Department Acceptance testing are identified in Table 450.17. All Acceptance testing of HMA Lots will be performed by the Engineer in accordance with the AASHTO, ASTM, NETTCP, or Department test methods specified in Table 450.17 and the procedures outlined below. The Engineer will furnish a copy of all Department Acceptance test results/data to the Contractor within five (5) days following completion of testing.

(1) PG Asphalt Binder Grading.

The Department will review the Supplier's Bill of Lading (BOL) submitted by the Contractor along with the Certificate of Compliance (COC) and Certificate of Analysis (COA) showing the corresponding certified test results for each Supplier Lot of PGAB from which the HMA Producer's PGAB was obtained. The Engineer will also obtain and test a minimum of one random Acceptance sample of PGAB for each 12,000 ton HMA Sublot, as defined in Table 450.17, to determine conformance with AASHTO M 320. A minimum of one (1) 1-quart container of PGAB will be obtained for each Acceptance sample from the HMA Producer's tanks in accordance with Subsection 450.30. All PGAB Acceptance samples will be split prior to testing and the un-tested portion of the sample will be retained for a minimum of thirty (30) days.

(2) PG Asphalt Binder Content.

The Engineer will test each HMA Lot produced and placed for PG Asphalt Binder Content in accordance with either AASHTO T 308. The test results will be reported with all correction factors. The Sublot size and minimum frequency of Acceptance testing for PG Asphalt Binder Content will be as specified in Table 450.17. Each material sample for PG Asphalt Binder Content will be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(3) Volumetrics (Air Voids).

The Engineer will test each HMA Lot produced and placed for Volumetrics (Air Voids) in accordance with AASHTO T 312 and R 35. The requirement for Volumetric testing of laboratory compacted specimens applies to HMA mixtures for all pavement courses, with the exception of Open Graded Friction Courses. The Sublot size and minimum frequency of Acceptance testing for Volumetrics will be as specified in Table 450.17. Each material sample for Volumetrics will be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

(4) Combined Aggregate Gradation.

Each HMA Lot produced and placed shall be tested for Combined Aggregate Gradation in accordance with AASHTO T 30. The Sublot size and minimum frequency of Acceptance testing for Combined Aggregate Gradation shall be as specified in Table 450.17. Each material sample for Combined Aggregate Gradation shall be obtained at the HMA plant from a randomly selected quadrant from the haul vehicle in accordance with Subsection 450.65A and AASHTO T 168 and R 47.

If the Acceptance test results for an individual Sublot fall outside of the Action Limits specified in Table 450.12, the Engineer shall inform the Contractor so that they may evaluate the HMA production process and determine any adjustments necessary to bring the Combined Aggregate Gradation back within the Action Limits. If the subsequent Sublot test result falls outside of the Action Limits, the Contractor shall suspend Lot production until it can be demonstrated that the HMA mixture can be produced within the Action Limits.

Table 450.17 - Department Acceptance Sampling and Testing of HMA Lots

Quality Characteristic	Test Method(s)	Sublot Size	Minimum Test Frequency	Point of Sampling	Sampling Method
PG Asphalt Binder Grading	AASHTO M 320	12,000 tons of HMA using same PG Grade	1 per Sublot	From In-line Sample Valve at HMA Plant	Random AASHTO R 66
PG Asphalt Binder Content	AASHTO T 308	600 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Haul Vehicle at HMA Plant	Random AASHTO T 168 & R 47
Combined Aggregate Gradation	AASHTO T 30	600 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Haul Vehicle at HMA Plant	Random AASHTO T 168 & R 47
Volumetrics: Air Voids	AASHTO T 312 and R 35	600 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Haul Vehicle at HMA Plant	Random AASHTO T 168 & R 47
In-place HMA Mat Density (Cores)	AASHTO T 269	600 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Compacted HMA Course	Random AASHTO R 67
In-place HMA Mat Density (Bridge Courses)	AASHTO T 343 or T 355	150 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Compacted HMA Course	Random AASHTO T 343 or T 355
Thickness	ASTM D3549	600 tons	1 per Sublot sampled per Subsection 450.74A(1)	From Compacted HMA Course	Random AASHTO R 67
Ride Quality (IRI)	AASHTO R54 per Subsection 450.65F(11)	0.1 miles per each Wheel Path	1 Per Sublot	Each Pavement Course per Subsection 450.65F(11)	Random per Subsection 450.65F(11)

(1) In the event that the total daily HMA production is less than one Sublot but greater than 150 tons, a minimum of one random Acceptance sample shall be obtained for the day's production.

(5) In-Place HMA Mat Density.

The Engineer will test each HMA Lot produced and placed for In-place HMA Mat Density. The requirement for In-Place Density testing applies to all pavement courses, with the exception of Open Graded Friction Courses and Leveling Courses, as outlined below.

(a) Testing In-Place Density by Cores. Acceptance testing of HMA pavement courses (other than bridge courses) for In-place Density will be performed using cores in accordance with the procedures outlined in Subsection 450.65F(8)(b). The Sublot size and minimum frequency of Acceptance testing for In-place Density of HMA pavement courses by core will be as specified in Table 450.17. In order to ensure that the correct maximum specific gravity is utilized to determine the In-Place Density of a core, the Engineer reserves the right to determine the maximum specific gravity of the core itself after its bulk specific gravity has been determined and verified.

(b) Testing In-Place Density by Density Gauge. Acceptance testing of all HMA Bridge Protective Courses and Bridge Surface Courses for In-place Density will be performed using a density gauge in accordance with the procedures outlined in Subsection 450.65F(8)(a). The Sublot size and minimum frequency of Acceptance testing for In-place Density of HMA bridge courses by density gauge will be as specified in Table 450.17.

(6) Thickness.

Each HMA pavement course specified to be placed at a compacted thickness of 1 inch or greater, with the exception of the HMA pavement courses identified in Subsection 450.65F(9), will be tested by the Engineer for Thickness using cores. Acceptance sampling and testing for Thickness of the applicable pavement courses shall be in accordance with AASHTO R 67 and ASTM D3549, respectively. The Sublot size and minimum frequency of Acceptance testing for Thickness will be as specified in Table 450.17. If the mean thickness of the Lot is greater than the target, it may remain in place presuming that the final pavement elevation is within project requirements, but payment will be based upon the HMA tonnage calculated at the target thickness.

(7) Ride Quality.

Department Acceptance testing for Ride Quality will be required for all projects having a posted speed equal to or greater than 40 mph with HMA Lots falling under Lot Category A or Category B. The Engineer will perform Ride Quality testing on the final HMA pavement course placed (either Surface Course or OGFC, when specified) for all mainline travel lanes, auxiliary lanes, ramps, and side road travel lanes using an inertial profiler in accordance with the procedures outlined in Subsection 450.65F(11). Pavement courses and surfaces that are specifically excluded from Acceptance testing for Ride Quality are as specified in Subsection 450.65F(11)(b). The Sublot size and minimum frequency of Acceptance testing for Ride Quality will be as specified in Table 450.17.

The inertial profiler equipment used to perform Acceptance testing will be certified and correlated by the Department in accordance with the requirements and procedures outlined in Subsection 450.65F(11). The Department Acceptance data and Contractor QC data will be correlated and normalized using statistical procedures. The normalization of data will be based on the measurement difference/bias from the Department Reference Profiling Device determined during the device correlation conducted at MassDOT's designated Profiler Correlation Center. The Department will provide software and procedures to perform the data normalization. The normalized Acceptance Ride Quality data and QC Ride Quality data will be used to determine the quality level (PWL) and corresponding pay for each Lot.

450.75 Split Sample Correlation.

Split Sample Correlation is an important part of the Department acceptance system for HMA Category A Lots and Category B Lots. Split Sample Correlation shall be performed when Validated Contractor QC test data is to be included in the acceptance determination. The purpose of Split Sample Correlation testing is to identify and eliminate any discrepancies in testing procedures or equipment that could result in significant differences between the Contractor's QC testing results and the Engineer's Acceptance testing results. The Engineer may waive the requirement for Split Sample Correlation if the following requirements are met:

- The Contractor and the Department have successfully completed correlation on another project within the same calendar year in accordance with the Split Sample Correlation procedures below.
- The Contractor's most recent Category A Lot(s) or Category B Lot(s) on the other project(s) during the same calendar year have a Quality Level of 90 PWL or better (for each Quality Characteristic).

Either prior to or on the first day of production and placement of any HMA Category A or B Lot, the Contractor and the Department will conduct Split Sample Correlation. The Engineer or the Contractor may also request that Split Sample Correlation be performed at any time during HMA Lot production and placement. Department IA personnel may also test a split of the Correlation samples.

Split Sample Correlation will be performed on split material samples for those Quality Characteristics identified in Table 450.18. Correlation samples for HMA mixture testing shall be either laboratory prepared specimens or plant produced HMA specimens. Samples for HMA Category A Lots may be obtained from the Control Strip Lot. The Contractor's QC personnel shall test one portion of the split sample using the equipment in their qualified QC laboratory. The Engineer shall test the other portion using the Department's equipment. Both parties shall not perform testing using the same equipment.

Correlation testing for In-place HMA Mat Density and Thickness shall be performed by both parties using the same sample. Correlation testing of the Contractor's QC ride quality testing equipment and the Department's Acceptance ride quality testing equipment will be performed in accordance with Subsection 450.65F(11)(d).

Table 450.18 Split Sample Correlation Allowable Differences

Quality Characteristic	Test Method(s)	Allowable Difference Between Contractor and Department Split Samples (d2s)
PG Asphalt Binder Content	AASHTO T 308	+/- 0.35
Maximum Theoretical Specific Gravity (G_{mm})	AASHTO T 209 (Method A)	+/- 0.020
Bulk Specific Gravity (G_{mb})	AASHTO T 166 (Method A)	+/- 0.020
Volumetrics - Air Voids	AASHTO T 269	+/- 1.20
In-Place Mat Density (Cores)	AASHTO T 269	+/- 1.20
Thickness	ASTM D3549	+/- 0.125
Ride Quality (IRI)	AASHTO R 56	Per Subsection 450.65F(11)(d)

If the Contractor's Split Sample Correlation results differ from the Department's results by more than the allowable differences specified in Table 450.18, then the Contractor and the Department shall determine and resolve the reasons for the differences prior to the start or continuation of HMA Lot production and placement.

450.76 Lot Acceptance Determination Based on Inspection Results.

The Department's Acceptance Inspection results will be used in the final acceptance determination for all HMA Lots (Lot Category A, B, and C). Prior to final acceptance of each HMA Lot produced and placed, the Department will periodically evaluate all Acceptance inspection information for the prepared underlying surface and the Lot. The materials and product workmanship for the completed work will be evaluated for conformance with the plans and the requirements specified in Subsections 450.43 thru 450.52.

When the Acceptance information identifies deficiencies in either material quality or product workmanship for any underlying surface location or HMA Sublot(s), the location or Sublot(s) will be isolated and further evaluated by the Engineer through additional Acceptance inspection (or sampling and testing, if relevant or possible). Depending upon the findings of the additional Acceptance inspection activity, the Engineer will determine the disposition of the nonconforming work in accordance with Division I, Subsection 5.03, Conformity with Plans and Specifications.

After each HMA Lot (and corresponding prepared underlying surface) is complete, including any corrective action, the Engineer will evaluate all Acceptance inspection information for the Work. The Department will accept the subject Work if the Engineer's evaluation of all inspection information for the completed Lot (and underlying surface) indicates that the corresponding materials and product workmanship meet the specified requirements (provided the evaluation of all Acceptance testing data for the subject work per Subsection 450.77 also finds the work to be acceptable).

450.77 Lot Acceptance Determination Based on Testing Data.

A. Evaluation of Lot Category A Testing Data.

Prior to final acceptance of each HMA Category A Lot produced and placed, the Engineer will periodically evaluate all available Department Acceptance testing data for the Lot.

The Contractor's random QC testing data for each Lot will be included with the Department's random Acceptance testing data in the acceptance determination, provided that the QC data has been Validated in accordance with paragraph (1) below. The Department's Acceptance data and all Validated Contractor QC data will be evaluated using the Quality Limits specified in Table 450.19 and as further outlined below.

(1) Validation of Contractor QC Test Results.

Validation is defined as the mathematical comparison of two independently obtained sets of data to determine whether it can be assumed they came from the same Population. The Validation of each HMA Lot will be performed through a statistical comparison of the Engineer's random Acceptance testing data and the Contractor's random QC testing data for the Lot.

The statistical comparison of testing data will be made using the test result Variances (***F-test***) and the test result Means (***t-test***) at a significance level of 0.01 and in accordance with the procedures contained in Appendix F of the *AASHTO Implementation Manual For Quality Assurance* (February 1996). The Validation worksheet in the Department's QA Data Spreadsheets will be used to perform the Validation of each Lot.

If the Validation results indicate that the Contractor's QC test results and the Department's Acceptance test results can be assumed to be from the same Population, then the Contractor's QC test results will be included with the Department's Acceptance test results in the final acceptance determination for each Lot. If Validation results indicate that the Contractor's QC test results and the Department's Acceptance test results cannot be assumed to be from the same Population, then the Contractor's QC test results will be excluded from the final acceptance determination for the Lot and no incentive will be paid for any of the Quality Characteristics.

If the Validation results indicate that the Contractor's QC test results and the Department's Acceptance test results cannot be assumed to be from the same Population, then the Department will endeavor to determine the reason for the difference between the two data sets. If a reason for the difference cannot be determined, then only the Department's Acceptance test results will be used in the final acceptance determination for each Lot.

(2) Conformance with Engineering Limits.

The Engineer will evaluate all Department Acceptance testing data and Validated Contractor QC testing data for each Category A Lot to determine conformance with the Engineering Limits in Table 450.19. Each Sublot test value for the Acceptance Quality Characteristics identified in Table 450.19 shall be within the Engineering Limits.

If a Sublot test result is outside of the Engineering Limits, the QC Manager and Engineer will further assess the Sublot quality to determine whether the material in the Sublot can remain in place as follows:

1. When it is possible to obtain additional samples, the Sublot will be isolated and divided into three equal Sublots. A random sample shall be obtained from each Sublot.
    a. If any of the additional samples are outside of the Engineering Limits the Sublot will be rejected and the Contractor will be required to submit a corrective action plan for review by the Engineer.
    b. If all three (3) samples are within Engineering Limits then the average of the original value along with the three additional values will be determined.
        i. If the average of the four (4) results is found to be within the Engineering Limits, the Sublot will be considered acceptable and the average of all four values will replace the original value in the Quality Level Analysis for the Sublot.
        ii. If the average of the four (4) results is found to not be within the Engineering Limits, the Sublot will be considered rejected and the Contractor will be required to submit a corrective action plan for review by the Engineer.

2. If it is not possible to obtain additional samples, the Engineer will determine the disposition of the Sublot in accordance with Division I, Subsection 5.03, Conformity with Plans and Specifications. If the Engineer's assessment determines that the material quality is sufficient to permit the Sublot to remain in place without corrective action, the Engineer shall request a credit for that Sublot. In addition, the original out of Engineering Limits test result will be included in the Quality Level Analysis for the Lot in accordance with Subsection 450.77A(3) below.

If the Engineer's assessment determines that the material quality is not sufficient to permit the Sublot to remain in place the Sublot shall be removed and replaced. When a nonconforming Sublot is corrected or replaced, the Engineer will perform Acceptance testing of the Sublot and evaluate the test results for conformance with the Engineering Limits. The Acceptance test data for the corrected Sublot will replace the original Acceptance test result and will be included in the Quality Level Analysis for the Lot in accordance with paragraph (3) below. Once the above requirements have been met, the Department will accept all completed Sublots, provided that the overall Lot quality is above the Acceptance Limit as further outlined below.

(3) Analysis of Lot Quality Level.

For each HMA Category A Lot, the Engineer will determine the Lot Quality Level, for the applicable Quality Characteristics in Table 450.19, using the Quality Level Analysis (QLA) procedures outlined in Subsection 450.78. The QLA procedure will evaluate all Department Acceptance testing data and Validated Contractor QC testing data using the applicable Specification Limits in Tables 450.19a, 450.19b, or 450.19c. The Department's QA Data Spreadsheets will be used to perform the QLA for each Lot.

All random test results that are within the Engineering Limits will be included in the Quality Level Analysis. Individual Sublot test results that are beyond the Engineering Limits, but for which the corresponding Sublot is permitted to remain in place per paragraph (2) above, will also be included in the Quality Level Analysis.

The QLA procedure will determine the Percent Within Limits (PWL) for each Lot. The Acceptance Limit (Rejectable Quality Level) for each completed Lot is 60 PWL. Each Lot must achieve a final Quality Level of at least 60 PWL in order to be accepted by the Department. The payment for the Lot will be as follows:

1. If the final computed Lot Quality Level for each of the applicable Quality Characteristics in Tables 450.19a, 450.19b, or 450.19c is at 90 PWL, the Contractor will receive full payment at the unit bid price for the Lot.
2. If the Lot Quality Level for an individual Quality Characteristic is greater than 90 PWL, the Contractor will receive an incentive pay adjustment for the Lot in accordance with Subsection 450.92.
3. If the Lot Quality Level for an individual Quality Characteristic is less than 90 PWL but greater than or equal to 60 PWL, the Contractor will receive a disincentive pay adjustment for the Lot.
4. If the Lot Quality Level for any Quality Characteristic in Tables 450.19a, 450.19b, or 450.19c is below 80 PWL, the Contractor will receive no incentive pay adjustments for any Quality Characteristics with a PWL over 90. The Contractor, however, will receive any disincentive pay adjustments for the Lot.
5. If the final computed Lot Quality Level for an individual Quality Characteristic is below 60 PWL, the Lot will not be accepted. Payment for the Lot will be withheld and the Contractor shall submit a corrective action plan within fourteen (14) days following determination of the Lot PWL. The Engineer will review the corrective action plan and render a decision within fourteen (14) days of receipt of the corrective action plan. If the Engineer determines that the Lot or some of the Sublots cannot remain in place, the Contractor shall remove and replace the affected Lot or Sublots. If the Engineer allows the Lot to remain in place, payment will be limited to a maximum of 75% of the bid price for the item.

(4) Final Lot Acceptance Determination.

After each HMA Category A Lot is complete, including any corrective action, the Engineer will perform a final evaluation of all Department Acceptance data and Validated Contractor QC data for the Lot. The Department will accept the subject Lot if the Engineer's evaluation of all testing data for the Lot is in conformance with the applicable Quality Limits as outlined in Subsections 450.77A(2) and 450.77A(3) above.

Table 450.19a - Quality Limits for Acceptance of HMA Lots

Quality Characteristic	Target	Specification Limits		Engineering Limits		Acceptance Limit
		LSL	USL	LEL	UEL	
PG Asphalt Binder Grading	Per Binder Grade specified	N/A	N/A	Per AASHTO M 320	Per AASHTO M 320	N/A
PG Asphalt Binder Content	Per JMF	Target - 0.3 %	Target + 0.3 %	Target - 0.4 %	Target + 0.4 %	60 PWL
Volumetrics: Air Voids	4 %	2.7 %	5.3 %	2 %	6 %	60 PWL
In-Place HMA Mat Density (Cores)	95 % of G_{mm}	92.5 % of G_{mm}	97.5 % of G_{mm}	91.5 % of G_{mm}	98.5 % of G_{mm}	60 PWL
In-Place HMA Mat Density (Bridge Courses)	95 % of G_{mm}	N/A	N/A	90 % of G_{mm}	N/A	N/A
Thickness: (All Courses 1 inch or greater)	Per Plans	-20 % of Target Thickness	+20 % of Target Thickness	-30 % of Target Thickness	+30 % of Target Thickness	60 PWL
Ride Quality: Posted Speed Limit ≥ 55 mph(1)	50 in/mile	N/A	70 in/mile	N/A	80 in/mile	60 PWL
Ride Quality: Posted Speed Limit ≥ 40 mph, but < 55 mph(1)	70 in/mile	N/A	100 in/mile	N/A	110 in/mile	60 PWL
Ride Quality: Posted Speed Limit < 40 mph	Not subject to Ride Quality testing					

(1) Note that projects with posted speed limits that fall into more than one of the Posted Speed Limit ranges above will be divided into multiple Lots and evaluated separately.

Table 450.19b - Quality Limits for Acceptance of ARGG Lots

Quality Characteristic	Target	Specification Limits		Engineering Limits		Acceptance Limit
		LSL	USL	LEL	UEL	
PG Asphalt Binder Grading	Per Binder Grade specified	N/A	N/A	Per ASTM D6114	Per ASTM D6114	N/A
PG Asphalt Binder Content	Per JMF	Target - 0.4 %	Target + 0.4 %	Target - 0.6 %	Target + 0.6 %	60 PWL
Volumetrics: Air Voids	Per JMF	Target - 1.3 %	Target + 1.3 %	Target - 2.0 %	Target + 2.0 %	For Information Only
In-Place HMA Mat Density (Cores)	95 % of G_{mm}	92.5 % of G_{mm}	97.5 % of G_{mm}	91.5 % of G_{mm}	98.5 % of G_{mm}	60 PWL
In-Place HMA Mat Density (Bridge Courses)	95 % of G_{mm}	N/A	N/A	90 % of G_{mm}	N/A	N/A
Thickness: (All Courses 1 inch or greater)	Per Plans	-20 % of Target Thickness	+20 % of Target Thickness	-30 % of Target Thickness	+30 % of Target Thickness	60 PWL
Ride Quality: Posted Speed Limit ≥ 55 mph(1)	50 in/mile	N/A	70 in/mile	N/A	80 in/mile	60 PWL
Ride Quality: Posted Speed Limit ≥ 40 mph, but < 55 mph(1)	70 in/mile	N/A	100 in/mile	N/A	110 in/mile	60 PWL
Ride Quality: Posted Speed Limit < 40 mph	Not subject to Ride Quality testing					

(1) Note that projects with posted speed limits that fall into more than one of the Posted Speed Limit ranges above will be divided into multiple Lots and evaluated separately.

Table 450.19c - Quality Limits for Acceptance of OGFC Lots

Quality Characteristic	Target	Specification Limits		Engineering Limits		Acceptance Limit
		LSL	USL	LEL	UEL	
PG Asphalt Binder Grading	Per Binder Grade specified	N/A	N/A	Per ASTM D6114	Per ASTM D6114	N/A
PG Asphalt Binder Content (OGFC-P)	Per JMF	Target - 0.3 %	Target + 0.3 %	Target - 0.4 %	Target + 0.4 %	60 PWL
PG Asphalt Binder Content (OGFC-AR)	Per JMF	Target - 0.4 %	Target + 0.4 %	Target - 0.6 %	Target + 0.6 %	60 PWL
Volumetrics: Air Voids	Per JMF	Target - 2 %	Target + 2 %	Target - 3 %	Target + 3 %	For Information Only
Ride Quality: Posted Speed Limit ≥ 55 mph(1)	50 in/mile	N/A	70 in/mile	N/A	80 in/mile	60 PWL
Ride Quality: Posted Speed Limit ≥ 40 mph, but < 55 mph(1)	70 in/mile	N/A	100 in/mile	N/A	110 in/mile	60 PWL
Ride Quality: Posted Speed Limit < 40 mph	Not subject to Ride Quality testing					

(1) Note that projects with posted speed limits that fall into more than one of the Posted Speed Limit ranges above will be divided into multiple Lots and evaluated separately.

B. Evaluation of Lot Category B Testing Data.

Prior to final acceptance of each HMA Category B Lot produced and placed, the Engineer will periodically evaluate all available Department Acceptance testing data for the Lot.

The Contractor's random QC testing data for each Lot will be included with the Department's random Acceptance testing data in the acceptance determination, provided that the QC data has been Validated. The Department's Acceptance data and all Validated Contractor QC data will be evaluated for conformance with Engineering Limits and for Lot Quality Level in accordance with the requirements of Subsection 450.77A above using the applicable Quality Limits specified in Tables 450.19, 450.19b, or 450.19c.

After each HMA Category B Lot is complete, including any corrective action, the Engineer will perform a final evaluation of all Department Acceptance data and Validated Contractor QC data for the Lot. The Department will accept the subject Lot if the Engineer's evaluation of all testing data for the Lot is in conformance with the applicable Quality Limits.

C. Evaluation of Lot Category C Testing Data.

For each HMA Category C Lot produced and placed, the Engineer will evaluate all Department Acceptance testing data for the Lot entered into the Department's QA Data Spreadsheets after all HMA Sublots are complete in-place. The Contractor's random QC testing data for each Lot will not be included with the Department's random Acceptance testing data in the Acceptance determination. Work under HMA Lot Category C will not be subject to an evaluation of Lot Quality Level using QLA procedures.

The individual Sublot test results for each HMA Category C Lot will be evaluated against the applicable Specification Limits contained in Tables 450.19, 450.19b, or 450.19c. (Note: The Engineering Limits are not applied since the inherent variability for Minor Lot quantities is expected to be within the Specification Limits). For Sublots which are outside of the Specification Limits a credit shall be calculated using the following formula:

When below LSL: Disincentive Value = $(LSL - x_i) \times 0.05 \times Q \times P$

When above USL: Disincentive Value = $(x_i - USL) \times 0.05 \times Q \times P$

where: LSL = Lower Specification Limit for the particular Quality Characteristic
USL = Upper Specification Limit for the particular Quality Characteristic
x_i = Individual Sublot test result
Q = Sublot quantity
P = Item bid price per ton

If a Sublot test result is outside of the Engineering Limits, the Engineer will further assess the Sublot quality in accordance with the requirements of Subsection 450.77A(2). The Engineer will determine the disposition of the Sublot in accordance with Division I, Subsection 5.03, Conformity with Plans and Specifications.

After each HMA Category C Lot is complete, including any corrective action, the Engineer will perform a final evaluation of all Department Acceptance data. The Department will accept the subject Lot if the Engineer's evaluation of the testing data for each Sublot is in conformance with the Engineering Limits.

450.78 Quality Level Analysis Procedures.

For each Quality Characteristic subject to analysis of Lot Quality Level, the Quality Level Analysis (QLA) - Standard Deviation Method will be used to determine the percentage of the Lot that is within the Specification Limits. The number of significant figures retained in each step of the QLA calculations and the rounding of all reported values will be as established in the Department's QA Data Spreadsheets. The estimated percentage of work that is within the Specification Limits for a given Lot will be determined as follows:

A. Step 1 – Determine Lot Mean.

The Mean (X) will be determined for each Lot using all random Department Acceptance sample test values and all random Contractor QC sample test values (provided they have been Validated). The Mean is calculated using the following equation:

$$X = \frac{\Sigma x}{n}$$

Where: Σ = summation of
x = individual test value of each material sample
n = total number of material samples tested

B. Step 2 – Determine Lot Standard Deviation.

The Standard Deviation (s) will be determined for each Lot using all random Department Acceptance sample test values and all random Contractor QC sample test values (provided they have been Validated). The Standard Deviation is calculated using the following equation:

$$s = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x)^2}{n(n-1)}}$$

Where: $\Sigma(x^2)$ = summation of the squares of individual test values
$(\Sigma x)^2$ = summation of the individual test values squared

C. Step 3 – Determine Upper Quality Index for Lot.

The Upper Quality Index (Q_U) will be determined for each Lot using the Lot Mean and Lot Standard Deviation calculated in Step 1 and Step 2 above. The Upper Quality Index is calculated using the following equation:

$$Q_u = \frac{USL - X}{s}$$

Where: USL = Upper Specification Limit from Table 450.19
X = Lot Mean
s = Lot Standard Deviation

D. Step 4 – Determine Lower Quality Index for Lot.

The Lower Quality Index (Q_L) will be determined for each Lot using the Lot Mean and Lot Standard Deviation calculated in Step 1 and Step 2 above. The Upper Quality Index is calculated using the following equation:

$$Q_L = \frac{X - LSL}{s}$$

Where: LSL = Lower Specification Limit from Table 450.19
X = Lot Mean
s = Lot Standard Deviation

E. Step 5 – Determine Percentage of Lot Below Upper Specification Limit.

The estimated percentage of the Lot falling below the Upper Specification Limit (P_U) will be determined using Table 450.20. The P_U value is determined from the table by entering the column for the number of material samples (n) representing the Lot and locating the row that corresponds to the Q_u value determined in Step 3 above. If no USL is specified in Table 450.20, the P_U value is equal to 100.

F. Step 6 – Determine Percentage of Lot Above Lower Specification Limit.

The estimated percentage of the Lot falling above the Lower Specification Limit (P_L) will be determined using Table 450.20. The P_L value is determined from the table by entering the column for the number of material samples (n) representing the Lot and locating the row that corresponds to the Q_L value determined in Step 4 above. If no LSL is specified in Table 450.20, the P_L value is equal to 100.

G. Step 7 – Determine Estimated Percent Within Limits for Lot.

The Lot Quality Level will be determined by estimating the Percent Within Limits (PWL). The PWL is determined using the P_U value from Step 5 and the P_L value from Step 6 above. The Percent Within Limits is calculated using the following equation:

$$PWL = (P_U + P_L) - 100$$

Table 450.20 - Values for Estimating Percent of Lot Within Specification Limits

P_U Or P_L (%)[1]	Upper Quality Index (Q_U) or Lower Quality Index (Q_L)														
	n = 3	n = 4	n = 5	n = 6	n = 7	n = 8	n = 9	n = 10 to n = 11	n = 12 to n = 14	n = 15 to n = 18	n = 19 to n = 25	n = 26 to n = 37	n = 38 to n = 69	n = 70 to n = 200	n = 201 to n = ∞
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the calculated value of Q_U or Q_L does not correspond exactly to a value in the table, use the next lower value.
If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.
(1) P_U or P_L = Percent Within limits for positive values of Q_U or Q_L

DISPUTE RESOLUTION

450.80 Disputable items

The Contractor or the Department may dispute any of the test values that are utilized in the acceptance determination for a given Lot. The specific Quality Characteristics which may be disputed are as listed in Table 450.21 below. All disputes shall be initiated within the 30 day split sample retention time limit as specified in Subsection 450.82 below.

450.81 Basis for Dispute

Differences from one individual Contractor QC test value to another (or from one individual Department Acceptance test value to another) within a Lot are expected due to inherent variability. Differences are also expected between the QC test values and the Acceptance values for a given Lot as a result of inherent variability. An individual QC test value cannot be directly compared to an individual Acceptance test value since the samples are randomly obtained independent of one another. However, if one or more of either the Contractor's random QC test values or Department's random Acceptance test values for a Lot significantly differs from the rest of the test values for the same Lot, either party may dispute the validity of an individual test value.

450.82 Dispute Resolution Samples

Samples used for Dispute Resolution testing shall be the split samples required to be retained for thirty (30) days by the Contractor and the Department in accordance with Subsection 450.65D and Subsection 450.74E. Original cores are to be retained and shall be protected from damage. If In-place density or thickness is disputed, then the original core, unless damaged, will be used in the Dispute Resolution process. If the original disputed core is damaged, then a new core shall be obtained from within a 2-foot radius of the location of the original core by the party whose data is being disputed in the presence of the other party. If ride quality smoothness test data is disputed, then the disputed Sublot(s) shall be re-sampled/retested by the party whose data is being disputed in the presence of the other party.

450.83 Dispute Resolution Process

The Contractor may dispute the Department's Acceptance results and the Department may dispute the Contractor's Quality Control results by requesting that the dispute resolution split sample be tested. Such a request, either from the Contractor or the Department, must be made in writing within five (5) days after the original sample was tested. The following shall be provided in the written request:

- Sample reference number, including Lot and Sublot
- The specific Quality Characteristic and test result(s) being disputed
- The complete NETTCP test report form containing the disputed results

MassDOT's Research and Materials Section (RMS) shall act as the Arbitrator in all disputes related to the specific Quality Characteristics listed in Table 450.21. Once RMS receives the written request, they shall review the dispute and determine the Final Disposition. RMS will perform Dispute Resolution testing or evaluation to resolve the dispute. RMS's decision will be final. RMS will determine which of the following steps will be completed as part of the Dispute Resolution Process.

A. Step 1 – Split Sample Correlation.

Immediately prior to conducting testing for Dispute Resolution, the Contractor's QC testing personnel, the Department's Acceptance testing personnel (from the District), and a Department Independent Assurance (IA) technician will conduct Split Sample Correlation testing as detailed in Subsection 450.75. Split Sample Correlation testing will be conducted on a separate material sample obtained independent from the original sample and the Dispute Resolution sample.

The purpose of the Split Sample Correlation testing is to determine if testing procedures or equipment utilized by the Contractor or the Department might be the cause of the disputed result(s).

B. Step 2 – Dispute Resolution Sample Testing.

RMS will test the Dispute Resolution split sample obtained per Subsection 450.82. Testing of the Dispute Resolution split sample shall be performed in the presence of both the Contractor and the Department.

C. Step 3 – Additional Dispute Resolution Testing.

If either the Contractor or the Department believes that the results of the Dispute Resolution split sample testing in Step 2 above do not conclusively resolve the dispute, additional sampling and testing within the disputed Sublot may be requested. In such case, RMS will obtain and test three (3) random samples from the disputed Sublot. The Mean of the three test results will be used as the Dispute Resolution test value.

450.84 Final Disposition.

If the difference between the original test value and the Dispute Resolution test value (as determined under either Step 2 or Step 3 above) is within the maximum test difference values listed in Table 450.21, then the original test value will be used in the Acceptance determination for the Lot. If the difference between the original test value and the Dispute Resolution test value exceeds the maximum difference values in Table 450.21, then the Dispute Resolution test value will be used in the Acceptance determination. In such case, the record of the original test value will be retained (with notation of the outcome of Dispute Resolution); however, it will not be used in calculating the Lot quality level.

Table 450.21 – Dispute Resolution Maximum Test Difference Values

Quality Characteristic	Test Method(s)	Maximum Test Difference (d2s)
PG Asphalt Binder Content	AASHTO T 308	+/- 0.35
Maximum Theoretical Specific Gravity (G_{mm})	AASHTO T 209 (Method A)	+/- 0.020
Bulk Specific Gravity (G_{mb})	AASHTO T 166 (Method A)	+/- 0.020
Volumetrics - Air Voids	AASHTO T 269	+/- 1.20
In-Place Mat Density (Cores)	AASHTO T 269	+/- 1.20
Thickness	ASTM D3549	+/- 0.125
Ride Quality (IRI)	AASHTO R 56	Per Subsection 450.65F(11)(d)

COMPENSATION

450.90 Method of Measurement.

A. Patching.

HMA for Patching will be measured for payment by the ton and shall be the actual quantity complete, in place and accepted by the Engineer.

B. Tack Coat.

Asphalt Emulsion for Tack Coat, as required by the plans or these specifications, will be measured by the gallon.

C. Joint Sealer.

HMA Joint Sealant used for sealing all longitudinal joints and transverse joints in HMA pavement courses will be measured by the foot.

D. Hot Mix Asphalt.

Hot Mix Asphalt pavement course mixtures will be measured by the ton and shall be the actual pavement course quantity complete, in place and accepted by the Engineer. The quantity shall be determined only by weight slips that have been properly countersigned by the Engineer at the time of delivery.

450.91 Basis of Payment.

A. Patching.

HMA for Patching will be paid for at the contract unit price per ton of the HMA mixture type specified under Pay Item 451. Payment shall include all sawcutting, removal of existing distressed or unsound pavement, applying hot poured rubberized asphalt sealant to vertical faces, applying the tack coat to all required surfaces at the specified rate in accordance with Subsection 450.43G, and transportation, delivery, placement, and compaction of HMA for Patching in accordance with Subsection 450.43C.

B. Tack Coat.

Asphalt Emulsion for Tack Coat will be paid for at the contract unit price per gallon of applied tack coat under Pay Item 452. Payment shall include sweeping existing surfaces and applying the tack coat to all required surfaces at the specified rate in accordance with Subsection 450.43G.

C. Joint Sealer.

HMA Joint Sealant will be paid for at the contract unit price per foot of joint sealed under Pay Item 453. Payment shall include application of the joint sealer to all longitudinal joints and transverse joints in HMA pavement courses as required and in accordance with Subsection 450.49.

D. Hot Mix Asphalt.

Each HMA pavement course will be paid for at the contract unit price per ton of in-place mixture under the HMA Pay Items specified (Pay Items 450.10 through 450.70). Payment shall include sweeping the underlying surface, transportation, delivery, placement (including providing an MTV when required), and compaction of each HMA pavement course in accordance with Subsection 450.43 through Subsection 450.52. Mobile lighting for nighttime milling and paving, in accordance with Subsection 450.47C, is considered incidental to the cost of each HMA pavement course placed.

All sawcutting required for transverse joints or longitudinal joints in accordance with Subsection 450.49 shall also be included in the contract unit price for each HMA pavement course. All required sawcutting in the existing pavement in accordance with this specification will be included in the contract unit price for each HMA pavement course, except sawcutting pavement for box widening, which will be paid under Item 482.5.

E. Contractor Quality Control.

The Contractor's Quality Control system will be considered incidental to the work and shall be included in the Contract unit price for each HMA pavement course. No separate payment will be made for any assistance provided by the Contractor to the Engineer in obtaining Department Acceptance samples. Failure of the Contractor to perform adequate Quality Control in accordance with the specifications and the Contractor’s approved QC Plan will be justification for withholding payment.

450.92 Pay Adjustment (PA).

Payment for each HMA Category A Lot and Category B Lot will be determined based on the final Lot Quality Level (PWL) computed in accordance with the QLA procedures contained in Subsection 450.78. Pay adjustments will be determined for each of the Acceptance Quality Characteristics identified in Table 450.22. The relative pay adjustment weight assigned to each of the HMA Quality Characteristics is indicated in Table 450.22.

Table 450.22 - Pay Adjustment Weight Assigned to HMA Quality Characteristics

HMA Quality Characteristics	Pay Adjustment Weight
PG Asphalt Binder Content	10 percent
Volumetrics - Air Voids	15 percent
In-Place HMA Mat Density	35 percent
Thickness	10 percent
Ride Quality (IRI)	30 percent

A. Lot Pay Factor.

A Pay Factor (PF) will be determined for each HMA Lot using the Quality Level (PWL) computed for the Lot and the equation below:

$$PayFactor(PF) = \frac{55 + 0.5(QualityLevel)}{100}$$

The Lot Pay Factor will be used to determine the pay adjustment for each Quality Characteristic as further outlined below.

B. Pay Adjustment for PG Asphalt Binder Content.

Pay adjustment for PG Asphalt Binder Content shall be applied to Pay Item 999.490 at the completion of the HMA Lot. The total Lot pay adjustment for PG Asphalt Binder Content will be determined as follows:

$$PA_{PGAB} = \Sigma(PF_i - 1)\,(Q_i)\,(P_i)\,(PAW_{PGAB})$$

Where: PA_{PGAB} = Pay adjustment in dollars for PG Asphalt Binder Content.
PF_i = Pay factor based on Quality Level (PWL) of PG Asphalt Binder Content for individual Lot (i).
Q_i = Quantity represented by individual Lot (i) in tons.
P_i = Contract unit price per ton for individual Lot (i).
PAW_{PGAB} = Weight given to PG Asphalt Binder Content pay adjustment, from Table 450.22, expressed as a decimal.

C. Pay Adjustment for Volumetrics (Air Voids).

Pay adjustment for Volumetrics (Air Voids) shall be applied to Pay Item 999.491 at the completion of the HMA Lot. The total Lot pay adjustment for Volumetrics (Air Voids) will be determined as follows:

$$PA_{Air\ Voids} = \Sigma(PF_i - 1)\,(Q_i)\,(P_i)\,(PAW_{Air\ Voids})$$

Where: $PA_{Air\ Voids}$ = Pay adjustment in dollars for Volumetrics (Air Voids).
PF_i = Pay factor based on Quality Level (PWL) of Volumetrics (Air Voids) for individual Lot (i).
Q_i = Quantity represented by individual Lot (i) in tons.
P_i = Contract unit price per ton for individual Lot (i).
$PAW_{Air\ Voids}$ = Weight given to Volumetrics (Air Voids) pay adjustment, from Table 450.22, expressed as a decimal.

D. Pay Adjustment for In-Place HMA Mat Density.

Pay adjustment for In-Place HMA Mat Density shall be applied to Pay Item 999.492 at the completion of the HMA Lot. The total Lot pay adjustment for In-Place HMA Mat Density will be determined as follows:

$$PA_{In\text{-}Place\ Density} = \Sigma(PF_i - 1)\ (Q_i)\ (P_i)\ (PAW_{In\text{-}Place\ Density})$$

Where: $PA_{In\text{-}Place\ Density}$ = Pay adjustment in dollars for In-Place HMA Mat Density.
PF_i = Pay factor based on Quality Level (PWL) of In-Place HMA Mat Density for individual Lot (i).
Q_i = Quantity represented by individual Lot (i) in tons.
P_i = Contract unit price per ton for individual Lot (i).
$PAW_{In\text{-}Place\ Density}$ = Weight given to In-Place HMA Mat Density pay adjustment, from Table 450.22, expressed as a decimal.

E. Pay Adjustment for Thickness.

Pay adjustment for Thickness shall be applied to Pay Item 999.493 at the completion of the HMA Lot. The total Lot pay adjustment for Thickness will be determined as follows:

$$PA_{Thickness} = \sum(PF_i - 1)\ (Q_i)(P_i)\ (PAW_{Thickness})$$

Where: $PA_{Thickness}$ = Pay adjustment in dollars for Thickness.
PF_i = Pay factor based on Quality Level (PWL) of Thickness for individual Lot (i).
Q_i = Quantity represented by individual Lot (i) in tons.
P_i = Contract unit price per ton for individual Lot (i).
$PAW_{Thickness}$ = Weight given to Thickness pay adjustment, from Table 450.22, expressed as a decimal.

F. Pay Adjustment for Ride Quality.

Pay adjustment for Ride Quality shall be applied to Pay Item 999.494 at the completion of all HMA Lots. Although Ride Quality Acceptance testing will be performed only on the final pavement course, the pay adjustment will be applied to the total quantity of all HMA pavement courses placed. Since each wheel path of the final pavement course represents a Lot for Ride Quality, the quantity for each Lot shall be computed by dividing the total quantity of all pavement courses placed by the number of wheel paths for all lanes tested in the final pavement course. The total Lot pay adjustment for Ride Quality will be determined as follows:

$$PA_{Ride\ Quality} = \sum(PF_i - 1)\ (\sum(Q_{pc})(P_{pc}))/N_{wp}\ (PA_{Ride\ Quality}))$$

Where: $PA_{Ride\ Quality}$ = Pay adjustment in dollars for Ride Quality.
PF_i = Pay factor based on Quality Level (PWL) of Ride Quality for individual Lot (i).
Q_{pc} = Quantity represented by individual pavement course (pc) in tons.
P_{pc} = Contract unit price per ton for individual pavement course (pc).
N_{wp} = Total number of wheel paths for all lanes tested.
$PAW_{Ride\ Quality}$ = Weight given to Ride Quality pay adjustment, from Table 450.22, expressed as a decimal.

450.93 Payment Items.

450.10	Open Graded Friction Course - 9.5 - Polymer (OGFC - P)	Ton
450.11	Open Graded Friction Course - 9.5 - Asphalt Rubber (OGFC - AR)	Ton
450.21	SUPERPAVE Surface Course - 4.75 (SSC - 4.75)	Ton
450.211	SUPERPAVE Surface Course - 9.5 - Polymer (SSC - 9.5 - P)	Ton
450.22	SUPERPAVE Surface Course - 9.5 (SSC - 9.5)	Ton
450.221	SUPERPAVE Surface Course - 9.5 - Polymer (SSC - 9.5 - P)	Ton
450.23	SUPERPAVE Surface Course - 12.5 (SSC - 12.5)	Ton
450.231	SUPERPAVE Surface Course - 12.5 - Polymer (SSC - 12.5 - P)	Ton
450.24	SUPERPAVE Surface Course - 19.0 (SSC - 19.0)	Ton
450.241	SUPERPAVE Surface Course - 19.0 - Polymer (SSC - 19.0 - P)	Ton
450.31	SUPERPAVE Intermediate Course - 12.5 (SIC - 12.5)	Ton
450.311	SUPERPAVE Intermediate Course - 12.5 - Polymer (SIC - 12.5 - P)	Ton
450.32	SUPERPAVE Intermediate Course – 19.0 (SIC – 19.0)	Ton
450.321	SUPERPAVE Intermediate Course – 19.0 - Polymer (SIC – 19.0 - P)	Ton
450.41	SUPERPAVE Base Course - 25.0 (SBC - 25.0)	Ton
450.42	SUPERPAVE Base Course – 37.5 (SBC – 37.5)	Ton
450.51	SUPERPAVE Leveling Course - 4.75 (SLC - 4.75)	Ton
450.52	SUPERPAVE Leveling Course – 9.5 (SLC – 9.5)	Ton
450.53	SUPERPAVE Leveling Course – 12.5 (SLC – 12.5)	Ton
450.60	SUPERPAVE Bridge Surface Course - 9.5 (SSC-B - 9.5)	Ton
450.601	SUPERPAVE Bridge Surface Course – 9.5 - Polymer (SSC-B – 9.5 - P)	Ton
450.61	SUPERPAVE Bridge Surface Course - 12.5 (SSC-B - 12.5)	Ton
450.611	SUPERPAVE Bridge Surface Course - 12.5 - Polymer (SSC-B - 12.5 - P)	Ton
450.70	SUPERPAVE Bridge Protective Course - 9.5 (SPC-B - 9.5)	Ton
450.701	SUPERPAVE Bridge Protective Course - 9.5 - Polymer (SPC-B - 9.5 - P)	Ton
450.71	SUPERPAVE Bridge Protective Course – 12.5 (SPC-B – 12.5)	Ton
450.711	SUPERPAVE Bridge Protective Course – 12.5 - Polymer (SPC-B – 12.5 - P)	Ton
450.80	Asphalt Rubber Gap Graded - 12.5 (ARGG - 12.5)	Ton
451.	HMA for Patching	Ton
452.	Asphalt Emulsion for Tack Coat	Ton
453.	HMA Joint Sealant	Ton
999.490	HMA Pay Adjustment – PG Asphalt Binder Content[1]	Dollar
999.491	HMA Pay Adjustment – Volumetrics (Air Voids)[1]	Dollar
999.492	HMA Pay Adjustment – Thickness[1]	Dollar
999.494	HMA Pay Adjustment –Ride Quality[1]	Dollar

[1] Not a bid item

SUBSECTION 460.21 Composition and Compaction Acceptance Tests.
(page 121 English, page II.79 Metric) Delete this Subsection.

SUBSECTION 460.40 General.
(page 121 English, page II.80 Metric) Add the following materials requirement to the end of this Subsection.

Composition and Compaction Acceptance Tests	M3.11.09

SUBSECTION 460.60 General.
(page 122 English, page II.80 Metric) Replace the fifth paragraph of the Subsection with the following:

The Contractor will supply an approved dial type thermometer with a temperature range of 50º to 500ºF (10º-260ºC) and an infrared pistol thermometer for each paving machine in operation on the project. The Infrared pistol thermometer shall be Fahrenheit or Celsius selectable and conform to the following requirements:

Portable and battery operated	Accuracy of ±2%
Repeatability of ±5ºF (3ºC)	Emissivity preset at 0.95
LCD display to nearest 1º	Temperature operating range 0º to 750º F (-18º to 400ºC)

The thermometers will remain the property of the Contractor upon completion of the project.

(page 122 English, page II.80 Metric) Add the following paragraph above the last paragraph of the Subsection:

For night time paving operations the temporary illumination of the paving area shall be in accordance with the requirements of Section 850, and shall require an approved lighting plan before any paving work begins.

SUBSECTION 460.61 Transportation and Delivery of Mixtures.
(page 122 English) Add this paragraph beneath the second paragraph.

During paving operations, the Contractor shall provide continuous radio communication between the plant and the project to ensure immediate response due to breakdowns, emergencies such as accidents, and to insure the best quality results possible.

SUBSECTION 460.62 Tack Coat.
(page 122 English, II.81 Metric) Replace this Subsection with the following:

All pavement surfaces shall be tack coated immediately prior to placing each HMA lift. HMA placed over milled surfaces shall be tack coated at an application rate of 0.07 gallon per square yard (0.28 L/m^2). HMA placed over smooth pavements (unmilled) shall be tack coated at an application rate of 0.05 gallons per square yard (0.2 L/m^2).

Tack coat shall meet the requirements of M3.11.06.

The existing surface shall be cleaned of all foreign matter and loose material and shall be dry before the tack coat is placed.

SUBSECTION 460.63 Spreading and Finishing.

(pages 123 English, page II.82 Metric) Replace the 3 paragraphs beginning with "The construction of bituminous concrete pavement shall …" with the following:

Hot mix asphalt shall not be placed after November 15 or before April 1 without the written permission of the Engineer.

When the air temperature falls below 50°F (10°C), extra precautions shall be taken in drying the aggregates, controlling the temperatures of the materials, placing, and compacting the mixtures.

No HMA mixture shall be placed unless the breakdown and intermediate rolling can be completed by the time the material has cooled to 175°F (75°C), and provided that the density of the completed pavement attains at least 92.5% of the maximum theoretical density as determined by AASHTO T 209.

No mix shall be placed on wet or damp surfaces.

OGFC mixtures shall only be placed when both the surface and ambient temperatures are at least 50°F (10°C) and rising when measured in the shade and away from artificial heat. Regardless of any temperature requirements, OGFC mixtures shall not be placed after October 31 or before May 1 without the written permission of the Engineer.

SUBSECTION 460.64 Compaction.

(page 125 English, page II.84 Metric) Add the following paragraph before the 4th paragraph from the bottom of the Subsection:

For Open Graded Friction Course, OGFC, initial rolling may be accomplished with the breakdown roller within a short distance of the paver, allowing earlier compaction. Any subsequent rolling shall be adjusted in order not to over-roll the mixture. No mixture shall be placed unless the breakdown and intermediate rolling can be completed by the time the material has cooled to 195°F (90°C). Vibratory rollers or rubber tire rollers will NOT be permitted on OGFC mixtures.

(page 125 English, page II.85 Metric) Replace the last paragraph of this Subsection with the following:

The Engineer will obtain all core samples with the Contractor's assistance. The cost of all labor and equipment provided to assist the Engineer in obtaining core samples and all material required for filling all core holes shall be considered incidental to the HMA pay items. The in place density shall be 95% ±2.5% of the maximum theoretical density as determined by AASHTO T 209.

SUBSECTION 460.65 Joints.

(page 126 English, page II.84 Metric) Replace this Subsection with the following:

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 here specified, provision shall be made for proper bond with the new surface for the full specified depths of the courses.

All transverse joints, all longitudinal joints of the surface course and all longitudinal joints in the Dense Binder Course under Open Graded Friction Course or Open Graded Friction Course-Modified shall be treated prior to laying the next lane of hot mix asphalt as follows:

The joint shall be coated with a hot poured rubberized asphalt sealant meeting the requirements of M3.05.0.

When using pavers in tandem, the use of the hot poured rubberized asphalt sealer may be omitted at the discretion of the Engineer, if the temperature of the mixture at the longitudinal joint does not fall below 200°F (95°C) prior to the placement of the adjacent mat. No re-heating of the joint shall be permitted.

The hot poured rubberized asphalt shall be applied to the joints 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 transverse and longitudinal paving joint between two adjacent lanes of hot mix asphalt.

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, transverse joints for all courses and longitudinal joints for the top course 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.

SUBSECTION 460.65 (continued)

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 (300 mm) 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 (300 mm) 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.

SUBSECTION 460.67 Testing Surfaces.

(page 126 English, page II.85 Metric) Replace the last sentence of the second paragraph with the following:

Any irregularities which vary 1/4 inch (5 mm) or more from a true finished surface or 3/8 inch (10 mm) or more from a true surface in base or binder courses shall be corrected.

SUBSECTION 460.80 Method of Measurement.

(page 127 English) Add a third paragraph as follows:

Measurement for sealing of longitudinal joints in asphalt pavement shall be by the foot of joint sealed.

SUBSECTION 460.81 Basis of Payment.

(page 127 English, page II.86 Metric) Replace this Subsection with the following:

Hot mix asphalt, determined as provided above, will be paid for at the contract unit price per ton of the kind of hot mix asphalt required, complete in place including butt joint sealant and temporary illumination.

Asphalt emulsion 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 Asphalt Emulsion for Tack Coat, complete in place.

Sealing of longitudinal joints in asphalt pavement will be paid for at the unit bid price and shall be complete payment for sealing the edge of the previously laid mat with hot poured rubberized asphalt sealer and all incidentals required to complete the item.

SUBSECTION 460.82 Payment Items.

(page 127 English, page II.86 Metric) Replace this Subsection with the following:

460.	Hot Mix Asphalt	Ton
460.2	Hot Mix Asphalt - Open Graded	Ton
461.	Hot Mix Asphalt - Type ST	Ton
462.	Hot Mix Asphalt - Dense Binder Course for Bridges	Ton
464.	Asphalt Emulsion for Tack Coat	Gallon
464.5	Hot Poured Rubberized Asphalt Sealer	Foot

SECTION 468
PEASTONE COVER FOR BITUMINOUS CONCRETE PAVED SHOULDERS

SUBSECTION 468.40 General.

(page 131 English) The material designation for Asphalt Cement should read M3.01.0.

SECTION 472 HOT MIX ASPHALT FOR PATCHING
(page 133 English, page II.93 Metric) Replace this Section with the following:

SECTION 472
ASPHALT MIXTURES FOR TEMPORARY WORK

DESCRIPTION

472.20 General.

The work under this section shall consist of placing and removal of temporary asphalt material for use as curbing, berm, sidewalk, roadway patches, ramps, or other incidental work performed primarily by hand methods. This work may also include pothole repair and filling in milled rumble strips.

The work shall be at locations shown on the plans or as directed by the Engineer, except that Item 472 shall not be used when the work is to be permanent or is included under other items in the contract.

MATERIALS

472.40 General.

Temporary pavement materials shall meet the patching requirements of Section 450, except if hot mix asphalt is not available due to seasonal limitations the Contractor shall use approved stockpiled mixtures (cold patch) meeting the requirements of the following subsections of Division III, Materials:

Cutback Asphalt M3.02.0
Aggregate for Hot Mix Asphalt M3.11.2
Plant Requirements M3.11.7
*Curing of Mixture

*The mixture shall be cured by placing in a stockpile for a period of 1 week or more prior to delivery.

CONSTRUCTION METHODS

472.60 General.

The Contractor shall obtain asphalt pavement of the type specified by the Engineer. The work shall meet the patching requirements of Section 450 but will not be required to meet the minimum QC Inspection and Testing requirements. The Engineer may waive specific requirements of 450.43C depending on the application in which the temporary HMA will be used.

Existing patch material shall be completely removed before a temporary surface is placed.

The placing of the various asphalt pavement mixtures is intended to be primarily by hand methods.

Temporary pavement shall be laid to the required thickness and be compacted to the satisfaction of the Engineer.

COMPENSATION

472.80 Method of Measurement.

Asphalt Mixtures for Temporary Work will be measured as required for patching under Section 450.

472.81 Basis of Payment.

Asphalt mixtures for temporary work will be paid for at the contract unit price per ton complete in place which includes full compensation for the satisfactory removal and disposal of temporary material at a later date. Payment shall include all sawcutting, removal of existing distressed or unsound pavement, and transportation, delivery, placement, and compaction of HMA.

472.82 Payment Items.

472.	Asphalt Mixtures for Temporary Work	Ton

SECTION 476
CEMENT CONCRETE PAVEMENT

SUBSECTION 476.40 General.
(page 134 English) Add the following material designation:

Scored Concrete Pavement-Air Entrained-5000 psi, ¾", 705.....M4.02.00

SUBSECTION 476.73 Sealing Joints.
(page 148 English, page II.108 Metric) Replace the fifth paragraph of the Subsection with the following:

Joints shall be sealed with an approved joint sealing compound conforming to M3.05.0.

SUBSECTION 476.81 Basis of Payment.
(page II.110 Metric) Change 10 millimeters to 15 millimeters in the last sentence of the first paragraph and in the first sentence of the second paragraph.

SECTION 477
MILLED RUMBLE STRIPS

SECTION 477 MILLED RUMBLE STRIPS
(page 151 English, page II.111 Metric) Add this new Section in numerical order.

DESCRIPTION

477.20 General.

The work consists of constructing rumble strips on paved highway shoulders by milling grooves into finished hot mix asphalt surfaces.

CONSTRUCTION METHODS

477.61 Equipment.

The equipment shall self-align with the slope of the roadway surface and/or any irregularities in the roadway surface.

The Contractor shall demonstrate to the Engineer the ability to achieve the desired groove without tearing or snagging the roadway surface prior to beginning the work.

477.62 Installation of Rumble Strips.

Rumble strips shall be installed in accordance with the locations, dimensions and patterns shown on the plans. Rumble strips shall not be installed on shoulders less than 2 feet wide, on bridge decks, within 50 feet of an intersection or major driveway, or on roadways with posted speeds less than 40 MPH.

In areas where acceleration and/or deceleration lanes have no paved outside shoulders, any rumble strips in the outside shoulders shall be terminated at the beginning of each deceleration lane and initiated at the end of each acceleration lane.

477.63 Control of the Work Area.

At the end of each working day, all equipment shall be moved to a location where it does not present a hazard to traffic. The pavement shall be cleaned by sweeping and the work area shall be reopened to traffic.

Pavement millings shall become the property of the Contractor and shall be removed and disposed of off site.

COMPENSATION

477.80 Method of Measurement.

Milled Rumble Strip will be measured by the total length of installed rumble strip. Milled Rumble Strip for Bicycle Traffic will be measured by the total length of installed rumble strip excluding the designed gaps. Breaks at castings, bridge decks, intersections or other breaks will not be measured for payment.

477.81 Basis of Payment.

Payment for Milled Rumble Strip and Milled Rumble Strip for Bicycle Traffic will be made at the contract unit price per foot of rumble strips, complete in place. Such payment will be full compensation for furnishing all equipment and labor for satisfactorily performing the work including cleanup and disposal of excess materials.

477.82 Payment Items.

477.	Milled Rumble Strip	Foot (m)
477.1	Milled Rumble Strip for Bicycle Traffic	Foot (m)

SECTION 482
SAWCUTTING

SECTION 482 SAWCUTTING

(page 151 English, page II.111 Metric) Add this new Section in numerical order.

DESCRIPTION

482.20 General.

This work shall consist of the sawcutting of asphalt and concrete pavements, sidewalks and trenches where shown on the plans, and as required by the Engineer.

EQUIPMENT

482.40 General.

The saw shall be capable of wet cutting to neat lines established by the Engineer. The equipment shall be approved by the Engineer prior to commencing work.

CONSTRUCTION

482.60 General.

The pavement shall be sawcut through its full depth at all joints between existing and proposed pavements, and at all utility trenches, to provide a uniform, smooth vertical surface. Existing pavements shall be sawcut at the limits of work as shown on the plans and as required by the Engineer.

Sawcut edges which become broken, ragged or undermined as a result of the Contractor's operations shall be re-cut prior to the placement of abutting proposed pavement at no additional cost to the Department.

Sawcut surfaces in asphalt pavements shall be sprayed or painted with a uniform, thin coat of asphalt emulsion tack coat immediately before placement of hot mix asphalt against the cut surfaces.

COMPENSATION

482.80 Method of Measurement.

Sawing pavement will be measured by the foot along the cut line.

482.81 Basis of Payment.

Sawing pavement will be paid for at the respective contract unit prices per foot, which prices shall include all labor, materials and equipment necessary to perform the work.

Sawcutting will be paid separately when made in areas of full depth box widening.

Sawcuts made in existing pavement in areas of trenching for new conduit, in areas of new or reset curb, or trench limits for drainage/water work, will be included in the unit price under the respective items and will not be paid for separately under this item.

Asphalt emulsion tack coat will be paid for under Item 452. Asphalt Emulsion for Tack Coat.

482.82 Payment Items.

482.3	Sawcutting Asphalt Pavement	Foot
482.4	Sawcutting Portland Cement Concrete	Foot
482.5	Sawcutting Asphalt Pavement for Box Widening	Foot
452.	Asphalt Emulsion for Tack Coat	Gallon

SECTION 485
GRANITE RUBBLE BLOCK PAVEMENT

SUBSECTION 485.80 Method of Measurement.
(page 152 English) Replace this Subsection with the following:

Granite Rubble Block will be measured by the square yard for the work complete in place including the required excavation and materials.

SECTION 501
CURB AND EDGING

SUBSECTION 501.40 General.
(page 153 English, page II.113 Metric) Replace the M4.02.00 designation with the following;

Cement Concrete M4.02.00

SUBSECTION 501.60 Excavating Trench.
(page 153 English, page II.113 Metric) Add this new sentence to the end of the subsection.

Existing pavements shall be sawcut in accordance with the requirements of Section 482 as shown on the plans and as required by the Engineer.

SUBSECTION 501.81 Basis of Payment.
(page 156 English, page II.116 Metric) Revise this subsection to read as follows;

Curb or edging will be paid for at the contract unit price per foot, complete in place which shall include sawcuts made in existing pavement, cement concrete placed to set the curb or edging and all other work necessary to complete the installation.

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.

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 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 curbed, 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 Excavation, when done in conjunction with excavation for sub-base will be paid for under the appropriate excavation item. 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.

SECTION 580
CURB OR EDGING REMOVED AND RESET; REMOVED AND STACKED OR REMOVED AND DISCARDED

SUBSECTION 580.60 Removal.
(page 157 English, page II.117 Metric) Add the following sentence to the end of the subsection.

Existing pavements shall be sawcut in accordance with the requirements of Section 482 as shown on the plans and as required by the Engineer.

SUBSECTION 580.81 Basis of Payment.
(page 158 English, page II.118 Metric) Revise this subsection to read as follows

Removing and resetting curb and edging will be paid for at the contract unit price per foot at the new location complete in place, which shall include sawcuts made in existing pavement, cement concrete placed to set the curb or edging and all other work necessary to complete the installation.

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 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 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.

SECTION 601 HIGHWAY GUARD

(page 159 English, page II.120 Metric) Replace the section with the following;

SECTION 601
GUARDRAIL

DESCRIPTION

601.20 General.

This work shall consist of the construction of guardrail and guardrail end treatments in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

601.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Guardrail	M8.07.0
Guardrail End Treatment	M8.07.1
Guardrail Delineator	M9.30.7
Guardrail Termini Delineator	M9.30.10

The contractor shall provide a detailed list of all system components for maintenance purposes.
No work shall commence under these items until the Engineer has received all documentation.

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 posts 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.

Posts to be set in areas of proposed bituminous concrete surfacing shall be erected prior to laying the surrounding finished surface.

Posts set in areas of bituminous concrete or cement concrete surfacing shall conform to the special post design shown on the plans.

601.62 Guardrail Panel.

The rail shall be erected in a smooth continuous rail conforming to the required line and grade. All rail elements and splices shall be per the plans. 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.

Curved guardrail shall be used when the radius is 150 feet or less.

Guardrail delineators shall be installed at intervals as indicated on the plans. Retroreflective sheeting shall conform to the following colors:

a. White on the upstream face in the right shoulder.
b. Yellow on the upstream face in the left shoulder.
c. Red on the downstream (wrong-way travel direction) face within 1000’ upstream of a median break of a divided highway or interchange.

601.63 Guardrail End Treatment.

Proprietary end treatment systems shall be installed in accordance with the manufacturers' specifications and recommendations.

COMPENSATION

601.80 Method of Measurement.

Guardrail and curved guardrail will be measured along the top edge of the rail element from the center of the first mid-span splice to the center of the last mid-span splice.

Transition to NCHRP 350 Guardrail will be measured as individual units 34 feet 4.5 inches in length, measured over two 12 foot 6 inch and one 9 foot 4.5 inch panels, as shown on the plans.

Transition to Rigid Barrier (Single Faced) will be measured as individual units 39 feet 10.75 inches in length, measured from the mid-span splice with the guardrail or end terminal to the end of the W beam terminal connector, as shown on the plans.

Transition to Rigid Barrier (Double Faced) will be measured as individual units 45 feet 7.75 inches in length, measured from the mid-span splice with the guardrail or end terminal to the end of the thrie beam terminal connector, as shown on the plans.

Transition to Bridge Rail will be measured as individual units 33 feet 9 inches in length, measured from the mid-span splice with the guardrail or end terminal to the end of the thrie beam terminal connector, as shown on the plans.

Transition to Thrie Beam, for connections between new guardrail and existing thrie beam guardrail, will be measured as individual units 6 feet 3 inches in length, measured from the W Beam post bolt slots to the thrie beam post bolt slots, as shown on the plans.

Trailing Anchorage will be measured as an individual unit 9 feet 4.5 inches in length, measured from the mid-span splice with the guardrail to the centerline of the short timber breakaway post, as shown on the plans.

Flared end treatments, tangent end treatments and guardrail end treatments will be measured as individual units, measured from the Begin Length of Need to the face of the impact head, as shown on the plans.

601.81 Basis of Payment.

The construction of all guardrail items shall include the assembly and erection of all components, parts and materials complete at the intended locations.

Guardrail and curved guardrail will be paid for at the contract price per foot, complete in place, including posts, offset blocks, panels and connecting hardware.

Transition to NCHRP 350 Guardrail, Transition to Rigid Barrier (Single Faced), Transition to Rigid Barrier (Double Faced), Transition to Bridge Rail, and Transition to Thrie Beam Guardrail will be paid for at the contract unit price each, complete in place.

Trailing Anchorage will be paid for at the contract unit price each. Guardrail flared end treatments, tangent end treatments and guardrail terminal ends will be paid for at the contract unit price each, complete in place.

Guardrail delineators shall be considered incidental to the cost of the guardrail, guardrail end treatment or guardrail trailing anchorage.

The use of special post designs, where necessary or directed by the Engineer, shall be incidental to the work with no additional compensation.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic foot under the item for Class B Rock Excavation.

601.82 Payment Items.

620.12	Guardrail, TL-2 (Single Faced)	Foot
620.13	Guardrail, TL-3 (Single Faced)	Foot
620.32	Guardrail - Curved, TL-2 (Single Faced)	Foot
620.33	Guardrail - Curved, TL-3 (Single Faced)	Foot
621.12	Guardrail, TL-2 (Double Faced)	Foot
621.13	Guardrail, TL-3 (Double Faced)	Foot
621.32	Guardrail - Curved, TL-2 (Double Faced)	Foot
621.33	Guardrail - Curved, TL-3 (Double Faced)	Foot
627.1	Trailing Anchorage	Each
627.72	Guardrail End Treatment, TL-2 (Double Faced)	Each
627.73	Guardrail End Treatment, TL-3 (Double Faced)	Each
627.82	Guardrail Tangent End Treatment, TL-2	Each
627.83	Guardrail Tangent End Treatment, TL-3	Each
627.92	Guardrail Flared End Treatment, TL-2	Each
627.93	Guardrail Flared End Treatment, TL-3	Each
628.21	Transition to NCHRP 350 Guardrail	Each
628.22	Transition to Rigid Barrier (Single Faced)	Each
628.23	Transition to Rigid Barrier (Double Faced)	Each
628.24	Transition to Bridge Rail	Each
628.25	Transition to Thrie Beam	Each
144.	Class B Rock Excavation	Cubic Yard

SECTION 628
PERMANENT IMPACT ATTENUATORS

SECTION 628 PERMANENT IMPACT ATTENUATORS

(page 161 English, page II.122 Metric) Add (English) / Replace (Metric) the following Section.

DESCRIPTION

628.20 General.

This item shall consist of furnishing and installing impact attenuators in close conformance with the specifications of the manufacturer, and in close conformance with the locations, lines, and grades shown on the plans and/or designated in the Special Provisions.

MATERIALS

628.40 General.

All materials used in the foundation and anchorage of the impact attenuator shall meet the requirements specified in Division III, Materials.

The impact attenuator may be any impact attenuator which meets the requirements of ***National Cooperative Highway Research Program, Report 350*** and its subsequent revisions, and has been accepted by the Federal Highway Administration in the location intended. Impact attenuators which have not been accepted by the Federal Highway Administration, or which have been designated as approved for experimental use by the Federal Highway Administration shall be rejected by the Engineer. The manufacturer must provide evidence of the suitability and acceptance by the Federal Highway Administration of the impact attenuator.

The impact attenuator shall be designed to fit within reasonably close tolerance of the dimensions given in the plans or the Special Provisions for a given location. The manufacturer shall design the impact attenuator for the design speed given on the plans or other such speed designated in the Special Provisions. Copies of the design shall be given to the Engineer for inclusion in the contract record. A listing of the parts shall also be given to the Engineer for future maintenance operations.

The approach end shall be covered with a Type 3 Object Marker sheeting conforming to the requirements of Section 2C.65 of the MUTCD. The sheeting material shall meet the requirements of M9.30.0, Type VIII (High Intensity Prismatic) or better.

CONSTRUCTION METHODS

628.60 General.

Excavation for attenuator foundations and anchorage 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 replaced with gravel borrow.

The impact attenuator shall be installed in accordance with the specifications and recommendations of the manufacturer. Copies of these specifications and recommendations shall be provided to the Engineer.

COMPENSATION

628.80 Method of Measurement.

Impact attenuators will be measured as a single unit, each in place. There will be a separate bid item for each location.

628.81 Basis of Payment.

Impact attenuators will be paid for at the contract unit price for each location, which includes full compensation for all labor, equipment, materials, foundation and anchorage, and all incidental work necessary to complete the work as specified.

Gravel Borrow required for any foundation and anchorage work will be paid for at the contract unit price under Item 151, Gravel Borrow.

628.82 Payment Items.

628.31	Impact Attenuator for Shoulder, Incapable of Redirection	Each
628.32	Impact Attenuator for Shoulder, Capable of Redirection	Each
628.33	Impact Attenuator for Median, Incapable of Redirection	Each
628.34	Impact Attenuator for Median, Capable of Redirection	Each
151.	Gravel Borrow	Cubic Yard (m^3)

SECTION 629
CONCRETE BARRIER

SUBSECTION 629.40 General.
(page 161 English, page II.123 Metric) Replace the M4.02.00 designation with the following;

Cement Concrete M4.02.00

SUBSECTION 629.60 General.
(page 161 English, page II.123 Metric) Replace the first sentence of this subsection with the following;

Concrete barriers shall be either precast or cast-in-place and conform to Section M4.02.00 Cement Concrete.

SECTION 630
HIGHWAY GUARD REMOVED AND RESET, AND REMOVED AND STACKED

SECTION 630. Highway Guard Removed and Reset, and Removed and Stacked.
(page 163 English, page II.126 Metric) Change the title of the section to:

SECTION 630
MAINTENANCE OF HIGHWAY GUARD

SUBSECTION 630.20 General.
(page 163 English, page II.126 Metric) Replace this Subsection with the following:

This work consists of removing present highway guard, replacing individual components (posts, offset blocks and panels) and resetting in accordance with the drawings for new guardrail, these specifications and in close conformity with established lines and grades, or stacking them as directed.

SUBSECTION 630.40 General.
(page 163 English, page II.126 Metric) Replace this Subsection with the following:

The materials removed shall be utilized in the highway guard as reset except, where necessary, new posts and new offset blocks 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 guardrail post. 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.

SUBSECTION 630.80 Method of Measurement.
(page 164 English, page II.127 Metric) Replace this Subsection with the following:

Highway Guard Removed and Reset will be measured in its final position. Highway Guard Removed and Stacked and Highway Guard Removed and Discarded will be measured in its original position. Measurements shall be from center to center of end post to which the guard is attached, along the top edge of rail element.

Individual guard rail posts, offset blocks and panels will be measured by the unit each.

Individual posts removed and reset and individual posts removed and stacked, shall be measured by the unit each including all hardware.

SUBSECTION 630.81 Basis of Payment.
(page 164 English, page II.127 Metric) Replace this Subsection with the following:

Removing and resetting highway guard will be paid for at the contract unit price per foot of Highway Guard Removed and Reset, complete in its final position, including posts, offset blocks, panels and connecting hardware.

Individual posts, panels and offset blocks shall include all hardware and will be paid for at the contract unit price each.

Guard panels shall include all hardware and will be paid for at the contract unit price each

Individual posts removed and reset shall include all hardware and which shall be paid for at the contract unit price each.

Realignment of existing posts shall be incidental to the work with no additional compensation.

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 foot of Highway Guard Removed and Stacked.

Removing and stacking individual posts will be paid for at the contract unit price each for Individual Posts Removed and Stacked.

Rock excavation, if necessary, will be paid for at the contract unit price per cubic foot under the item for Class B Rock Excavation.

SUBSECTION 630.82 General.
(page 165 English, page II.127 Metric) Replace this Subsection with the following:

630.	Highway Guard Removed and Reset	Foot (m)
630.1	Highway Guard Removed and Stacked	Foot (m)
630.2	Highway Guard Removed and Discarded	Foot (m)
632.	Guardrail Post – Steel	Each
632.1	Guardrail Post – Wood	Each
632.2	Individual Post Removed and Reset	Each
632.3	Individual Post Removed and Stacked	Each
632.4	Individual Post Removed and Discard	Each
633.	Guardrail Offset Block – W Beam	Each
633.1	Guardrail Offset Block – Thrie Beam	Each
634.	W Beam Guard Panel	Each
634.1	Thrie Beam Guard Panel	Each
144.	Class B Rock Excavation	Cubic Yard (m^3)

SECTION 639
WOVEN WIRE FENCE AND GATES

SECTION 639 WOVEN WIRE FENCE AND GATES
(page 165 English) Delete this Section.

SECTION 644
CHAIN LINK FENCES AND GATES

SUBSECTION 644.20 General.
(page 167 English, page II.127 Metric) Delete the last paragraph starting with "Chain link fence shall…".

SUBSECTION 644.40 General .
(page 167 English, page II.128 Metric) Change M8.09.2 to M8.09.1

SUBSECTION 644.63 Top Tension Cable.
(page 168 English, page II.128 Metric) Delete this Subsection and renumber Subsections 644.64, 65 and 66 starting with 644.63.

SUBSECTION 644.63 Spring Tension Wire.
(page 168 English, page II.129 Metric) Replace this Subsection with the following:

One continuous length of spring tension wire shall be used between end, corner or intermediate brace posts. Sufficient tension shall be applied so that there is no visible sag. On completion of the spring tension wire installation the wire shall be attached to the fence fabric with hog rings and to each line post with tie wire.

SUBSECTION 644.81 Basis of Payment.
(page 169 English) Delete the last sentence of the third paragraph and substitute the following:

The chain link fence fabric and posts shall be of the type used throughout the installation.

SUBSECTION 644.82 Payment Items.
(page 169 English, page II.130 Metric) Replace this Subsection with the following:

English:

*644.	__ Inch Chain Link Fence (Spring Tension Wire) (Line Post Option)	Foot
*644.1	__ Inch Chain Link Fence (Spring Tension Wire) Vinyl Coated (Line Post Option)	Foot
*645.	__ Inch Chain Link Fence (Pipe Top Rail) (Line Post Option)	Foot
*645.1	__ Inch Chain Link Fence (Pipe Top Rail) Vinyl Coated (Line Post Option)	Foot
*647.	__ Inch Chain Link Fence (Pipe Top Rail) with Barbed Wire (Line Post Option)	Foot
*649.	__ Inch Chain Link Fence (Spring Tension Wire) with Barbed Wire (Line Post Option)	Foot
*650.	__ Inch Chain Link Gate with Gate Posts	Foot
*651.	__ Inch Chain Link Gate with Gate Posts and Barbed Wire	Foot
*652.	__ Inch Chain Link Fence End Post	Each
*653.	__ Inch Chain Link Fence Corner or Intermediate Brace Post	Each
*654.	__ Inch Chain Link Fence Fabric	Foot
144.	Class B Rock Excavation	Cubic Yard
901.3	4000 psi, 1½", 565 Cement Concrete for Post Foundation	Cubic Yard

Metric:

*644.	__ Meter Chain Link Fence (Spring Tension Wire) (Line Post Option)	Meter
*644.1	__ Meter Chain Link Fence (Spring Tension Wire) Vinyl Coated (Line Post Option)	Meter
*645.	__ Meter Chain Link Fence (Pipe Top Rail) (Line Post Option)	Meter
*645.1	__ Meter Chain Link Fence (Pipe Top Rail) Vinyl Coated (Line Post Option)	Meter
*647.	__ Meter Chain Link Fence (Pipe Top Rail) With Barbed Wire (Line Post Option)	Meter
*649.	__ Meter Chain Link Fence (Spring Tension Wire) With Barbed Wire (Line Post Option)	Meter
*650.	__ Meter Chain Link Gate with Gate Posts	Meter
*651.	__ Meter Chain Link Fence with Gate Posts and Barbed Wire	Meter
*652.	__ Meter Chain Link Fence End Post	Each
*653.	__ Meter Chain Link Fence Corner or Intermediate Brace Post	Each
*654.	__ Meter Chain Link Fence Fabric	Meter
144.	Class B Rock Excavation	Cubic Meter
901.3	30 MPa - 40 mm - 335 kg Cement Concrete for Post Foundation	Cubic Meter

* Insert height of fence or gate at beginning of nomenclature description. The last digits of the item number will indicate this height when possible.

SUBECTION 644.82 (continued)

In the case of option items listed in the proposal, the Contractor shall inform the Engineer of his option prior to the installation of the material. Once the option is designated, all material for the work shall remain the same throughout the job.

SECTION 660
METAL PIPE RAIL

SUBSECTION 660.40 General.

(page 170 English) Delete Basic Lead Silico Chromate, Intermediate Paint, M7.02.06.

SECTION 665
FENCES AND GATES REMOVED AND RESET, AND REMOVED AND STACKED

SUBSECTIONS 665.80, 665.81 and 665.82

(page 172 English, page II.133 Metric) Replace these Subsections with the following:

665.80 Method of Measurement.

Fence that is removed and reset will be measured in the final position from outside to outside of end posts.

Fence that is removed and stacked will be measured in its original position from outside to outside of end posts and the quantity to be paid for will be the length actually removed and stacked.

Fence not required to be reset or stacked will become the property of the Contractor and shall be removed from the project without additional compensation.

Gates with gate posts will be considered as a unit, each.

665.81 Basis of Payment.

Fence that is removed and reset will be paid for at the contract unit price per foot (m), complete in the final position under the respective item.

Fence that is removed and stacked will be paid for at the contract unit price per foot (m).

Gates with gate posts removed and reset, or removed and stacked will be paid at the contract unit price each.

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.

Concrete bases for line posts shall be paid for under Item 901.3, 4000 psi, 1.5 inch, 565 Cement Concrete for Post Foundation, which shall include the excavation.

665.82 Payment Items.

665.	Chain Link Fence Removed and Stacked	Foot (m)
666.	Chain Link Fence Removed and Reset	Foot (m)
667.	Chain Link Fence Gate with Gate Posts Removed and Stacked	Each
668.	Chain Link Fence Gate with Gate Posts Removed and Reset	Each
669.	Fence Removed and Stacked	Foot (m)
670.	Fence Removed and Reset	Foot (m)
671.	Fence Gate and Gate Posts Removed and Stacked	Each
672.	Fence Gate and Gate Posts Removed and Reset	Each
144.	Class B Rock Excavation	Cubic Yard (m^3)
901.3	4000 psi, 1.5 inch, 565 Cement Concrete for Post Foundation	Cubic Yard (m^3)

SECTION 670 SEDIMENTATION FENCE

(page 173 English, page II.134 Metric) Add this new Section in numerical order.

DESCRIPTION

670.20 General.

This work shall consist of furnishing, installing, and removing sedimentation fence in accordance with these specifications and in close conformity with the lines and grades shown on the plans or established by the Engineer.

MATERIALS

670.40 General.

Materials shall meet the requirements specified in Division 3, Materials, M 9.50.0, for Temporary Silt Fence.

Fence post may be wood or metal. Wooden posts shall be at least 1¼ inches (30 mm) square by 5 feet (1.5 m) long. Metal posts shall be at least 1 inch (25 mm) in each dimension, 5 feet (1.5 m) long, and approved by the Engineer.

For each specific use, only commercially available fabric which is certified in writing by the manufacturer for the purpose intended shall be used. Torn or punctured fabrics shall not be used. The fabric shall be at least 3 feet (1 m) wide.

The contractor shall submit a 15 square yard (5 m^2) sample and a minimum one yard (1 m) of top seam and cord shall be furnished for testing each type of fabric to be used, along with technical data sheets, for review and approval by the Engineer. The Engineer reserves the right to reject any fabric which is deemed unsatisfactory for a specific use. The brand name shall be labeled on the fabric or the fabric container.

The contractor may use Department approved filter fabric, otherwise samples of proposed filter fabric shall be furnished 60 days prior to installation of the fabric.

Fabrics which are susceptible to damage from sunlight or heat shall be identified by suitable warning information on the packaging material and shall not be used in any installations where exposure to light will exceed 30 days.

The filter fabric shall have a cord (belt or rope) woven into the top edge of the roll to be used for attaching the fabric to the fence posts and providing support for the fabric.

CONSTRUCTION METHODS

670.60 General.

Installation

Install fence posts no further than 8 feet (2.4 m) apart along the line of the proposed fence. The top of the posts shall extend at least 2 feet (600 mm) above the normal water level. Posts shall be driven into the soil to a sufficient depth to form a stable support for the filter fabric.

Attach the fabric to the posts on the upstream side. Attachment of the fabric to the posts can be made with prefabricated pockets in the fabric, staples or other suitable arrangements approved by the Engineer. The fabric shall extend 2 feet (600 mm) above the normal water level and at least 1 foot (300 mm) shall extend horizontally along the soil at the bottom. Excavate a 6 x 6 inch (150 mm^2) trench along the bottom upstream side of the fence, wrap the bottom of the fabric around the inside of the trench and then backfill the soil into the fabric pocket so as to anchor the fence fabric.

Soil shall then be placed over the horizontal bottom layer of fabric to a depth of 6 inches (150 mm).

Fabric may be spliced together along the vertical edge by overlapping the pieces by one post spacing or 6 feet (2 m) whichever is greater and securing the layer together at intervals of 2 inches (50 mm).

Should the required height exceed the roll width, a second roll shall be used. The width shall be overlapped a minimum of 1 foot (300 mm) and the layers shall be secured together at not more than 2 foot (600 mm) intervals along the midpoint of the overlap.

Installation procedures may be varied to comply with manufacturer's recommended procedures with the approval of the Engineer. The contractor may submit alternate installation procedures for approval by the Engineer.

Maintenance

The installed fence shall be inspected at least daily by the contractor and restored as necessary to its approved, newly installed condition. Accumulations of debris and/or silt shall be removed and properly disposed of as necessary at no additional cost. In no case shall accumulations of more than 4 inches (100 mm) above the original ground line be permitted to remain. If a breach or other failure of the fence occurs, the fence shall be immediately restored. Any delay in maintaining the fence shall be cause to immediately suspend the work as provided for in Subsection 8.09.

Removal

Following the completion of the work and stabilization of adjacent soil, the fence shall be completely removed from the site and the area restored to its original condition.

COMPENSATION

670.80 Method of Measurement.

Sedimentation Fence approved by the Engineer shall be measured in place by the length along the top of the fence. Overlaps shall be measured as a single layer of cloth.

670.81 Basis of Payment.

The work will be paid for at the contract unit price per foot (m) of Sedimentation Fence complete in place and shall include all materials, labor, and equipment required to furnish, install, maintain, and remove the fence as herein described.

670.82 Payment Items.

697.	Sedimentation Fence	Foot (m)

SECTION 685
FIELD STONE MASONRY

SECTION 685 FIELD STONE MASONRY

(page 173 English, page II.134 Metric) Replace the entire Section with the following:

SECTION 685
STONE MASONRY WALL

DESCRIPTION

685.20 General.

This work shall consist of the construction of stone masonry 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

685.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Stone for Stone Masonry Wall	M9.04.4
Cement Concrete	M4.02.00
Mortar	M4.02.15

685.60 Cement Concrete.

Concrete for the footing and coping shall be placed in accordance with the requirements of Section 901. Cement Concrete.

685.61 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.

685.62 Headers.

Headers shall occupy at least one quarter of the face area of the wall and shall be evenly distributed. Headers in walls 2 feet (600 mm) or less in thickness shall extend entirely through the wall.

685.63 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 (150 mm) and no vertical joint shall be located directly above or below a header.

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.

685.64 Tree Wells.

Where directed, dry 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.

Stone masonry wall will be measured by the number of cubic yards in the completed structure, including the mortar (if required), concrete footing and the coping material complete in place and accepted. The quantity measured for payment shall not exceed that shown on the plans or as directed by the Engineer.

685.81 Basis of Payment.

Stone masonry will be paid for at the contract unit price per cubic yard under the item for Stone Masonry Wall in Cement Mortar or Stone Masonry Wall, 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.

685.82Payment Items.

685.	Stone Masonry Wall in Cement Mortar	Cubic Yard (m^3)
685.1	Stone Masonry Wall, Dry	Cubic Yard (m^3)
141.	Class A Trench Excavation	Cubic Yard (m^3)
144.	Class B Rock Excavation	Cubic Yard (m^3)

SECTION 701
SIDEWALKS, WHEELCHAIR RAMPS AND DRIVEWAYS

SECTION 701 SIDEWALKS, WHEELCHAIR RAMPS AND DRIVEWAYS

(page 177 English, page II.137 Metric) Replace this Section with the following:

DESCRIPTION

701.20 General.

This work shall consist of the construction of cement concrete wheelchair ramps, hot mix asphalt or cement concrete sidewalks and driveways in accordance with the specifications and within the tolerances established on the plans.

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, (4000 psi, ¾ inch, 610)	M4.02.00
Preformed Expansion Joint Filler	M9.14.0
Hot Mix Asphalt	M3.11.00
HMA for Driveways, Sidewalks, Berm, and Curb	M3.11.6

CONSTRUCTION

701.60 General.

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.

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 (200 mm) thick and parallel to the proposed surface of the walk.

701.61 Cement Concrete Sidewalks, Sidewalks at Driveways 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.

All wheelchair ramp joints and transition sections which define grade changes shall be formed staked and checked for dimension, grade and slope conformance prior to placing cement concrete.

All forms shall be oiled before placing concrete.

B. Placing and Finishing Cement Concrete.

The concrete shall be placed in alternate slabs 30 feet long except as otherwise ordered. The slabs shall be separated by transverse preformed expansion joint filler ½ inch thick (13 mm).

Preformed expansion joint filler shall be placed adjacent to or around existing structures as directed.

Detectable warning panels conforming to the plans shall be securely incorporated into the work by means acceptable to the Engineer.

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 (100 mm) deep. At driveways, the sidewalks shall be 6 inches (200 mm) deep. No finishing operation shall be performed while free water is present. Finishing operations shall be delayed until all bleed 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-troweled. 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 push broom 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 (3.25 m^2). The depth of the scoring shall be at least ½ inch (12 mm) deep and no more than ½ inch (12 mm) wide.

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.

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 Subsections 476.71 and 476.74.

701.62 Hot Mix Asphalt Sidewalks and Driveways

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 Hot Mix Asphalt Concrete.

The hot mix asphalt walk surface shall be laid in 2 courses to a depth after rolling of 2½ inches (60 mm). The bottom course shall be 1¼ inches (30 mm) thick, and its surface after rolling shall be 1¼ inches (30 mm) below and parallel to the proposed grade of the finished surfaces. The top course shall be 1¼ inches (30 mm) thick after rolling.

The hot mix asphalt driveway surface shall be laid in 2 courses to a depth, after rolling, of 3½ inches (90 mm). The Bottom Course shall be 2 inches (50 mm) thick, and its surface, after rolling, shall be 1½ inches (40 mm) below and parallel to the proposed grade of the finished surface. The top course shall be 1½ inches (40 mm) thick after rolling.

A pedestrian path of travel must be maintained across the driveway opening. The dimensions, cross slope, grades and tolerances of the pedestrian path shall be in conformance with the standard construction drawings.

The surface shall have sufficient pitch to the roadside edge to provide for surface drainage.

The courses shall be constructed in accordance with the applicable requirements of Section 450 and the following provisions:

Spreading Mixture for Sidewalks – 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 work is completed, it shall conform to the grade and surface contour required. An approved mechanical spreader may be used.

Spreading Mixture for Driveways – The Mixture shall be spread with an approved spreader. In areas not accessible to a spreader, the mix shall be placed as specified for hot mix asphalt sidewalks above.

Rolling Sidewalks – The surface shall be rolled with a self-propelled tandem roller with a mass not less than 1½ tons (1.4 Mg) and not more than 5 tons (4.5 Mg). In places inaccessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers with a mass not less than 50 pounds (25 kg) and having a tamping face not exceeding 100 square inches (600 m^2).

Rolling Driveways – The surface shall be rolled with a self-propelled tandem roller with a mass not less than 3 tons (2.8 Mg) nor more than 5 tons (4.5 Mg), or an approved roller as designated by the Engineer.

Testing Surface – When tested with a 10 foot (3 m) straightedge placed parallel to the center line of the courses, there shall be no deviation from a true surface in excess of ¼ inch (5 mm).

COMPENSATION

701.80 Method of Measurement.

Cement Concrete Sidewalks, Wheelchair Ramps and Sidewalks at Driveways will be measured in square yards.

Hot Mix Asphalt Walk Surface, and Hot Mix Asphalt Driveway 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 will be measured by the square yard.

701.81 Basis of Payment.

Cement Concrete Sidewalk, Cement Concrete Sidewalk at Driveway and Cement Concrete Wheelchair Ramp will be paid for at the contract unit price per square yard complete in place and shall include detectable warning panels.

Hot Mix Asphalt Walk Surface and Hot Mix Asphalt Driveway will be paid for at the contract unit price per ton (Mg) complete in place.

Gravel will be paid for at the contract unit price per cubic yard (m^3) under Item 151. Gravel Borrow.

Fine Grading and Compacting will be paid for at the contract unit price per square yard (m^2) under Item 170., Fine Grading and Compacting .

Excavation will be paid for at the contract unit price per cubic yard (m^3) under Item 120., Earth Excavation, or Item 121., Class A Rock Excavation.

701.82 Payment Items.

701.	Cement Concrete Sidewalk	Square Yard (m^2)
701.1	Cement Concrete Sidewalk at Driveways	Square Yard (m^2)
701.2	Cement Concrete Wheelchair Ramp	Square Yard (m^2)
702.	Hot Mix Asphalt Walk Surface	Ton (Mg)
703.	Hot Mix Asphalt Driveway	Ton (Mg)
120.	Earth Excavation	Cubic Yard (m^3)
121.	Class A Rock Excavation	Cubic Yard (m^3)
151.	Gravel Borrow	Cubic Yard (m^3)
170.	Fine Grading and Compacting	Square Yard (m^2)

SECTION 740
ENGINEER'S FIELD OFFICE AND MATERIALS LABORATORY
(EACH WITH PERTINENT EQUIPMENT)

SUBSECTION 740.22 Building Types and Construction.

(pages 184 and 185 English) Delete all references to the words Department of Environmental Quality Engineering and the abbreviation D.E.Q.E. and substitute the words Department of Environmental Protection and the abbreviation D.E.P.

SUBSECTION 740.40 General.

(page 186 English, page II.146 Metric) Add the following sentence after the second sentence of the paragraph:

All equipment will remain the property of the contractor.

SUBSECTION 740.41 Engineers Field Office (Type A).

(page 186 English, page II.146 Metric) Replace number 8 with the following:

8. An electric sanitary hot and cold water cooler, supplied with cups and drinking water, a 3 cubic foot capacity refrigerator with freezer compartment and a 1 cubic foot capacity microwave oven.

(page 186 English, page II.146 Metric) Delete number 11 (English), re-number 12 through 20 to 11 through 19 (English) and replace number 10 with the following:

10. Office equipment as follows:
    - A fully automatic electric calculator, with printout and sufficient supply of tapes.
    - Quantity Control Ledger covers, National model no. 94-592 or approved equal. QCL covers shall become the property of the Department.
    - A smoke alarm capable of being heard 500 feet away.
    - 2 portable amber colored strobe lights for mounting on vehicles

(page 186 English, page II.146 Metric) Replace number 15 (as re-numbered in English) with the following:

15. One 2 foot electronic smart level, one 100'foot steel tape, one 100'foot cloth tape and one plumb bob.

(page 186 English, page II.147 Metric) Replace number 17(as re-numbered in English) with the following:

17. The Contractor shall assume the cost of all equipment, including installation, service, maintenance, and removal. A working telephone with an answering machine shall be provided at the Engineer's Field Office.

SUBSECTION 740.41 (continued)

(page 186 English, page II.147 Metric) Delete paragraph number 18(d) and (i). Re-letter paragraphs (e), (f), (g) and (h) to (d), (e), (f), and (g)respectively.

(page 187 English, page II.147 Metric) Delete paragraph number 19(a) and re-letter paragraphs (b), (c), (d), and (e) to (a), (b), (c), and (d) respectively.

(page 187 English, page II.147 Metric) Add the following in numerical order:

20. The following sampling containers are to be supplied in the minimum quantity listed and more as needed to complete the project:

a. Flat Bottom Poly Lined Kraft Paper Bags capable of holding 60 pounds (30 kg) of soil or aggregates with dimensions of at least 12 x 3 x 25 inches (300 x 80 x 640 mm). Supply a minimum of 50 bags.
b. 4 inch or 6 inch (150 mm) Plastic Cylinder Molds and Covers meeting the requirements of AASHTO M 205 and approved for use by the Research and Materials Division. Supply 5 cylinders molds per 150 cubic yards of concrete placement or fraction thereof with a minimum of 50 molds.
c. 1 Quart Metal Cans with friction top covers. Supply a minimum of 12 cans when the contract specifies bridge painting.
d. 1 Quart Wide Mouth Plastic Bottles and Covers designed to hold acid. Supply a minimum of 12 bottles when the contract specifies bridge painting or traffic paint.
e. Cardboard Sample Boxes for hot mix asphalt. The sample boxes shall have dimensions of at least 17 x 12 x 4½ inches (450 x 300 x 120 mm) and fold to provide a tight closure for transporting. Supply a minimum of 25 boxes.

All unused containers remaining at the close of the project shall be delivered to the District laboratory and become property of MHD.

SUBSECTION 740.43 Engineers Field Office (Type C).

(page 187 English, page II.147 Metric) Delete this subsection.

SUBSECTION 740.44 Engineers Field Office (Type D).

(page 187 English, page II.148 Metric) Delete this subsection.

SUBSECTION 740.45 Materials Laboratory Building.

(page 189 English) Under number 36 add the words "with plastic covers" after Concrete Cylinder Molds.

SUBSECTION 740.81 Basis of Payment.

(page 189 English, page II.150 Metric) Replace the second paragraph of this subsection with the following;

Payment as described above shall be compensation for all services (heat, gas, light, water, sanitary, telephone, etc.) 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.

SUBSECTION 740.82 Payment Items.

(page 189 English, page II.150 Metric) Delete pay items 742., 743. and 999.740.

SECTION 748
MOBILIZATION

SUBSECTION 748.20 General.

(page 191 English, page II.152 Metric) Add the following sentence to the end of the paragraph:

The unit bid price for Mobilization (Item 748.) shall not exceed 3% of the contract bid total, exclusive of this item. Failure to observe this requirement may result in rejection of the bid in accordance with Subsection 2.04.

SECTION 751
LOAM BORROW, PLANTABLE SOIL BORROW, PROCESSED PLANTING MATERIAL OR TOPSOIL REHANDLED AND SPREAD

SECTION 751 LOAM BORROW LOAM BORROW, PLANTABLE SOIL BORROW, PROCESSED PLANTING MATERIAL OR TOPSOIL REHANDLED AND SPREAD

(page 192 English, page II.153 Metric) Replace this Section with the following:

SECTION 751
LOAM BORROW AND TOPSOIL REHANDLED AND SPREAD

DESCRIPTION

751.20 General.

The work under this item consists of furnishing and placing loam and related items 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. The work includes the placing, spreading and grading of loam borrow for seeded and planted areas, preparation of soil for plant material, amendment of loam as required to produce planting soil mix, and provision of soil additives required to adjust for pH requirements of specific plants.

MATERIALS

751.40 General.

Material shall meet the requirements specified in the following Subsections of Division III, Materials:

Loam Borrow M1.05.0
Topsoil M1.07.0
Organic Soil Additives M1.06.0
Inorganic Amendments M6.01.0

Samples and Submittals

At least 30 days prior to ordering, the Contractor shall submit to the Engineer representative samples, certifications, and certified test results for materials as specified below. No materials shall be delivered until the required submittals have been reviewed and approved by the Engineer. Delivered materials shall closely match the approved samples. Approval of test results does not constitute final acceptance. The Engineer reserves the right to reject on or after delivery any material which does not meet the Specifications.

Soil Additives for Loam

Additives shall be used to counteract soil deficiencies as recommended by the soil analysis.

Organic matter used as an amendment to soil shall be manufactured compost.

Lime or sulfur shall be used to bring soil to acceptable pH levels, per soil test reports.

For soils with more than 20 percent passing the No. 200 sieve (75 μm), gypsum shall be added at a rate of 3.2 pounds per cubic foot (5kg/m^3).

Soil amendments shall be incorporated thoroughly into loam to meet the specified requirements for loam prior to delivering the material on site.

CONSTRUCTION METHODS

751.60 Preparation of Areas on which Loam or Topsoil are to be Placed.

All areas to receive loam shall be free of construction debris, refuse, compressible or decayable materials and standing water. The area upon which the above materials are to be placed shall be raked, harrowed or dragged to form a smooth surface. All stones, undesirable growth and debris larger than 2 inches (50 mm) in diameter 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 Item 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 or Topsoil.

The Contractor shall notify the Engineer when areas to receive loam are ready for inspection and approval. Placement of loam fill material shall not begin until the Engineer has approved the grading of the material that the loam is placed upon.

Loam shall not be handled or placed when the subgrade or the loam is frozen or saturated, i.e. when squeezed sample shows any sign of free moisture.

The Engineer shall approve the use of the Contractor's equipment. Any equipment or procedures that are likely to damage or over-compact underlying structure or materials shall be rejected.

Loam shall be placed in lifts not to exceed 4 inches (100 mm). After each lift, the soil shall be thoroughly mixed into the soil layer beneath it. Compaction of each lift shall be minimal, sufficient only to achieve the required grades. Over-compaction of existing soils or fills that would be detrimental to planting objectives shall be corrected by tilling or other means at no additional cost.

Grade stakes shall be set to check finished grades. Deviation from lines and grades that are greater than 1 inch (25 mm) shall not be permitted.

The Contractor shall supply additional loam as necessary so that following finish the grading and compaction operations, the placed loam shall conform to the depth required.

Finish grades shall exhibit no abrupt changes, and shall blend in evenly with the undisturbed grade of the ground at the limits of work.

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 meet the requirements of M1.07.0 and be approved before it is spread. 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.

COMPENSATION

751.80 Method of Measurement.

The quantity of Loam Borrow, 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 and Topsoil Rehandled and Spread will be paid for at the contract unit price per cubic yard, complete in place, which prices shall include all testing, analysis and the grading of areas where stockpiles of topsoil are removed.

751.82 Payment Items.

751.	Loam Borrow	Cubic Yard (m^3)
752.	Topsoil Rehandled and Spread	Cubic Yard (m^3)

SECTION 767
MULCHING, SEED FOR EROSION CONTROL

SUBSECTION 767.80 Method of Measurement.
(page 199 English, page II.160 Metric) Replace the first sentence with the following:

Hay Mulch and Straw Mulch will be applied as required and measured by the ton (Mg) delivered on the site as determined from certified weight slips, or by the square yard (m^2), or by the acre (ha), depending on the payment item.

SUBSECTION 767.81 Basis of Payment.
(page 200 English, page II.160 Metric) Replace the first sentence with the following:

Hay Mulch and Straw Mulch will be paid for, complete in place, at the contract unit price.
Wood Fibre Mulch will be paid for, complete in place, at the contract unit price per ton (Mg).

SUBSECTION 767.82 Payment Items.
(page 200 English, page II.161 Metric) Add the following:

767.1	Hay Mulch	Acre (ha)
767.2	Hay Mulch	Square Yard (m^2)
767.31	Straw Mulch	Square Yard (m^2)
767.32	Straw Mulch	Acre (ha)

SECTION 769
PAVEMENT MILLING MULCH UNDER GUARDRAIL

SECTION 769 PAVEMENT MILLING MULCH UNDER GUARD RAIL
(page 204 English, page II.161 Metric) Add (English) / Replace (Metric) this Section in numerical order.

DESCRIPTION

769.20 General.

The work shall consist of placing a geotextile fabric under guard rail and placing 4 inches (100 mm) of pavement millings on top of the fabric.

MATERIALS

769.40 General.

Pavement milling mulch shall meet the requirements specified in Division III, M1.10.0.
The geotextile fabric shall conform to M9.50.0 for Stabilization Fabric.

CONSTRUCTION

769.61 General.

The mulched area will generally be 3 feet (1 m) wide and start at the back of the berm, sloped edging, curb or edge of roadway pavement. In end treatment areas where the guard rail is set back from the edge of roadway, the mulch will extend from the edge of roadway to 6 inches (150 mm) behind the back of the guard rail posts.

769.62 New Guard Rail.

Where the milling mulch is being placed at locations of new guard rail installation, the fabric and millings shall be placed prior to placing the guard rail. When posts are to be driven, the millings shall be moved aside in the vicinity of the post, the fabric cut, and then the posts shall be driven. After the posts are driven, the millings shall be raked closely around the posts.

769.63 Existing Guard Rail.

Where the milling mulch is to be placed in locations of existing guard rail, the fabric shall be placed on both sides of the post, and shall be cut at the posts to allow the fabric to lay flat between the posts, and to overlap a minimum of 1 foot (300 mm). The millings will then be placed and raked closely around the posts.

COMPENSATION

769.80 Method of Measurement.

The quantity of pavement milling mulch shall be the number of feet (m) based on actual measurements made along the guard rail.

769.81 Basis of Payment.

The work under this item shall be paid for at the contract unit price per foot (m) complete in place, which price includes the geotextile fabric, pavement millings, and all related excavation, borrow, and grading.

769.82 Payment Items.

769.	Pavement Millings Mulch Under Guard Rail	Foot (m)

SECTION 770
SODDING

SECTION 770 SODDING

(page 202 English, page II.162 Metric) Replace the entire Section with the following:

DESCRIPTION

770.20 General.

The work shall consist of the construction of lawn sod as required, on the areas indicated on the plans, or as designated by the Engineer, and in accordance with these specifications.

MATERIAL

770.40 General.

Materials shall meet requirements specified in the following Subsections of Division III, Materials:

Loam Borrow M1.05.0
Topsoil.....M1.07.0
Sod.....M6.05.0
Seed M6.03.0

CONSTRUCTION METHODS

770.61 Laying Sod.

A foundation for the sod shall consist of loam borrow or topsoil rehandled and spread in quantities sufficient to produce a depth of at least 4 inches (100 mm) after tamping and natural settlement as taken place for 1 month. Soil surface shall have a continuous surface free of stones, sticks or roots greater than 2 inches (50 mm) in any dimension, without voids or irregularities. Prior to placement of sod, loam shall be lightly scarified with a rake and watered lightly.

Fresh sods shall then be placed in final position on the designated areas. All sods shall be harvested, delivered and installed within 48 hours.

Planting season for sod shall be from April 15 to June 1 and from August 15 to November 1. Any requests to deviate from this schedule must be submitted by the Contractor to the Engineer in writing. When air temperature exceeds 90ºF, the period of time from harvest to installation shall be less than 24 hours. Sod shall not be planted in soil with a temperature greater than 90ºF.

Work shall progress in such a manner that workers are not walking on installed sod. Sod shall be placed parallel with the contour. Vertical joints between sods shall be staggered. Ends and sides of sod shall be butted closely together so that sod is not stretched and ends do not dry out. Contractor shall use full pieces throughout, and trim excess with clean straight cuts. Waste sod and scraps shall not be assembled to create a new piece. 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 (150 mm). The sod shall be settled by watering it and by tamping on a board laid over it.

If sod cannot be installed immediately upon arrival to the site, the sod shall be stored in a shaded location, sprinkled with water, and covered with burlap, straw or other acceptable material which shall be kept moist when required and as directed. The sod 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. The sod shall not be stored in such a manner to compress the thickness of sod below 2 inches (50 mm).

770.62 Fastening Sod to Slopes.

On slopes steeper than 3:1 (3 horizontal to 1 vertical), sod shall be held securely in place with wooden pegs. The pegs shall be placed at intervals not greater than 3 feet (1 m). Pegs shall be at least 1 foot (300 mm) in length, 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 Sodding.

When the sod has been set in final position, loam shall be used to fill the joint and as a surface dressing to cover the sodded areas to a depth of about ¼ inch (6 mm). 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 pounds per 100 square yards (.25 kg per 100 m^2). The sodded areas shall then be compacted, and the compaction shall be equivalent to that produced by hand roller with a mass of between 75 and 100 pounds per foot of width (110 and 150 kg/m) and to produce a smooth, uniform surface.

770.64 Maintenance and Care.

The Contractor shall maintain all of the sodded areas for a minimum of 30 days following installation, or until the work has been officially accepted, whichever is longer, without additional compensation. Before acceptance of the work, a satisfactory uniform stand of grass will be required. Partial acceptances will not be granted. Maintenance and care shall be as specified under Section 765.66 and the following:

If necessary, suitable signs and barricades of brush or other material shall be placed to protect the sodded areas. Barriers shall be removed prior to final inspection.

Maintenance shall include watering, mowing, and any reseeding or resodding determined necessary by the Engineer.

Sod shall be watered in sufficient quantities to maintain adequate soil moisture to a depth of 4 inches (100 mm). Watering shall be done in a manner that will provide uniform coverage, prevent erosion due to application of excessive quantities over small areas, and prevent damage to the turf by the watering equipment.

Mowing shall occur before turf exceeds 5 inches (125 mm), and shall be cut to a height of 3 inches (75 mm).

COMPENSATION

770.80 Method of Measurement.

The quantity of sodding shall be the number of square feet based on actual measurements made over the general contour of the areas sodded, complete in place and accepted.

770.81 Basis of Payment.

The work involved in sodding will be paid for at the contract unit prices per square yard (m^2), complete in place, under the respective items for Lawn Sodding, which prices shall include maintenance, loam for filler and top dressing and seed, except loam used for foundation of sod which will be paid for as Loam Borrow or Topsoil Rehandled and Spread.

770.82 Payment Items.

770.	Lawn Sodding	Square Yard (m^2)
751.	Loam Borrow	Cubic Yard (m^3)
752.	Topsoil Rehandled and Spread	Cubic Yard (m^3)

SECTION 771
PLANTING TREES, SHRUBS AND GROUNDCOVER

SECTION 771 PLANTING TREES, SHRUBS AND GROUNDCOVER

(page 204 English, page II.164 Metric) Replace this Section with the following:

771.20 General.

This work shall consist of furnishing, planting and/or transplanting specified trees, shrubs, vines and ground cover to 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 for transport, adding fertilizing and/or other soil amendments, seeding, weeding, watering, care of the plants, and replacement of unsatisfactory plants and materials during the life of the contract.

The Contractor performing work under this Section shall have five years continuous experience and expertise in management, handling and installation of ornamental plant material in large-scale landscape construction projects. Site foreman shall have at least five years experience, able to read and interpret plans, and shall be on-site during all times of plant installation.

MATERIALS

771.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials with the amendments and supplements contained herein:

Loam Borrow M1.05.0
Organic Soil Additives M1.06.0
Inorganic Amendments M6.01.0
Fertilizer M6.02.0
Wood Chip Mulch M6.04.3
Aged Pine Bark Mulch M6.04.5
General Planting M6.06.0
Nursery Stock - General M6.06.1
Wrapping for Transport M6.07.1
Materials for Guying and Staking M6.08.0
Water for Irrigation M6.09.0

The Contractor shall furnish written certificates of compliance, including nursery shipping lists, 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 with botanical name, including cultivar, and size so that proper identification can be made.

All plants shall be northern grown nursery stock. Botanical and common names shall conform to the current edition of Hortus Third, compiled by the staff of L. H. Bailey Hortorium, Cornell University. The latest edition of the *American Standard for Nursery Stock* (ASNS) published by the American Association of Nurserymen, Inc. shall be the Department's standard for plants and for plant, root ball, and container size, as well as growth and form requirements. The term "plant" shall refer to any tree, shrub, herbaceous perennial, seedling, vine or groundcover.

All trees and shrubs shall be balled and burlapped (B&B) or containerized. 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. The Contractor shall remove all plants not approved by the Engineer from the project.

The following standards shall apply to the work of this Section.

Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada. L.H. Bailey Hortorium. 1976.

American Standard for Nursery Stock (ASNS), ANSI Z-60.1, latest edition, published by American Association of Nurserymen (AAN).

Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. Michael Dirr, Stipes Publishing Company, latest edition.

ANSI A300 Standard Practices for Tree, Shrub, and Other Woody Plant Maintenance, Part 1: Pruning, available from Tree Care Industry Association and International Society of Arboriculture.

Examination of Conditions. The Contractor shall be responsible for judging the full extent of work requirements involved. This responsibility includes, but is not limited to, the following: transportation, purchase, temporary storage and maintenance of plants; plant rehandling prior to final installation; removal and off-site disposal of existing loam that has been determined unacceptable; purchase, transport, and supply of loam as required for backfill mixing operations.

771.41 Samples and Submittals.

The Contractor shall keep the Engineer apprised of the sources and availability of plant material in the Contract. Within 30 days of the pre-construction meeting, the Contractor shall provide nursery supplier lists indicating current and projected availability of all plant material for the project. All the material shall match species, cultivar, sizes and quantities specified in the Contract.

At least 120 days prior to planting, the Contractor shall submit to the Engineer for his approval a watering schedule for all planting in the project. Watering schedule shall include all methods for providing water to plants.

At the same time, the Contractor shall submit a confirmation of availability for all plants on the list, accompanied by nursery sources. When the specified types and sizes of plants are not available, the Contractor may submit written recommendations for substitutions for approval by the Engineer. Substitutions proposed by the Contractor shall have equivalent overall form, height, and horticultural characteristics and must be approved in writing by the Engineer prior to tagging.

For materials other than plants, at least 90 days prior to installation the Contractor shall submit material specifications and (where applicable) installation instructions attesting that the materials meet the requirements specified. No materials shall be ordered until submittals have been approved by the Engineer. Delivered materials shall match the samples. All material samples shall include supplier's literature and certification stating that material meets specifications.

The Contractor shall submit for approval equipment and methods for testing soil moisture and soil pH.

The Contractor shall provide two moisture gauges, including instructions for use and batteries if required, for his use during the duration of the Contract. The meters shall be hand held and shall be capable of measuring moisture at a depth of 6 inches. Meter scale shall be sufficient to determine moist, dry, or wet soil. The meters shall be regularly checked for calibration against watered loam, and shall be replaced if found faulty at no additional cost.

In addition, the Contractor shall provide to the Engineer one copy of the "American Standard for Nursery Stock," ANSI Z-60.1, latest edition, published by American Association of Nurserymen (AAN) for the duration of this Contract.

For work requiring an arborist, the Contractor will provide certification of Massachusetts Certified Arborist.

At least 60 days prior to planting, the Contractor shall submit a schedule for tagging material to the Engineer.

Materials may be temporarily stored within the highway layout as directed by the Engineer. Heavy equipment and fill material shall be stored outside of the drip line of existing tree canopy. If materials are stored within the layout, the Contractor shall restore the storage area to its original natural condition at the his expense, including tilling of compacted soils and reseeding .

Arrangements shall be made, to the extent that it is practicable, to have plants delivered as the pits or beds are made ready for them. Delivery of plants shall be made to the site, only according to the Contractor's ability to handle and properly care for them Whenever plants cannot be planted on the day of arrival, all those with bare roots shall be "heeled-in" in moist soil or mulch. The Contractor shall properly maintain all "heeled-in" plants 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, and shall be suitable for transplanting the following season. The root balls of B&B plants not planted immediately after delivery and inspection shall be covered with loam, mulch or wood chips and irrigated until planted. Throughout the work, care shall be taken 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 risk of the Contractor.

For B&B and container shrubs, a representative sample, up to three, shrubs of each species shall be washed of soil media for inspection of Engineer to confirm root conditions. If accepted, the sample plants shall be planted immediately and shall be subject to all planting performance guarantees.

771.42 Backfill Mixture for Plant Material

The Contractor shall provide testing of soils in planting locations. The Contractor shall provide test results and recommendations as necessary for soil amendment to the Engineer for his approval. Backfill shall be a blend of one part loam borrow, one part organic material and two parts existing subsoil.

CONSTRUCTION METHODS

771.60 General.

Furnishing and planting of plant material shall include, but is not limited to, the following: digging of the pits and plant beds; amendment of loam as required to produce planting soil mix; provision of soil additives for pH requirements of specific plants; provision of additional amendments as required, including soil wetting agents; furnishing the plants as specified; plant installation; watering and maintenance, including weeding.

771.61 Seasons for Planting.

The purpose of the planting dates is to establish an appropriate period of time for planting. The Contractor may submit request for planting outside the scheduled timeframes in writing to the Engineer for approval. Calendar guidance for planting is as follows:

Spring:	Deciduous materials - March 21 through May 15
	Evergreen materials - April 15 through June 1
Fall:	Deciduous materials - Oct. 1 through Dec. 1
	Evergreen materials - Aug. 15 through October 15

Spring planting for bare root material shall be after the ground has thawed, but before leafing out, approximately mid March to early April. Fall planting for bare root plants may occur in late October, after leaf drop, through mid November.

771.62 Plant Tagging and Approval.

The Contractor shall locate and tag plants at least one month prior to the expected planting date. The Contractor shall be responsible for tagging the material at the nursery. The Contractor shall request that the Engineer provide a representative to approve tagged stock to be planted under this Section. The Contractor shall be responsible for any expenses associated with any necessary travel and overnight accommodations for the Engineer's representative during the period of time required to locate, select, and approve plant material.

All trees and representative samples of each shrub species on the Plant List shall be tagged by the Contractor at the nursery and approved by the Engineer or his representative, prior to digging, for conformity to specification requirements as to quality, size, and variety. All plants will have labels that list the common name, botanical name, and size.

Approval of tagged material at the nursery shall not prevent the right of inspection and rejection upon delivery at the site or during the progress of the work. Cost of replacement of materials rejected by the Engineer at the site shall be borne by the Contractor.

771.63 Plant Delivery and Planting Preparation.

Tree trunks shall be protected during shipping by a heavy walled cardboard sleeve or other suitable material. Plants shall either be shipped in enclosed trucks or all surfaces, leaves and branches shall be wrapped to prevent damage and desiccation. Damaged plants may be rejected by the Engineer at any time.

Locations for all plants shall be approved by the Engineer before any plant pits or plant beds are dug.

The Contractor shall locate all underground utilities within 10 feet of the proposed planting pits and notify the Engineer of any conflicts prior to digging plant pits.

Stake all tree locations, and all shrub and perennial beds, for Engineer approval prior to digging. Contact DIGSAFE and other utilities if coordination has not already occurred for other phases of project.

Prior to the installation of any plant material, the Contractor shall dig test pits and determine percolation rates. Percolation of less than 1 inch per hour shall require corrective measures as recommended by the Contractor and approved by the Engineer.

The Contractor shall notify the Engineer 5 working days prior to the proposed arrival of plant material on the site. All plants shall be planted within 5 days of arrival on site or shall be rejected by the Engineer. Plants stored on site shall be shaded from direct sunlight at all times and shall not be stored on paved surfaces. Plants stored on site shall be watered daily.

771.64 Planting.

Pits excavated for plants shall be as shown on the plans. In general, pits shall be 3 times the width of the rootball or plant container. Depth of the pits shall correspond to the height of the rootball, measured from the bottom to the lower extent of the root flare, ensuring that the root flare will not be covered. The sides and bottom of pit shall be scarified to prevent glazed soils.

Plant material installed in infertile or manufactured soils shall have soil modification agents added per manufacturer specifications. After planting, the Contractor shall certify that appropriate agents have been used and properly applied per the manufacturer's specifications. Written certification shall be provided to the Engineer.

Place trees in the center of pit. Place shrubs and perennials in beds as a group, with grouping and spacing as noted on the plans.

For ball and burlap plants, remove all rope and wire baskets from the root balls. Burlap may be removed off the top and sides. Any excess burlap shall be cut away and disposed of off site. For container grown plants, score or butterfly cut the rootball of all container-grown plants prior to planting. For peat or other similar degradable containers, remove any portion of the projecting above the level of the soil. All metal, plastic or other non root-thru type container shall be completely removed during the process of planting.

Prepare planting soil mix as specified above to depths as shown on the drawings. Place backfill mix in layers of not more than 6 inches, and water each layer sufficiently to settle soil before the next layer is put in place.

Backfill mix shall meet finished grade after settlement. Shape edge of planting pit to form a saucer for holding water and place mulch as shown in the plans. On steep slopes, the mound around the saucer may be omitted on the uphill side. Do not cover the stem flare of the plants with mulch.

Water plants immediately following planting as necessary to thoroughly moisten rootball and planting soil. The Contractor shall be responsible for furnishing his own supply of water to the site at no extra cost. The Contractor shall, at his own expense, replace any plants injured or damaged due to the lack of water, or due to the use of too much water, as determined by the Engineer.

Plants shall not be wrapped after installation, except as discussed below. Wounds shall not be painted. Trees shall not be staked unless wind or other local conditions require the additional protection.

Once the root ball is placed in the pit and the container, wires and burlap removed, carefully rake the root ball to spread the roots and partially backfill the pit, ensuring that the soil filters in among the roots. The backfill shall be placed with care taken not to injure or bruise the roots.

771.65 Bare Root Planting.

Bare root material shall be delivered to the site in a dormant condition. Evergreens will be rejected if the fine roots were lost in digging. All bare root plants shall be prepared with hydrogel at the nursery prior to planting. The backfill mixture of soil placed beneath the plant shall be firmed prior to setting the plant. Do not fertilize bare root plants.

771.66 Staking and Guying and Wrapping.

The Contractor shall consult with the Engineer to determine whether wind exposure, potential vandalism, or other conditions warrant tree staking and guying. Evergreen trees up to 4 feet high and deciduous trees up to 6 feet in height shall be supported by one stake driven firmly 2-3 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 2 feet from the trunk. Secure the tree to the stake with biodegradable cloth webbing. Do not use wire for staking any plant.

Evergreen trees taller than 4 feet and deciduous trees taller than 6 feet, if less than 3 inches in caliper, shall be supported with two stakes on opposite sides and driven into the ground at least 2 feet. The stake shall not be higher than 3/4 the height of the tree. Any excess burlap shall be cut away and disposed of as directed.

Trees greater than 3 inches in caliper shall be securely guyed by biodegradable fabric webbing, protective material and anchors. Three anchors shall be equally spaced around the tree. Webbing 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 2 feet and the excess length of stake shall be cut off 3 inches above the ground.

Webbing shall be placed around the tree trunk and secured to the anchor stake.

Staking and guying shall be incidental to tree installation. Use cloth webbing rather than wire. Do not use hose.

All Flowering Cherries and Flowering Crabs shall be protected to a height of 12 to 18 inches 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. Otherwise, do not wrap trees except for transport. Remove transport wrapping after installation of plant material.

771.67 Mulching.

No mulch shall be applied prior to the first watering of the plant. Trees and shrubs shall be mulched no 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. Pull mulch away from stem flare.

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 shall be material as indicated on the plans or approved by the Engineer.

The Contractor shall, at his own expense, replace any plant material that has been damaged by too much or too little mulch, as determined by the Engineer.

771.68 Pruning.

Pruning of all plants shall be done only by a Massachusetts Certified Arborist or Horticulturist, 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. If damage is significant, then plant will be replaced per direction of Engineer.

Pruning shall not deform or otherwise destroy the typical shape or symmetry of the tree or shrub and shall not reduce the height or overall size by more than 1/3. The leader of the tree shall not be cut back.

771.70 Care and Maintenance During Maintenance and Establishment Periods.

The Contractor will be held responsible for all planted material, providing plant care for the duration of the Maintenance and Establishment periods described below, until the project is completed and accepted. At the completion of the Establishment period, all plants shall be in a healthy, growing condition and free from weeds or other noxious materials or conditions. Care shall include watering, weeding, cultivating, pruning, re-mulching, trimming, adjusting of guys, removal of dead material, resetting plants to proper grades or upright position, and maintaining the planting saucer, and by performing other operations as required to keep plants healthy and growing.

Pruning shall be in accordance with the ANSI standards for Class I, fine pruning, to preserve the natural character of the plant. All dead wood or suckers and all broken or badly bruised branches shall be removed. Do not cut leaders. The Engineer shall determine if plants require pruning, or should be rejected. All pruning work shall be done by a Massachusetts Certified Arborist. Contractor will submit a copy of the Arborist's current certification to the Engineer.

The Contractor will be responsible for weeding around planted materials. All weeding shall be completed before acceptance of the project. At no time shall weeds attain the height of 6 inches during the period of contract prior to acceptance. Newly planted material must be clearly visible in order to be approved for Conditional and Final Acceptance.

771.71 Watering.

All plants shall be watered during planting and all plants shall be watered at least twice each week during weeks where the average daily temperature exceeds 55 degrees (F) and when precipitation is less than 1 inch, as determined by local National Weather Service data. Watering shall be sufficient to provide moist soil to a depth of 6 inches, as determined by the Engineer. If soil is sufficiently moist, as determined by the Engineer, the required watering may be reduced.

Trees will require a minimum of 10 gallons of water each, and shrubs a minimum of 5 gallons per plant per watering. Watering may be achieved using individual drip irrigation bags.

Trees or shrubs planted after October 15 shall be thoroughly watered at the time of planting, after which subsequent watering will not be required until following season.

The Contractor shall maintain a watering log for all plants installed on the project, indicating dates of watering and weather events. Log shall be submitted for final payment.

771.72 Maintenance Period

The Maintenance Period shall begin immediately after all plants are planted and shall continue for a minimum of 60 days following the completion of all planting installations, or until the conditional acceptance of all planting work, whichever is a longer period of time. During the 60 day Maintenance Period, plants shall be inspected for watering, weeding, and other requirements at least twice each week.

Any decline in the condition of new plantings shall require the Contractor to take immediate action to identify potential problems and undertake corrective measures. If required, the Contractor shall immediately notify the Engineer and engage professional arborists and/or horticulturists to inspect plant materials and to identify problems and recommend corrective procedures. Inspection and recommendation reports shall be submitted to the Engineer.

At the end of the Maintenance Period, the Contractor will request inspection by the Engineer at least 10 days before the anticipated date of inspection.

At the time of inspection, if the plant materials, workmanship, and maintenance practices are acceptable to the Engineer, the date of the inspection shall establish the end of the Maintenance Period and the commencement of the required one-year Establishment Period for planting work.

If in the Engineer's opinion, plant materials, workmanship, or maintenance is deficient, acceptance will not be granted, and the Maintenance Period for all the plants shall be extended until plant replacements are made or other deficiencies are corrected. All dead, declining, or unsatisfactorily maintained plants shall be removed promptly from the project. Replacement plants shall conform in all respects to the Specifications for the original plants and shall be planted in the same manner.

Absolutely no debris may be left on the site. The Contractor shall repair any damage to site as directed by the Engineer, at no additional cost.

771.73 Establishment Period

The purpose of the Establishment Period is to nurture plants through at least one full growing season and one full winter. Planted areas shall be free of weeds and debris, and plantings shall be re-mulched as necessary.

The Contractor is responsible for arranging inspection early enough in the season to allow adequate time to procure and install replacement material. The Engineer will inspect the replacement planting work upon the request of the Contractor. Request for inspection, shall be received by the Engineer at least ten days before the anticipated date of inspection.

At the end of the Establishment Period, each plant shall show healthy growth on at least 75 percent of its terminal stems, as determined by the Engineer. Determination of healthy growth shall include, but is not necessarily limited to, viable leaves (in season) and terminal buds, as well as live cambium. Plants found to be unacceptable shall be removed promptly from the site and replaced immediately or during the next normal planting season, as permitted by the specifications.

Stakes and guying shall be removed from all plants before Final Acceptance, and materials will be disposed of off site at no extra cost to the Contract.

771.74 Replacement of Defective Plant Material.

Any 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 1. Replacement plantings shall conform to the provisions of this section, except the requirements for establishment.

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.

Mulch for planting beds and tree pits shall be incidental to the cost of the plants. Mulch used on areas other than over tree pits or planting beds will be measured by area and at the specified depth. The mulch taken from this measured volume and used for mulching trees and shrubs will be deducted on the basis of the volume of mulch placed over the rated size of each planting pit at a depth of 3 inches.

771.81 Basis of Payment.

The quantity of trees, shrubs, vines and ground cover plants measured as provided above will be paid for at the contract unit prices per 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, excavation for plant pits, planting, pruning, guying and staking, 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 under the contract unit price for the mulch specified. Mulch for 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 Aged Pine Bark Mulch.

No payment will be made for mulching specified as required and included in payment for other contract items.

771.82 Payment Items.

772 to 774	Evergreen Trees	Each
775 to 784	Deciduous Trees	Each
785 to 787	Evergreen Shrubs	Each
788 to 795	Deciduous Shrubs	Each
796	Vines and Groundcover	Each
767.6	Aged Pine Bark Mulch	Cubic Yard

SECTION 801
CONDUIT, MANHOLES, HANDHOLES, PULLBOXES AND FOUNDATIONS

SUBSECTION 801.60 Conduit.

(page 212 English, page II.172 Metric) Add this new sentence to the end of the paragraph A. Excavating Trench.;

Existing pavements shall be sawcut in accordance with the requirements of Section 482 as shown on the plans and as required by the Engineer.

SUBSECTION 801.62 Foundations.

(page 214 English) Replace the first sentence of the fourth paragraph with the following:

The actual existing soil conditions shall be determined from boring samples (see Section 190).

SUBSECTION 801.81 Basis of Payment.

(page 215 English, page II.175 Metric) Replace the first paragraph with the following:

The unit contract price per foot, shall be full compensation for furnishing and installing all conduits, couplings, expansion fittings, elbows, bends, caps, sleeves, clamps, hangers, reducers, 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 (except Class B Rock) 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 not 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.

(page 215 English) Replace the last paragraph with the following:

Borings will be paid for in accordance with Section 190.81.

SUBSECTION 801.82 Payment Items.

*(page 215 and 216 English) Delete pay items 802.2 to 802.4 __in. Electrical Conduit Type NM - Bituminous Fiber; 803.2 to 803.6 __in. Electrical Conduit Type NM - CEM, ASB, or Fire Clay Cement; 805.2 to 805.6 *__in. Electrical Conduit Type NM - Plastic (NEMA); and 807.05 to 807.6 *__in. Electrical Conduit Type RM - Aluminum. Replace the pay items listed below with the following:*

801.2 to 801.66	__ inch Electrical Conduit Type NM (#) (# = double , 4 bank, or 6 bank)	Foot
806.05 to 806.6	__ inch Electrical Conduit Type RM - Galvanized Steel	Foot
811.40 to 811.99	Junction Box __ x __ x __ inches	Each

(page 216 English) Replace payment items 811.30, 811.31, 812.20, 812.31 and 812.40 with the following:

811.30	Pull Box 8 x 23 Inches - SD2.030	Each
811.31	Pull Box 12 x 12 Inches - SD2.031	Each
812.20	Lighting Load Center Foundation	Each
812.31	Pedestal Signal Post Foundation SD 3.031	Each
812.40	Signal Mast Arm Foundation	Each

(page 216 English) Add the following Payment Items:

191.	Drive Sample Boring	Foot
191.11	Core Boring	Foot
193.	Mobilization and Dismantling of Boring Equipment	Lump Sum

*(page II.175 Metric) Delete pay items 805.05 to 805.15 *__millimeter Electrical Conduit Type NM - Plastic (NEMA), and 807.015 to 807.150 *__millimeter Electrical Conduit Type RM - Aluminum. Substitute the pay items listed below for the originals:*

801.051 to 801.156	*__millimeter Electrical Conduit Type NM (#) (*= 50 to 150 millimeter diameter) (#= double , 4 bank, or 6 bank)	Meter
806.15 to 806.150	*__millimeter Electrical Conduit Type RM - Galvanized Steel	Meter
811.40 to 811.99	Junction Box __ x __ x __ millimeters	Each

(page II.176 Metric) Add payment item 811.31 and replace payment item 811.30 with the following:

811.30	Pull Box 200 X 585 Millimeters - SD2.030	Each
811.31	Pull Box 300 X 300 Millimeters - SD2.031	Each

SECTION 813
WIRING, GROUNDING AND SERVICE CONNECTIONS

SUBSECTION 813.40 General.

*(page 217 English, page II.177 Metric) Replace the first sentence under **A. Wire and Cable** with the following:*

All traffic signal cable connectors shall be not less than #14 AWG, solid or stranded, and all conductors for mast arm and/or span wire shall not be less than #16 AWG stranded.

SECTION 815
TRAFFIC CONTROL SIGNALS

SUBSECTION 815.20 General.
(page 222 English, page II.182 Metric) Delete EIA and FSS from the second paragraph of the page.

SUBSECTION 815.21 Equipment.
(page 222 English, pages II.182/183 Metric) Delete the last sentence of the first paragraph.

SUBSECTION 815.41 Controllers.
*(page 224 English) Under the heading **A. General**, h. Wiring add the following:*

11. Three power service unfused terminal connections (AC-, AC+ and ground) having the ability to connect No. 6 AWG conductor.

*(page 224 English) Under the heading **A. General**, add the following:*

i. Meter Socket -- Each cabinet shall be provided with a standard residential meter socket with no knock-out on top. The rating shall be 125 Amps, 100 Amps continuous, 600 VAC, CU/AL rated. The meter socket shall be attached and electrically grounded to the cabinet using 1¼" lock nuts and bushings along with four 1½", ¼-20 nuts and bolts with split-lock washers.

*(page 224 English) Replace paragraphs d., e., f., and g. under the heading **B. Actuated Controllers - 1. Controller Unit (Dispatcher or Timer)** with the following:*

d. All timing and control parameters, except time clock operation, shall be retained in memory when power is "off", battery-backup to retain memory will not be accepted.

e. The controller units shall be modular or integral keyboard entry type.

f. Modular Controller Units
Operator programmable data entry adjustments for the modular units shall be accomplished through thumb-wheel, pin or keyboard devices located on the front panel of the unit. 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 and to prevent malfunctions.

g. Integral Keyboard Entry Controller Units
Operator programmable data entry adjustments for the integral keyboard entry units shall be accomplished through a front panel keyboard and a liquid crystal display. The unit shall utilize a menu driven format which shall list, in English, the major categories of programming data. Once the user selects the appropriate category the program shall provide prompting for additional keystrokes until full programming is accomplished. The integral keyboard entry unit shall have the capacity of operating in either a single ring or dual ring mode with two through eight phase control. The unit shall be capable of either sequential or concurrent phase control. Overlap phases shall be programmable through the keyboard. The unit shall be capable of operating as a volume density controller and shall also have internal time base coordination (TBC). The coordination control shall conform to Subsection 815.41.F.3. The keyboard entry controller unit shall have a security code function and internal pre-emption control capabilities. The phase or phases selected for "call to nonacutated" (CNA) modes shall be determined as needed by keyboard entries. The keyboard entry controller unit shall have a standard RS-232 serial port for data transfer to another controller or printer. A data transfer/printer cable shall be included with the controller.

*(page 227 English) Change the second line of Note 2 under **10. Technical Manuals and "Box Prints"** to read:*

CC cabinets are to be wired for 2-8 phase frames.

SUBSECTION 815.42 Detectors.
(page 231 English) Under the heading ***C. Inductive Loop Detector Amplifier and Sensors.*** *in the first sentence of 1. Type 1- delete the phrase "responding to a percentage change in inductance," and in the first sentence of 2. Type 2- delete the phrase "responding to an absolute change in inductance,"*

(page 231and 232 *English*) *Delete section* ***E. Pressure Sensitive Detectors****. and re-letter F. Pedestrian Push Buttons. to E. Under the new heading* ***E. Pedestrian Push Buttons.*** *delete the last sentence and substitute the following:*

Immediately above each pedestrian push button a 5" x 8" (nominal) metal sign shall be installed on the crosswalk side of the post or pole.

SUBSECTION 815.43 Mast Arms – Strain Poles and Span Wire Assemblies.
(page 232 English, page II.1923 Metric) Add the following paragraph immediately under A. General:

All metal support structures shall be in accordance with the requirements of Section 960. *Structural Steel and Miscellaneous Metal Products*.

SUBSECTION 815.44 Post and Bases.
(page 233 English) Replace the last sentence with the following:

All posts and their bases shall be of the same material, either steel or aluminum. Aluminum signal posts shall utilize a tapered shaft.

SUBSECTION 815.46 Pedestrian Signal Heads.
(page 233 English, page II. 194 Metric) Replace this Subsection with the following:

The pedestrian signal housing shall include a Light Emitting Module in a 12 inch (300 mm) square signal housing conforming to the *ITE Pedestrian Traffic Control Signal Indications - Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules* and be listed on the Qualified Construction Materials List. Pedestrian symbols shall conform to the MUTCD, Section 4E.04, Size, Design, and Illumination of Pedestrian Signal Head Indications.

SUBSECTION 815.64 Detectors.
(page 236 English) Replace the 6th paragraph with the following:

Magnetic Detector Single Lane shall be installed in accordance with manufacturer's instructions.

SUBSECTION 815.80 Method of Measurement.
(page 227/228 English, page II.200 Metric) Add the following paragraph after the third paragraph:

Wire Loop Installed in Roadway will be measured by the foot along the sawcut or trench that contains the wire, multiple wires or preformed loops.

SUBSECTION 815.81 Basis of Payment.
(page 227/228 English, page II.200 Metric) Add the following paragraph after the second paragraph:

The work of installing Wire Loop Installed in Roadway shall be full compensation for all labor, materials, and equipment necessary to sawcut, install the wire, multiple wires or preformed loops and seal the sawcut or trench as specified.

SUBSECTION 815.82 Payment Items.

(pages 238 and 239 English) Delete payment items 815.10 to 815.83, 815.89 to 815.95, 817.30 to 817.33, 817.70 to 817.73, 818.41 to 818.42, 819.01 to 819.38, 819.830, 819.831, 819.840, 819.841 to 819.843, and 819.844 to 819.846.; change payment item numbers 817.60 to 817.63 to 817.60 to 817.69; and add the following payment items:

815.	Traffic Control Signal	Lump Sum
815.1	Traffic Control Signal Location No. 1	Lump Sum
815.2	Traffic Control Signal Location No. 2	Lump Sum
815.3	Traffic Control Signal Location No. 3	Lump Sum
815.4	Traffic Control Signal Location No. 4	Lump Sum
815.5	Traffic Control Signal Location No. 5	Lump Sum
818.42	Pedestrian Signal Head	Each
819.	Traffic Signal Controller	Lump Sum
819.1	Traffic Signal Controller Location No. 1	Lump Sum
819.2	Traffic Signal Controller Location No. 2	Lump Sum
819.3	Traffic Signal Controller Location No. 3	Lump Sum
819.4	Traffic Signal Controller Location No. 4	Lump Sum
819.5	Traffic Signal Controller Location No. 5	Lump Sum
819.39	8 Phase, Menu-Driven Traffic Control Unit	Each
819.830	Inductive Loop Detector Amplifier	Each
819.831	Wire Loop Installed in Roadway	Foot
819.832	Microloop Installed in Roadway	Each

(page II.200 / 201 Metric) Delete payment items 815.4 to 815.8, 815.911 to 815.916, 817.70 to 817.73, 818.41, 818.42, 818.43, 819.04 to 819.08; change payment item numbers 817.60 to 817.63 to 817.60 to 817.69; change the pay unit of item 819.832 from Meter to Each and add the following payment items:

815.	Traffic Control Signal	Lump Sum
815.1	Traffic Control Signal Location No. 1	Lump Sum
815.2	Traffic Control Signal Location No. 2	Lump Sum
815.3	Traffic Control Signal Location No. 3	Lump Sum
815.4	Traffic Control Signal Location No. 4	Lump Sum
815.5	Traffic Control Signal Location No. 5	Lump Sum
818.42	Pedestrian Signal Head	Each
819.	Traffic Signal Controller	Lump Sum
819.1	Traffic Signal Controller Location No. 1	Lump Sum
819.2	Traffic Signal Controller Location No. 2	Lump Sum
819.3	Traffic Signal Controller Location No. 3	Lump Sum
819.4	Traffic Signal Controller Location No. 4	Lump Sum
819.5	Traffic Signal Controller Location No. 5	Lump Sum

SECTION 820
HIGHWAY LIGHTING

SUBSECTION 820.20 General.

(page 240 English, page II.202 Metric) Delete EIA and FSS from the first paragraph beneath "TRAFFIC CONTROL DEVICES".

(page 240 English) Add the following paragraph after the seventh paragraph beneath "TRAFFIC CONTROL DEVICES":

The contractor shall replace at his own expense any part of the lighting 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.

SUBSECTION 820.21 Definitions.
(page 240 English, page II.202 Metric) Replace paragraphs A and B with the following:

A. Highway Lighting Poles – An aluminum or galvanized steel structure providing up to a 50 foot mounting height for luminaires mounted on arms up to 10 feet long.

B. High Mast Tower – A steel structure providing a mounting height greater than 50 feet for luminaires and equipped with a lowering device to permit luminaire maintenance at ground level.

SUBSECTION 820.40 General.
(page 241 English, page II.203 Metric) Add the following paragraph to the end of this Subsection:

All metal support structures shall be in accordance with the requirements of Section 960. *Structural Steel and Miscellaneous Metal Products*.

SUBSECTION 820.41 Design Requirements.
SUBSECTION 820.42 Equipment.
(page 241 English, page II.203 Metric) Combine 820.41 and 820.42 into subsection 820.41 and replace the existing title of Subsection 820.41 through section B of Subsection 820.42 with the following:

820.41 Design and Equipment Requirements.

The complete 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*" for the following AASHTO criteria, 1) Fatigue Category No. 1, 2) Design Wind Speed 130 MPH and 3) 50 Year Design Life.

Where aluminum alloy parts are fastened to steel or other dissimilar materials, the aluminum shall be kept from direct contact with the steel or other dissimilar materials by methods approved by the Engineer.

A. Highway Lighting Poles

1. Poles from 30 to 50 feet shall be made of aluminum or galvanized steel. Galvanizing shall meet the requirements of Section M7. Aluminum poles over 40 feet may be in two sections telescoped together and lapped not less than two times the pole diameter at the lapped-joint. Aluminum poles shall be produced from continuous extruded tube and shall not be sleeved in the base portion to compensate for thinner walled tubing. Each pole shall be designed and fabricated in a manner that will accommodate a single or double arm ten feet in length.
2. Arms shall be designed for 2 inch slip fitter mounted with 75 pound luminaires that have 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 inches x 6 inches located approximately 12 inches from the bottom of the pole and placed 90 degrees to the arms. Pole cap shall be the same material as the pole, watertight and held securely in place on the pole by a set screw or screws or stamped cap.
4. Bonding and grounding shall be provided that will ensure an effective path for fault current that facilitates the operation of an overcurrent protection device.
5. Anchor bolts nuts, bolts, and washers shall conform to M8.01.5 and the Standard Drawings.
6. The arms shall be furnished with a finish similar to that of the pole. The exterior of the pole and arm shall be free of protuberances, dents, cracks, discolorations and other imperfections marring their appearance.
7. For shipping purposes, the pole and arm shall be protected to preserve the finish.
8. The dead load deflection at the top of the pole caused by the mass of the arm, luminaires and all appurtenances attached thereto shall not exceed 2% of the pole length.
9. Aluminum poles shall have a Combined Stress Ratio (CSR) no greater than 0.95. Aluminum poles over 20 feet in length shall have internal dampers installed to reduce vibrations.
10. An identifying tag shall be affixed to the pole at a readable location on the side of the pole away from traffic. Information on the tag shall include, manufacturer's name and order number, date of manufacture and pole material.

SUBECTION 820.41 (continued)

B. High Mast Towers.

All high mast towers shall be made of galvanized steel.

Anchorage shall consist of four or more high strength steel bolts, having two heavy duty hex nuts, and fabricated from high strength low alloy steel having a minimum yield of 50 ksi 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.

SUBSECTION 820.82 Payment Items.

*(page 245 English, page II.208 Metric) Delete pay items 822.80 to 822.82 Area Lighting Hinged Pole *__ft. Mounting Height *(40-50 ft.) (Metric description similar) and 823.72 Highway Lighting Pole and Luminaire Removed and Transported. Replace pay items 822.83 to 822.88 and 822.89 to 822.98 with the following:*

822.83 to 822.98 High Mast Tower (___ Foot (Meter) Mounting Height) Each

SECTION 828
TRAFFIC SIGNS

SUBSECTION 828.20 General.

(page 248 English) In the second paragraph of this page delete the words "galvanized steel".

(page 248 English, page II.210) Replace the third paragraph to the end of this subsection with the following;

The signs, foundations and supports shall be fabricated and erected in conformity with the following:

A. MUTCD with Massachusetts amendments.
B. AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals
C. MassDOT Construction Standards.

SUBSECTION 828.40 General.

(page 248 English) Replace the title of M9.30.4 with the following:

Acrylic Plastic 3¼ Inch Diameter Center-Mount Reflector.....M9.30.4

(page II.210 Metric) Replace the titles of M9.30.3 and M9.30.4 with the following:

Acrylic, Prismatic Reflectors and Embossed Aluminum Frames for Signs M9.30.3
Acrylic Plastic 82.5 Millimeter Diameter Center-Mount Reflector.....M9.30.4

SUBSECTION 828.41 Reflective Sheeting.

(page 248 English, page II.210 Metric) Replace the entire Subsection with the following:

Reflective Sheeting shall meet the requirements of Section M9.30.0.

High Intensity Prismatic sheeting, Type VII or better, shall be used on Type “B” Aluminum Signs, including Type A Individual Route Marker Panels mounted on Type “B” Signs.

High Intensity Prismatic sheeting, Type III or better, shall be used on Type “A” Aluminum Signs.

Flexible High Intensity Type VI sheeting shall be used on Channelizing Devices.

The panel and legend of signs shall be fabricated from the same grade and manufacturer of sheeting (i.e. Type VII legend on Type VII panel), except where black opaque legends or panels are specified. If sign legend is black opaque, panel sheeting shall be Type III or IV; if sign panel is black opaque, legend sheeting shall be Type III or IV.

SUBSECTION 828.42 Panels.
(page 248 English, page II.210 Metric) Replace the entire Subsection with the following:

Aluminum sign panels shall be either Type A or Type B. Sign supporting hardware shall be aluminum or stainless steel.

Type A Panels shall be fabricated from flat sheet Aluminum Alloy of the following types:

A-1 - Flat sheet sign panels shall be fabricated from aluminum sheeting meeting ASTM B209, Alloy 6061-T6 or Alloy 5052-H38. Panels mounted with P-5 posts (square tube posts or U channel posts) shall be 0.08 inches (2 mm) thick. Panels mounted with single round breakaway posts shall be 6 mm thick.

A-2 – Flat sheet sections with extruded tabs shall be fabricated from:

1. Sheeting 0.125 inches (3.18 mm) 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.

Route marker overlay on directional sign panels shall be fabricated from Aluminum Alloy 5052-H38 0.08 inches (2 mm) thick. Material for attachment shall be compatible with materials joined and shall conform to the following ASTM specifications:

Part	Aluminum	Stainless Steel
Bolts	B211 6061-T6 Alloy	F593 Type 304 or 305
Rivets	B316 6061-T6 Alloy	not applicable
Nuts	B211 6061-T6	F594 Type 304 or 305
Washers	B209 Alclad 2024-T4	compatible with materials joined

Type B Panels shall be fabricated of extruded Aluminum ASTM B221. Alloy 6063-T6 shall be 0.125 inches (3.18 mm) thick, 12 inches (305 mm) wide and of bolted joint design. Only one 6 inch (152.4 mm) panel shall be used where the overall height of a sign requires one panel less than 12 inches (305 mm).

SUBSECTION 828.43 Legends (Type A, B, C, D).
(page 249 English, page II.211 Metric) Change Subsection title to ***Legends (Type A, B and C).*** *and replace paragraphs 2 through 5 with the following:*

a. State and U.S. Route Markers shall have Type C Silk Screen Processed Legends.

b. Interstate Route Markers on Guide Signs on Feeder roads shall have Type B Permanently Applied Legends.

c. Individual Interstate Route Markers shall have Type B Permanently Applied Legends with the required Silk Screen Processed Legend superimposed thereon.

d. Individual Interstate Route Markers on Overhead Signs shall have Type A Demountable Flat Numerals fabricated from Type VII, VIII, IX or X reflective sheeting.

(page 249 English, page II.212 Metric) Delete the heading and the paragraphs that follow ***B. Legend Type B. Demountable Prismatic Reflectors****. Change paragraph heading C to "****B. Legend Type B – Permanently Applied Legend****". Change paragraph heading D to "****C. Legend Type C – Silk Screen Processed****".*

SUBSECTION 828.44 Demountable Reflectorized Delineators.
(page 249 English, page II.212 Metric) Delete this Subsection.

SUBSECTION 828.46 Delineation for Guardrail Termini.
(page 250 English) Add this new Subsection.

Delineators for Guardrail Termini shall meet the requirements of Subsection M9.30.10.

SUBSECTION 828.51 Reflective Sheeting.
*(page 250 English) Replace the last sentence of the third paragraph under **A. Application** with the following:*

No splices shall be allowed on sign panels 20 square feet or under. For D6 guide sign panels over 20 square feet, splices shall be avoided; however, a maximum of one splice is allowed if necessary.

SUBSECTION 828.52 Panels.
(page 251 English, page II.213 Metric) Replace the fourth paragraph of the Subsection with the following:

The code numbers of fabricators and manufacturers will be obtained from the Department.

(page 251 English, page II.213 Metric) Delete from the seventh paragraph of the Subsection and the lettered paragraphs that follow.

(page 251 English) Delete the heading and the section titled A. Plywood and the heading B. Aluminum.

(page 252 English, page II.214 Metric) Delete the heading and the section titled C. Panels for 24" Warning Cluster (H1-2).

SUBSECTION 828.53 Legends.
*(page 252 English, page II.214 Metric) Delete the heading and section titled B. Type B.. Change paragraph heading D to **C. Type C**. and replace section C with the following:*

B. Type B.
See Subsection 828.43-B

SUBSECTION 828.54 Demountable Reflectorized Mile and Tenth of a Mile Markers.
(page 252 English, page II.214 Metric) Replace this entire Subsection with the following:

828.54 Demountable Reflectorized Reference Location Signs.

The panels shall be aluminum (Type A) of the size shown on the plans. Reflective sheeting shall conform to Subsection 828.41
Legends shall be Type B as specified under Subsection 828.43-B.

SUBSECTION 828.55 Hazard Markers.
(page 253 English, page II.215 Metric) Delete the last sentence of the Subsection. "

SUBSECTION 828.56 Demountable Reflectorized Delineator.
(page 253 English, page II.215 Metric) Delete this Subsection.

SUBSECTION 828.58 Demountable Reflectorized Project Markers.
(page 253 English) Change the title to:

828.58 Demountable Reflectorized Station Markers and Project Markers

(page 253 English, page II.216 Metric) Replace the first paragraph with the following:

The panels shall be aluminum (Type A), 0.063 inches (1.6 mm) thick. They shall be 4" (100 mm) wide and of a length required to display the station numerals or Federal-aid Number shown on the plan.

SUBSECTION 828.59 Street Name Sign.

(page 254 English, page II.216 Metric) Add this new Subsection:

The panels shall be fabricated from Type A aluminum 0.080 inches (2 mm) thickness. Panels shall be a minimum of 12 inches (300 mm) wide and of a length required to display the street name.

Reflective sheeting shall conform to the requirements of Subsection 828.41. The color of the legend should be white and the color of the background should be green.

The legend shall be Type B or C. Legend size and font shall conform to the MUTCD.

If specified, city/town seals on signs shall conform to the MUTCD.

SUBSECTION 828.60 General.

(page 254 English, page II.216 Metric) Replace the entire subsection with the following:

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 aluminum panel (Type A) as specified. Posts shall be one standard P-5 breakaway assembly, conforming to Department standards.

Demountable reflectorized station markers and project markers shall be fabricated and erected as shown on the plans and/or as directed by the Engineer.

Demountable reflectorized reference posts 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.

Leading and trailing ends at bridges – 3 delineators: one at the connection of the terminal: the connector and 25 foot (7.62 m) plate; one at the middle of the 25 foot (7.62 m) plate; and one at the connection of the 25 foot (7.62 m) plate and the normal guard rail panel.

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 8 feet (2.5 m) from the edge of the paved surface.

Exceptions and/or modifications to the above shall be made only with the approval of the Engineer in the field.

When roadway alignment permits, the reflector portion of each delineator shall be positioned so that it will be clearly visible for a distance of 1000 feet (300 m) 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.

SUBSECTION 828.60 (continued)

Delineation for Guard Rail Termini shall be mounted within 6 inches (150 mm) perpendicular to the web of the first and last full height guard rail posts in a section of guard rail.

Street name signs shall be mounted on one standard P-5 breakaway post assembly. Street name signs shall be fabricated and erected as shown on the plans and/or as directed by the Engineer.

SUBSECTION 828.61 Attachment to P-9 Posts.

*(page 254 English, page II.216 Metric) Delete **P-9** from the title, delete the last paragraph of the Subsection and replace the first paragraph with the following:*

Demountable Reflectorized Reference Location Signs, shall be attached to P-5 posts as shown in the Construction and Traffic Standard Details.

Demountable Reflectorized Station Markers and Project Markers, and Delineation for Guardrail Termini shall be attached to the P-9 posts by a connection fabricated as follows:

SUBSECTION 828.80 Method of Measurement.

(page 255 English, page II.217 Metric) Replace the 6th through 8th paragraph with the following:

Demountable Reflectorized Reference Location Signs with P-5 Post will be measured by the respective unit complete in place.

Demountable Reflectorized Delineators – Guardrail shall be measured by the unit, complete in place, with P-9 post or bracket.

Demountable Reflectorized Station Markers and Project Markers including P-9 Post will be measured by the unit complete in place.

(page 255 English, page II.217 Metric) Revise the 7th paragraph to read as follows:

Demountable Reflectorized Delineator - Guard Rail shall be measured by the unit, complete in place, with P-9 post or bracket.

(page 255 English, page II.217 Metric) Add the following paragraphs (English) / Replace the last paragraph (Metric) as follows:

Delineation for Guardrail Termini with P-9 will be measured by the unit each post complete in place.

Each Street Name Sign shall be considered as one unit (excluding post). The P-5 breakaway post assembly for the sign shall be furnished under Item 847.1.

SUBSECTION 828.81 Basis of Payment.

(page 255 English, page II.217 Metric) Replace the 5th through 7th paragraph with the following:

Demountable Reflectorized Reference Location Signs with P-5 Post will be paid for at the contract unit price each complete in place.

Demountable Reflectorized Delineator - Guard Rail will be paid for under the contract unit price each complete in place.

Demountable Reflectorized Station Markers and Project Markers with P-9 Post shall be paid for at the contract unit price each complete in place.

(page 255 English, page II.217 Metric) Add the following paragraphs (English) / Replace the last paragraph (Metric) as follows:

Delineation for Guardrail Termini will be paid for at the contract unit price each complete in place.

Street Name Signs will be paid for at the contract unit price each complete in place.

SUBSECTION 828.82 Payment Items.

(page 255 English) Delete payment items 827.3, 827.31, 828., 828.2, 829.1, 829.2, 830., 830.1, 830.2, 831.1, 831.2, 832.1, 833.1, 833.11, 833.2, 833.3, 833.4. 834.1, 834.11 and 836.1, and add item 833.7 as follows:

833.7	Delineation for Guardrail Termini	Each

(page 255 English, page II.218 Metric) Replace or add the following payment items in numerical order:

829.	Roadside Guide Sign (G) - Aluminum Panel (Type B)	Square Foot (m^2)
831.	Roadside Guide Sign (D6/D8) - Aluminum Panel (Type A)	Square Foot (m^2)
832.	Warning – Regulatory and Route Marker - Aluminum Panel (Type A)	Square Foot (m^2)
834.	Demountable Reflectorized Reference Location Sign	Each
836.	Demountable Reflectorized Project Marker	Each
836.5	Demountable Reflectorized Station Marker	Each
874.	Street Name Sign	Each

(page II.218 Metric) Delete payment items 827.31, 829.1, 830.1, 831.1, 832.1, 833.1, 833.11, 833.2, 833.3, 833.4, 834.1, 834.11, 836.1 and 836.6.

SECTION 840
SIGN SUPPORTS

SUBSECTION 840.20 General.

(page 256 English) Replace the first paragraph of this subsection with the following:

The work to be done hereunder consists of the erection and fabrication of steel structural supports on 4000 psi cement concrete foundations.

(page II.218 Metric) Replace the first paragraph of this subsection with the following:

The work to be done hereunder consists of the erection and fabrication of steel structural supports on 30 MPa cement concrete foundations.

(page 256 English, page II.218 Metric) Replace the third and fourth paragraph with the following:

The foundations and supports for ground mounted signs shall be based on the plans and the standard drawings.

The design for overhead structures and foundations shall conform to the requirements of Section 828.21. Boring samples or actual determination of soil properties are required for all footings for overhead structures.

(page 257 English, page II.219 Metric) Replace the twentieth paragraph of the Subsection with the following:

The Contractor shall submit all design work, together with hand or computerized calculations and plans used for design purposes, to the Department; which shall become property of the Department with no additional compensation. All design work shall bear the seal of a Professional Engineer registered in Massachusetts.

SUBSECTION 840.30 General.
(page 257 English, page II.219 Metric) Replace this Subsection with the following:

All materials shall be new and shall meet the requirements specified in the following Subsections of Division III, Materials:

4000 psi Cement Concrete.....M4.02.00
Reinforcing Steel.....M8.01.0
Anchor Bolts.....M8.01.5
Steel Sign Supports.....M8.18.5
P-5 Sign Supports.....M8.18.3

All overhead and cantilevered support structures shall be in accordance with the requirements of Section 960. Structural Steel and Miscellaneous Metal Products.

SUBSECTION 840.60 General.
(page 258 English) Replace the first paragraph of this subsection with the following:

Work hereunder includes excavation, reinforcing steel, 4000 psi cement concrete, 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.

(page II.220 Metric) Replace the first paragraph of this subsection with the following:

Work hereunder includes excavation, reinforcing steel, 30 MPa cement concrete, 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.

(page 258 English, page II.220 Metric) Add the following to the end of this Subsection:

P-5 posts may be either the square tube post or U channel type at the Contractor's option. Signs mounted with square tube posts shall be installed as follows:

Area in square feet (m^2)	**Mounting with P-5 square tube posts**
Up to 7.5 (0.75)	Single 2¼ x 2¼" post
Over 7.5 to 15 (0.75 –1.5)	Two 2¼ x 2¼" posts
Over 15 to 20 (1.5 – 2.0)	Two 2½ x 2½" posts

Single post installation shall be in accordance with the Standard Drawing and Signs and Supports. Signs with two posts require a slip base and shall be installed as per manufacturer's recommendations except that the sign post anchor shall be embedded at least 4 feet (1.2 m) below ground surface.

Signs mounted with U-channel posts shall be installed as follows:

Area in square feet (m^2)	**Mounting with P-5 U Channel posts**
Up to 10 (1.0)	Single post
Over 10 to 20 (1.0 – 2.0)	Two posts

Breakaway capabilities shall be maintained via the use of a lap splice or slip base system. Signs with two posts shall be installed as per manufacturer's specifications except that the sign post anchor shall be embedded at least 4 feet (1.2 m) below ground surface.

Damage to the galvanized coating shall be repaired before erection with high zinc dust content paint meeting M7.04.11.

SUBSECTION 840.81 Basis of Payment.
(page 258 English, page II.220 Metric) Replace this Subsection with the following:

Payment items in the 841. payment item series, and payment items 845.1 through 848.1 shall be paid at the contract unit price for each sign installed. Payment for work done under payment items 840.1* and item 844.1* shall be at the contract lump sum price.

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, gravel backfill and compaction except rock excavation, which shall be paid under Class B Rock Excavation.

SUBSECTION 840.82 Payment Items.
(page 258 English, page II.221 Metric) Replace this Subsection with the following:

840.1*	Support for Overhead Guide Sign (OD-*) - Steel	Lump Sum
841.1	Support for Guide Sign (D6 with D8 – 5 Inch Tubular Post) Steel	Each
841.1	Support for Guide Sign (D6 with D8 – 125 mm Tubular Post) Steel	Each
841.2	Support for Guide Sign (D6 – 5 Inch Tubular Post) Steel	Each
841.2	Support for Guide Sign (D6 – 125 mm Tubular Post) Steel	Each
841.3	Support for Guide Sign (D6 – P5 Posts) Steel	Each
841.4	Support for Guide Sign (D8 – 4 Inch Tubular Post) Steel	Each
841.4	Support for Guide Sign (D8 – 100 mm Tubular Post) Steel	Each
841.5	Support for Guide Sign (D8 – P5 Posts) Steel	Each
841.6	Support for Guide Sign (I-2A – 5 Inch Tubular Post) Steel	Each
841.6	Support for Guide Sign (I-2A – 125 mm Tubular Post) Steel	Each
841.7	Support for Guide Sign (D6 with D8 – Special Design) Steel	Each
841.8	Support for Guide Sign (D6 – Special Design) Steel	Each
844.1*	Support for Guide Sign (G*) Steel	Lump Sum
845.1	Support for Guide Sign (E5-1) Steel	Each
846.1	Supports for Guide Sign (E5-1A) Steel	Each
847.1	Sign Support (Not Guide) and Route Marker with 1 Breakaway Post Assembly - Steel	Each
848.1	Sign Support (Not Guide) and Route Marker with 2 Breakaway Post Assemblies - Steel	Each
144.	Class B Rock Excavation	Cubic Yard (m^3)

* = as per MHD Standard Nomenclature

SECTION 850 TRAFFIC CONTROLS FOR CONSTRUCTION AND MAINTENANCE OPERATIONS

(page 259 English, page II.221 Metric) Replace this Section with the following:

DESCRIPTION

850.20 General.

Work under this Section consists of furnishing, installing and maintaining in proper operating condition various traffic control devices for the protection of the traveling public and working personnel during construction and maintenance operations. The design, application, and installation of all devices shall conform to MassDOT's "Standard Details and Drawings for the Development of Temporary Traffic Control Plans" and the "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 all project personnel.

All construction vehicles not protected by any form of traffic control device on a project which is open to traffic shall have an 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 or travelway. Amber flashers must be a minimum of 40 candelas and have a flashing frequency of 50 to 60 times per minute. Either rotating beacons or strobe lights meeting these requirements are acceptable.

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 under this Section shall conform to the approved Temporary Traffic Control Plan.

850.21 Roadway Flagger.

The Contractor shall provide the number of flaggers required in either the appropriate Temporary Traffic Control Plan (TTCP) template (see MassDOT's website at http://www.massdot.state.ma.us/), the Temporary Traffic Control Plan or that the Engineer deems necessary for the direction and control of traffic within the site. A flagger shall be used as directed by the Engineer in accordance with 701CMR 7.00, this section, and the TTCP. Any flagger determined by the Engineer to be ineffective in controlling traffic may be removed at the discretion of the Engineer. If a flagger is directed to be removed, the Contractor shall immediately comply with the directive from the Engineer and shall suspend operations as necessary until a qualified replacement can be provided. Such a suspension of operations shall not be considered as a basis for a claim or an extension of time.

MassDOT reserves the right to provide certified Roadway Flaggers or police officers, at the discretion of the Engineer.

850.22 Traffic Cones for Traffic Management.

Traffic Cones for Traffic Management consists of furnishing, positioning, repositioning, maintaining and removing, as needed and/or as directed, traffic cones and necessary ballast for the purpose of closing a lane, shifting traffic, channelizing, or otherwise re-directing traffic.

850.23 Safety Signing for Traffic Management.

Safety Signing for Traffic Management consists of furnishing, positioning, repositioning, covering and uncovering, maintaining and removing, as needed and/or as directed: regulatory, warning, and guide signs together with their supports. If additional supports are needed due to site conditions they will be considered incidental to the work.

Signs over 50 square feet (5 m^2) will require approval of design calculations and shop drawings of the breakaway support system if the signs are installed at an unprotected location.

850.24 Temporary Pavement Markings and Temporary Raised Pavement Markers.

Temporary Pavement Markings and Temporary Raised Pavement Markers consist of furnishing, applying, maintaining and removing temporary white and yellow reflectorized pavement markings and temporary raised pavement markers during construction and maintenance operations.

Temporary markings shall be effective for a period of 90 days. Re-application or replacement within the 90 day period shall be done at no additional cost to the Department.

850.25 Arrow Board.

Arrow Board consists of providing, operating, positioning, repositioning, maintaining and removing a portable truck-mounted or trailer-mounted flashing arrow unit on the project at designated locations.

850.26 Reflectorized Drums.

Reflectorized Drums consists of furnishing, positioning, repositioning, maintaining, and removing reflectorized plastic drums and necessary ballast, as needed and/or as directed by the Engineer.

850.27 Pavement Marking Removal and Raised Pavement Marker Removal.

Pavement Marking Removal consists of removing existing pavement markings as required to support the Temporary Traffic Control Plan and as directed by the Engineer. Raised Pavement Marker Removal consists of removal and disposal of the existing raised pavement markers including filling the void.

850.29 Temporary Barrier and Temporary Barrier Removed and Reset.

Temporary Barrier consists of furnishing, installing, maintaining and final removal of temporary barriers, including delineation, for traffic control or work zone protection in construction zones. This barrier shall be continuous as a unit across bridges and other limited construction areas unless designated on the plans as "Temporary Restrained Barrier."

Temporary Barrier Removed and Reset consists of removing, transporting and resetting of temporary barrier units from alignments established along the roadway to new alignments as required by the construction and staged construction operations for the control of traffic or work zone protection.

850.30 Temporary Restrained Barrier and Temporary Restrained Barrier Removed and Reset.

Temporary Restrained Barrier consists of furnishing, installing, maintaining and final removal of temporary restrained barriers on bridge decks and other locations including delineation, in accordance with details as shown on the traffic management plans and/or bridge plans and as directed by the Engineer. The work shall also include furnishing and installing all hardware and associated materials necessary to restrain the barriers in position, or attach the barriers to the roadway or the bridge deck.

Only barrier systems that have been crash tested and approved by FHWA are acceptable for the intended use.

Temporary Restrained Barrier Removed and Reset consists of removing, transporting and resetting of temporary restrained barriers in accordance with details as shown on the plans and as directed by the Engineer. The work shall also include furnishing and installing all hardware and associated materials necessary to restrain the barrier or attach the barriers to the roadway or bridge deck.

850.31 Portable Breakaway Barricades Type III.

Portable Breakaway Barricades Type III consists of furnishing, positioning, repositioning, maintaining and removing Portable Breakaway Barricades Type III where indicated on the plans and/or as directed by the Engineer.

850.32 Temporary Impact Attenuators and Temporary Impact Attenuators Removed and Reset.

Temporary Impact Attenuators consists of furnishing, installing, maintaining and final removal of temporary impact attenuators in conformance with the specifications of the manufacturer and in close conformance with the locations, lines, and grades shown on the plans and/or designated in the special provisions.

Temporary Impact Attenuators Removed and Reset includes maintaining, removing and reinstalling temporary impact attenuators where indicated on the plans or as indicated by the Engineer.

850.33 Portable Changeable Message Sign.

Portable Changeable Message Sign consists of furnishing, positioning, repositioning, operating, maintaining, and removing a portable changeable message sign as needed and/or as directed by the Engineer. All messages displayed shall be approved by the Engineer prior to being displayed.

850.34 Truck Mounted Attenuator.

Truck Mounted Attenuator consists of furnishing a moveable impact attenuator equipped with a flashing arrow board. The impact attenuator can be either a truck-mounted or a tow-behind unit.

850.35 Temporary Illumination.

Temporary Illumination shall conform to the relevant provisions of Section 800, the Massachusetts Electrical Code and OSHA Safety Standards. The work consists of illuminating the work areas and lane drops on a temporary basis as designated by the Engineer. Lighting for paving and planning operations shall also conform to the requirements of Section 450.

All lighting equipment shall be approved by the Engineer prior to use. The Contractor shall submit to the Engineer a lighting plan for approval. No nighttime work shall be performed until the plan is approved by the Engineer. The lighting plan shall be prepared by a Professional Electrical Engineer and consist of the means and methods of the proposed lighting and contain supporting calculations.

MATERIALS

850.40 General.

Devices required under this Section need not be new but must be in first class condition and acceptable to the Engineer. The condition of the work zone traffic control devices shall meet the quality standards set forth in the *Quality Standards for Work Zone Traffic Control Devices* compiled by the American Traffic Safety Services Association (ATSSA). Any devices that, in the judgment of the Engineer, are unsatisfactory in appearance and/or performance shall be removed and immediately replaced by acceptable devices.

850.41 Roadway Flagger.

Each flagger shall be equipped with the following high visibility clothing, signaling, and safety devices:

1. A white protective hard hat with a minimum level of reflectivity per the requirements of ANSI, Type I, Class E&G;
2. A clean, non-faded, non-torn lime/yellow reflective safety vest and safety pants meeting the requirements of ANSI 107 Class 3;
3. A 24 inch “STOP / SLOW” traffic paddle conforming to the requirements of Part 6E.03 of the Manual on Uniform Traffic Control Devices (MUTCD), a weighted, reflectorized red flag, flagger station advance warning signage, and two-way radios capable of providing clear communication within the work zone between flaggers, the Contractor, and the Engineer. The traffic paddle shall be mounted on a pole of sufficient length to be seven feet above the ground as measured from the bottom of the paddle;
4. A working flashlight with a minimum of 15,000 candlepower and a six inch red attachable wand, a whistle with an attached lanyard, and a First Aid kit that complies with the requirements of ANSI Z308.1.
5. An industrial/safety type portable air horn that complies with the requirements of the U.S. Coast Guard.

850.42 Traffic Cones for Traffic Management.

Traffic cones shall meet the requirements of M9.30.11.

850.43 Safety Signing for Traffic Management.

Rigid signs shall be fabricated from plywood, aluminum or approved alternate substrate material.

Plywood sign material shall be 5/8 inch Exterior MDO – General (one sided).

Aluminum sign material shall be Type A, 0.080 inch thick, as specified in Subsection 828.42.

The entire sign face shall be retro-reflectorized. Reflective sheeting shall conform to M9.30.0.

Rollup signs shall be fabricated from vinyl microprismatic retroreflective material.

Background sheeting for all construction warning signs shall be of a fluorescent orange color. The minimum spectral radiance factor, in accordance with Section 5.1 of ASTM E991, for the fluorescence shall be as follows:

New	110% minimum
Weathered	60% minimum

850.44 Temporary Pavement Markings and Temporary Raised Pavement Markers.

Glass beads, tapes and paints used for temporary pavement markings shall be lead free, conform to Subsections M7.01.07, M7.01.16, M7.01.23 and M7.01.24 and meet the retroreflectivity requirements of the MUTCD for a period of 90 days. Final determination as to pavement marking quality shall be made by the Engineer. The Contractor shall supply a retroreflectometer for this purpose.

The colors of the marking materials shall be the standard highway colors of white or yellow and as outlined in the MUTCD.

Temporary Raised Pavement Markers shall conform to Subsection M9.30.6.

850.45 Arrow Board.

The unit shall consist of a black background panel meeting the requirements of MUTCD Type C and shall contain at least 15 amber lamps of approximately 8,000 initial maximum candelas each.

Panels shall have the capability of the following mode selections: (1) left or right flashing or sequential arrows; (2) left or right sequential chevrons; (3) flashing double arrow; (4) flashing caution and (5) alternating diamond caution.

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 or more than 40 flashes per minute.

Minimum mounting height should be 7 feet (2.1 m) above the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practicable.

850.46 Reflectorized Drums.

Reflectorized drums shall conform to Subsection M9.30.9. Warning lights shall conform to the MUTCD Type A. All drums shall be maintained in a satisfactory manner including the removal of dirt and road film that causes a reduction in sheeting retroreflective efficiency.

850.49 Temporary Barrier.

The Contractor shall use a temporary barrier system that meets the requirements of MASH TL-2 and is listed on the Qualified Traffic Control Equipment List.

850.50 Temporary Restrained Barrier.

Temporary restrained barriers for use on roadways or on bridges shall be restrained by blocking or other system, affixed to the roadway by pinning, sett into the roadway surface or other tested system or bolted down to the bridge deck, and shall be manufactured in accordance with the plans and Section 629 of the Standard Specifications.

The Contractor shall supply a barrier and anchorage system that was crash tested in accordance with NCHRP 350, TL-3 or MASH, TL-3 and accepted by FHWA. The Contractor shall provide evidence of FHWA acceptance.

850.51 Portable Breakaway Barricades Type III.

Portable Breakaway Barricades shall conform to the plans and the following requirements:

1. MUTCD.
2. Reflectorized sheeting conforming to M9.30.0. Type VI. 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).
3. The alternating 6 inch (150 mm) wide reflectorized diagonal stripe shall be orange and white and shall slope downward at 45° toward the end by which the 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.

850.52 Temporary Impact Attenuators.

Only those Temporary Impact Attenuators previously approved for the purpose intended and listed on the Qualified Construction Materials List may be used. The temporary impact attenuator shall be designed to fit within reasonably close tolerance of the dimensions given on the plans or in the special provisions for a given location. The Contractor shall provide a design for temporary impact attenuator at the design speed shown on the plans or other speed designated by the Engineer.

850.53 Portable Changeable Message Sign.

The Portable Changeable Message Sign shall be capable of performing all functions at ambient temperatures ranging from -31° to 165°F (–35 to 74°C). There shall be no degradation of operation due to fog, rain or snow.

Maintenance shall include periodic cleaning. When not being used the sign shall be stored in a secure area approved by the Engineer.

The Portable Changeable Message Sign shall consist of the following major components:

A. Message Sign.

1. Type – The technology can be LED or a combination of both Flip Disk and LED (Hybrid).
2. Matrix Displays – Shall be character, line or full matrix.
3. Size – The message sign shall have a minimum height of 6 feet (1.85 m), maximum height of 6.5 feet (2.0 m) and a minimum width of 8 feet (2.5 m), maximum width of 12 feet (3.7 m).
4. Colors – The display shall be either fluorescent yellow or ITE amber.
5. Lines – The message sign shall have the capability of displaying at least three lines of 18 inch (450 mm) characters with a minimum of 8 characters per line.
6. The sign shall be illuminated for nighttime visibility.

B. Operator Interface.

A means of creating and controlling the display message(s) on–site and remotely through an NTCIP compatible IP addressable modem, shall be provided with each sign. The operator interface shall contain as a minimum the following:

1. Display terminal with keyboard to allow previewing the message content and format before it is sent to the sign panel. The keyboard shall be of a standard design.
2. Controller (CPU).
3. Lockable weatherproof enclosure for interface components.

C. Controller.

The controller shall possess, at a minimum, the following features:

1. Full 32K user memory with the option for additional archive memory.
2. Capacity to store a minimum of 50 messages .
3. Changeable message flash rate capability.
4. A minimum of 24 hour battery back-up.
5. Password activation shall be software available.

D. Power Supply.

The sign shall be capable of operation from a diesel powered generator, a battery or solar power. The power supply shall be protected from the weather and be locked for security

E. Trailer.

The trailer shall have at least the following features:

1. A current Registry of Motor Vehicles registration as per Section 7.04.
2. Swivel jacks capable of leveling the trailer on a 1:6 (1 vertical to 6 horizontal) slope and capable of stabilizing the trailer in winds of up to 80 miles per hour (130 km/hr).
3. The sign shall be capable of being locked in a stowed position while being towed.
4. A lift mechanism shall be provided to elevate the sign to its operating position.
5. The capability to lock the sign panel in several off-angle positions with respect to the trailer axis.

850.54 Truck-Mounted Attenuator.

Only those truck mounted attenuators previously approved for the purpose intended and listed on the Qualified Construction Materials List may be used. Since most approvals are conditional, any associated issues including but not limited to anticipated conditions, model, variations, modifications, proper installation of truck-mounted units and tow-vehicle specifications shall be resolved to the satisfaction of the Engineer before use in the field. The submitted information shall include estimated displacement characteristics for a variety of impacts (assumptions regarding both impacting vehicle weight and speed) so that appropriate temporary traffic control set-ups can be undertaken in the field.

The flashing arrow board shall conform to the requirements of Section 850.45 of the Standard Specifications.

850.55 Temporary Illumination for Work Zones.

All floodlights shall have flat lenses securely fastened to the housing. All floodlight fixtures shall be mounted at a sufficient height to allow for an aiming angle of 45 degrees from the vertical to the job site. An inventory of spare lamps and fixtures shall be maintained on the job site and all lamp or fixture failures shall be repaired or replaced immediately.

Illumination Standards for Work Area

The entire work area shall be illuminated to a minimum average of 10 foot-candles measured on a horizontal plane 6 inches above the work surface. A uniformity ratio (average to minimum) of 4 to 1 or better shall be maintained at all times in the work area. This shall apply to the work areas only. Any area where all phases of the work are completed need not be illuminated except for the safety and transition area lighting.

Illumination Standards for Transition Areas

The transition areas are the sections of roadway where road users are redirected out of their normal path.

The traveled way within these areas and all cones, drums, or other physical barriers placed on the roadway for the purpose of channelizing or restricting vehicular traffic shall be illuminated to a minimum average of 2 foot-candles measured on a horizontal plane 6 inches above the roadway surface. A uniformity ratio (average to minimum) of 4 to 1 or better shall be maintained at all times in the transition area. These areas to be illuminated shall be defined as beginning at the first cone, barrel drum or other physical channelizing device, continuing across the full roadway width through the transition area, and ending where the traveled way attains a constant width.

Lighting Equipment Mounting

Mounting shall be designed and constructed by the contractor to suit the configuration of the equipment to which the lighting is attached.

Mounting shall be secure to prevent excessive vibration. Care shall be exercised to ensure that fixture mounting will clear all overhead structures.

All equipment lighting shall be aimed in such a manner as to maximize the illumination on each individual task.

All lighting units shall be placed in such a manner as to avoid shadows on the work area or the travel area and to prevent excessive glare to the motorist.

An inventory of spare lamps and spare fixtures shall be maintained on the job site by the contractor and all lamp or fixture failures shall be repaired or replaced immediately.

850.61 Roadway Flagger.

Flaggers used during the performance of the Work shall be at least eighteen years of age.
Flaggers used during the performance of the Work shall possess a current certificate of satisfactory completion from a Department-approved flagger training program within the previous two years.

Prior to the start of work, the Contractor shall provide to the Engineer a written list of certified flaggers to be used, including the most recent date of certification or re-certification for each person listed.

All flaggers shall carry their approved flagging training program certification card with them while performing flagging duties. Flagger certifications shall remain valid for the duration of the project or the flagger shall be removed from the project.

Flaggers shall have completed a First Aid training course according to the standards and guidelines of the American Heart Association or the American Red Cross. Flaggers shall carry their First Aid certification cards with them while performing flagging duties. First Aid certifications need not be renewed once the initial certification has expired.

850.62 Traffic Cones for Traffic Management.

Traffic Cones shall be in good condition and sufficiently ballasted as determined by the Engineer. Any cones damaged by traffic shall be immediately replaced. The Contractor shall keep an adequate supply of spare cones on hand to replace any damaged cones.

The Contractor shall take steps to prevent cones from being blown over or displaced by wind or moving vehicular traffic. Cones shall not be left in position or on the highway when the construction operations have ceased. If it becomes necessary for the Department to remove any cones from the project due to negligence by the Contractor, all costs for this work will be charged to the Contractor.

850.63 Safety Signing for Traffic Management.

Signs which are damaged or are missing from their locations shall be replaced by the Contractor without additional compensation except as described in Section 7.17.

All signs shall be maintained in a satisfactory manner including the removal of dirt or road film that causes a reduction in sign reflective efficiency.

All signs shall be mounted in compliance with the requirements of the MUTCD.

All signs not consistent with the use of the roadway shall be removed, completely covered, or turned away from traffic each day. In no case shall signs or their portable supports be left in the traveled way when the traffic management set-up has been removed.

Rollup signs shall only be used for single work shift setups.

850. 64 Temporary Pavement Markings and Temporary Raised Pavement Markers.

The Contractor shall install all necessary temporary pavement markings and temporary raised pavement markers, or both, prior to opening the roadway to traffic following the completion of each day's operations. Temporary raised pavement markers shall be supplemented with tape or painted markings to assure lane delineation. The Contractor shall make all necessary arrangements for this work beforehand so that it may be properly coordinated with construction operations. Temporary pavement markers and temporary raised pavement markers shall be installed in accordance with the requirements of the MUTCD.

850.65 Arrow Board.

The arrow board shall be deployed as shown on the approved Temporary Traffic Control Plan or as directed. The unit shall be properly maintained throughout its use on the project.

850.66 Reflectorized Drums.

Reflectorized drums are to be used as channeling devices in highway work zones. The first five drums used for any taper or as designated on the Temporary Traffic Control Plan shall be equipped with flashing lights.

850. 67 Pavement Marking Removal.

Existing pavement markings shall be removed to the fullest extent possible by an approved method. 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. It is not permissible to paint over existing markings with black paint in lieu of removal. Approved methods include but are not limited to:

1. High pressure air.
2. High pressure water (cold weather use not permitted)
3. Sand blasting,
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 permitted. Conflicting 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.

Any damage to the pavement or surfacing caused by pavement marking removal shall be satisfactorily repaired at no additional cost to the Department.

Where the removal operation is being performed near a lane occupied by traffic, a vacuum attachment operating concurrently with the removal operation must be in use. All residue shall be removed immediately from the surface being treated.

850. 68 Raised Pavement Marker Removal.

Existing raised pavement markers shall be removed by a method approved by the Engineer. Any damage to the pavement or surfacing caused by pavement marking removal shall be repaired at no additional cost by methods acceptable to the Engineer. Voids in the pavement shall be filled with like materials with adhesive bonding to the substrate.

850.69 Temporary Barrier and Temporary Barrier Removed and Reset.

The Temporary Barrier shall be installed as shown on the plans, in accordance with these provisions and/or as directed by the Engineer.

Each run of temporary barrier units shall be fastened together to form a continuous chain.

Temporary impact attenuators with delineation shall be installed at ends of barriers within 30 feet (10 m) of approaching traffic. The Contractor shall not leave a barrier leading-end unprotected.

Delineators shall be installed in conformance with manufacturer's recommendations on the barriers at their termini; at 20-foot (6 m) intervals on tangent sections; and 10 foot (3 m) 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 the left edge. Side mounted delineators shall have amber delineating the left edge, white delineating the right edge and have red as the back color. If mounted on the sides they shall be 6 inches (150 mm) below the top and on the side of traffic. Delineators shall be mounted at angles that provide maximum reflectorization.

Temporary Barriers shall be removed from existing locations and reset in accordance with above requirements, as directed by the Engineer.

850.70 Temporary Restrained Barrier and Temporary Restrained Barrier Removed and Reset.

The Contractor shall ensure that where the restrained barrier is to be pinned to the roadway, the pin holes are filled with a sand mortar mix upon removal of the barrier. If the barrier is to be restrained by setting it into the roadway in a planed slot, the roadway surface shall be restored by appropriate full depth HMA or Cement Concrete roadway reconstruction.

The Contractor shall ensure that where the plans require the restrained barrier to be bolted to the bridge deck, the deck reinforcement will not be damaged during the installation of the proposed barrier anchor bolts. Any damage to the deck reinforcement, which occurs during the course of the Contractor's operations, shall be repaired to the satisfaction of the Engineer at the Contractor's expense.

Impact or percussion drills are allowed if no distress occurs to the existing concrete. Their use is subject to the approval of the Engineer.

If core drilling, the holes may be cored using either a carbide or diamond bit. The diameter of the cored holes shall be in accordance with the recommendations of the resin manufacturer. If a diamond bit is used to core the holes in the proposed deck, a sandblast, high-pressure water blast, or other mechanical means must be used to properly roughen the inner surface of the holes. The type of abrasive surface roughening used shall be approved by the Engineer.

On the concrete deck all holes shall be blown clear of any debris prior to placement of resin. The Contractor shall have the approval of the Engineer signifying that the holes are clean prior to placing the resin adhesive. The Contractor shall strictly follow the recommendations of the manufacturer for mixing and placing the adhesive material prior to the placement of the bolts. The Contractor shall not place adhesive material when the existing concrete temperature is below 40° F (4° C). Any excessive resin adhesive around the hole after placement of the bolt shall be struck off smooth while the resin adhesive is still workable.

The anchor bolt holes shall be repaired as needed by methods acceptable to the Engineer at no additional cost to MassDOT. Damage to the concrete-to-remain shall be repaired to a condition equal to or better than that prior to the beginning of these operations, at no additional cost to the Department.

High strength bolts shall be installed through pockets formed in the barriers and bonded in holes drilled in either the existing or proposed concrete deck. The bolts shall be suitably coated to facilitate removal from the mating threads of the cured resin adhesive once the barriers are no longer needed. The process of removing the bolts shall cause no distress to the proposed deck concrete.

The bolt embedment length and resin adhesive shall be adequate to develop a minimum of 36 Kips of tension in the bolts. The embedment length shall not be less than 6½" in concrete and shall not extend below the bottom of the proposed deck.

Where the condition of the existing deck is unsuitable due to deterioration or insufficient embedment depth, bolts extending through the deck and fastened to an appropriately sized steel member which will provide the required pull strength may be used.

The details of the proposed bolted anchorage system and all installation and removal procedures shall be in accordance with the recommendations of the manufacturer, and shall be submitted to the Engineer for approval.

Field tests shall be performed to verify the effectiveness of the anchorage detail including the drilled hole diameter, embedment length, and the resin adhesive capacity. Two test bolts in both the existing concrete and the new concrete shall be installed and tested by the Contractor for pullout as required by the system manufacturer. If the desired strength is not achieved, the Contractor shall adjust the hole size, embedment length, bolt size, and/or adhesive material to meet this test requirement. Retesting as required by the Engineer shall be performed by the Contractor, at no additional cost to the Department.

All testing shall be performed by the Contractor and is incidental to the work under this item. The method of applying the tension test load to the bolts shall be in accordance with ASTM E488. The testing equipment used and the locations and details of the test bolts shall be submitted to the Engineer for approval. The Contractor shall perform this test as soon as possible in order to eliminate delays in construction due to the approval process. Bolts shall not be ordered until the embedment lengths have been approved.

The delineators shall be single units, with yellow or white lenses on both sides, placed 6" below the top and on the traffic side of the median barrier at 20' on center. The delineators shall be the type designed expressly for this type of attachment and may be made entirely of plastic.

Temporary impact attenuators with delineation shall be installed at ends of barriers within 30 feet (10 m) of approaching traffic. The Contractor shall not leave a barrier leading end unprotected.

Temporary Barriers on Bridge shall be removed from existing locations and reset in accordance with above requirements, as directed by the Engineer.

850.71 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.

850.72 Temporary Impact Attenuators and Temporary Impact Attenuators Removed and Reset.

Excavation for temporary attenuator foundations and anchorage 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 replaced with compacted gravel borrow.

The temporary impact attenuator shall be installed in accordance with the manufacturers' specifications and recommendations. Copies of these specifications and recommendations shall be provided to the Engineer.

Temporary Impact Attenuators damaged by traffic shall be replaced by the Contractor within 24 hours or as directed by the Engineer.

Temporary Impact Attenuators Removed and Reset consists of removing temporary impact attenuators furnished above, relocating and re-installing it at new locations in accordance with the specifications and recommendations of the manufacturer.

850.73 Portable Changeable Message Sign.

The changeable message unit shall be available for immediate use throughout the duration of the project and be positioned in accordance with the Temporary Traffic Control Plan and/or at the direction of the Engineer. The sign shall be visible from a minimum distance of 900 feet (275 m) with a viewing angle of no less than 30 degrees. The Contractor shall take appropriate measures as needed within the roadway layout to provide the required minimum sight distance. The Contractor shall be responsible for the maintenance of each device and appurtenance. If the unit is found to be defective in any way it shall be replaced immediately at the Contractor's expense.

850.74 Truck-Mounted Attenuator.

The truck-mounted attenuator shall be utilized as shown on the plans or as directed by the Engineer, at the proper orientation and height above the paved surface.

A damaged truck-mounted attenuator shall not be used. Any repairs to the attenuator shall be accompanied by a statement from the product manufacturer certifying the repairs that were performed. Any work that becomes delayed due to the lack of a properly functioning truck-mounted attenuator will not constitute justification for an extension of time.

850.75 Temporary Illumination.

All portable lighting shall be located off the travel way. Whenever possible the lighting shall be located on the side of the road opposite the closed lanes.

The contractor shall provide power to adequately energize the lighting equipment specified. Generator placement and wiring shall be in compliance with the Massachusetts Electrical Code and OSHA safety standards.

The Contractor shall furnish to the Engineer a Multi-function digital luminance meter, complete with instructions and capable of measuring from 0.01 to 200 foot candles. The illumination on the project shall be monitored at random intervals for conformance to the specifications set forth herein. Substandard illumination shall be sufficient reason for the Engineer to stop all affected work until the substandard situation is corrected.

COMPENSATION

850.80 Method of Measurement.

Construction Vehicle Warning Devices and Personal Protective Safety Equipment shall be incidental to the work of the Contract and shall not be measured for payment.

Roadway Flagger will be measured on an hourly basis for only the actual time spent flagging. Partial hours shall be measured in ½ hour increments rounded up to the next ½ hour if a portion of that ½ hour is worked.

Traffic Cones for Traffic Management will be measured by the day. Traffic Cones for Traffic Management will be measured for payment only when 50 or more cones are used together in a string, spaced in accordance with the Traffic Control Plan and the MUTCD, for the purpose of closing a traffic lane, shifting traffic, channelizing, or otherwise redirecting traffic. The use of less than 50 cones in a string shall be incidental to the work with no additional compensation. Other uses of traffic cones shall be incidental to the work activity with which the cones are associated. Each period of up to 24 hours during which Traffic Cones for Traffic Management are in place will be measured as one day, regardless of the number of times that the cones are positioned, repositioned, removed or returned to service and regardless of the number of locations at which traffic cones are used. Ballast to weight the cones shall be incidental to the work with no additional compensation.

Safety Signing for Traffic Management will be measured by the square foot (m^2) and the quantity will 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.

Temporary Pavement Markings will be measured by the foot (m) using the procedure outlined for Permanent Pavement Markings in Subsection 860.80.

Temporary Raised Pavement Markers will be measured by the unit each.

Arrow Board will be measured by the day. Each period of up to 24 hours during which an arrow board is in use will be measured as one day, regardless of the number of times that the unit is positioned, repositioned, removed or returned to service.

Reflectorized Drums will be measured by the day. Each period of up to 24 hours during which a reflectorized drum is in use will be measured as one day regardless of the number of times that the drum is positioned, repositioned, removed or returned to service.

Pavement Marking Removal will be measured by the square foot (m^2) of existing pavement marking actually removed.

Raised Pavement Marker Removal will be measured by the unit each.

Temporary Barrier and Temporary Barrier Removed and Reset will be measured by the foot (m), in place. Barrier removed and reset for the purpose of gaining access to the construction work zone shall not be measured for payment. Any barrier removed and reset for the convenience of the Contractor will not be measured for payment.

Temporary Restrained Barrier and Temporary Restrained Barrier Removed and Reset will be measured by the foot (m) in place.

Portable Breakaway Barricade Type III will be measured as one unit each regardless of size.

Temporary Impact Attenuators will be measured as a single unit each.

Temporary Impact Attenuator Removed and Reset will be measured as a single unit each.

Portable Changeable Message Signs will be measured by the day. Each period of up to 24 hours during which a Portable Changeable Message Sign is in place will be measured as one day, regardless of the number of times that the sign is positioned or repositioned, removed or returned to service.

Truck-Mounted Attenuator will be measured by the day which shall include the attenuator, the truck or tow vehicle, the operator or driver, maintenance of the vehicle and components, and arrow board. Each period of up to 24 hours during which a Truck-Mounted Attenuator is in place will be measured as one day, regardless of the number of times that the Truck Mounted Attenuator is positioned, repositioned, removed or returned to service during that period. In either case, the unit and the accompanying truck are considered one unit for measurement and payment purposes.

Temporary Illumination for Work Zone will be measured by the day for each period of up to 24 hours during which temporary illumination is used, regardless of the number of operations requiring lighting, or the number of times that the illumination is positioned, repositioned, removed or returned to service.

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. Devices damaged by traffic will be compensated in accordance with Subsection 7.17 including temporary impact attenuators. This shall not include other temporary traffic control devices, such as cones, drums and temporary signs.

Roadway Flagger will be paid for at the contract unit price per hour which shall include full compensation for all costs for providing flaggers. No allowance or additional payment will be made for required training, equipment, travel time, transportation, or any administrative charges associated with the costs of flaggers. No allowance shall be made for overtime payment rates. The Contractor shall not be charged nor compensated for the use of MassDOT employee flaggers. This item shall not be subject to renegotiation for any reason under Section 4.06 regardless of whether or not this item overruns or underruns.

Traffic Cones for Traffic Management will be paid for at the contract unit price per day which shall provide full compensation for furnishing, positioning, repositioning, and removing traffic cones as directed by the Engineer. A day shall cover all traffic cones for traffic management necessary in that time period, regardless of the total number of cones and regardless of the number of locations at which cones are used. The Contractor will receive the day payment for the period in which the Traffic Cones for Traffic Management are deployed.

Safety Signing for Traffic Management will be paid for at the contract unit price per square foot (m^2) which shall include full compensation for furnishing, installing, maintaining, positioning, repositioning, and removing the signs.

Temporary Pavement Markings will be paid for at the contract unit price per foot (m) which shall include full compensation for furnishing, installing, maintaining and removing, the markings and markers.

Temporary Raised Pavement Markers will be paid for at the contract unit price each which shall include full compensation for furnishing, installing, maintaining and removing, the markings and markers.

Arrow Boards will be paid for at the contract unit price per day which shall include full compensation for furnishing, positioning, repositioning, and removing Arrow Boards as directed by the Engineer.

Reflectorized Drums will be paid for at the contract unit price per day which shall include full compensation for furnishing, positioning, repositioning, and removing Reflectorized Drums as directed by the Engineer. Flashing lights as shown on the Temporary Traffic Control Plan shall be considered incidental to Item 859. Reflectorized Drum.

Pavement Marking Removal will be paid for at the contract unit price per square foot (m^2) which shall provide full compensation for removing existing markings including any necessary repairs to the roadway surface.

Raised Pavement Markers Removal will be paid for at the contract unit price each which shall provide full compensation for removing the existing markers and filling the voids in the pavement.

Temporary Barrier will be paid for at the contract unit price per foot (m) which shall provide full compensation for furnishing, installing, delineating, aligning, maintaining and final removal of the temporary barrier.

Temporary Barrier Removed and Reset will be paid for at the contract unit price per foot (m) which shall provide full compensation for removing, relocating, re-setting, re-aligning, transporting and maintaining the temporary barrier including delineation, as specified above. The Contractor will be paid Removed and Reset each time the barrier is relocated either to a new work zone, to off-season storage, or back to the project from storage. The Contractor will not be separately compensated for any work necessary to maintain or re-align units or replace damaged units. No payment will be made for removing and resetting barriers for the purpose of gaining access to the construction work zone. No payment will be made for removing, relocating and resetting any barriers moved for the convenience of the contractor.

Temporary Restrained Barriers as shown on the plans will be paid for at the contract unit price per foot (m) which shall provide full compensation for furnishing, initial installation, planing operations, delineation, testing, maintaining the temporary barrier and delineation, final removal and transportation of the temporary barriers, restoration of the planed surfaces or pin holes, and shall include all hardware, materials, equipment, and labor necessary to restrain the barriers. The Contractor shall have no claim for extra compensation for any variations in the system due to diameter of the bolt hole, the embedment length, the method of producing the hole, repairing the hole or the type of adhesive used in anchoring the proposed barriers.

Temporary Restrained Barriers Removed and Reset will be paid for at the contract unit price per foot (m) which shall provide full compensation for removing, relocating, re-setting, testing, re-aligning, maintaining the temporary barrier and delineation, and transportation of the temporary barrier including delineation, restoration of the planed surfaces or pin holes, and shall include all hardware, materials, equipment, and labor necessary to restrain the barriers. The Contractor shall have no claim for extra compensation for any variations in the system due to diameter of the bolt hole, the embedment length, the method of producing the hole, repairing the hole or the type of adhesive used in anchoring the proposed barriers. The Contractor shall be paid Remove and Reset each time the barrier is relocated either to a new work zone, to off-season storage, or back to the project from storage.

Portable Breakaway Barricades Type III will be paid for at the contract unit price each which shall provide full compensation for all material, labor and equipment necessary to furnish, install, maintain, move and remove the barricades.

Temporary Impact Attenuators will be paid for at the contract unit price each which shall provide full compensation for furnishing, installing and removing the attenuator, as well as all labor, equipment, materials, foundation and anchorage, and all incidental work necessary to complete the work as specified, and to maintain the attenuator in proper working condition.

Temporary Impact Attenuator Removed and Reset will be paid for at the contract unit price each which shall provide full compensation for installing the attenuator, all labor, equipment, materials, foundation and anchorage, and all incidental work necessary to complete the work as specified.

Gravel Borrow for any foundation and anchorage work for Temporary Impact Attenuators will be paid for at the contract unit price under Item 151. Gravel Borrow.

Portable Changeable Message Signs will be paid for at the contract unit price per day which shall provide full compensation for furnishing, positioning, repositioning, and removing Portable Changeable Message Signs as specified or as directed by the Engineer.

Truck Mounted Attenuator will be paid for at the contract unit price per day which shall provide full compensation for positioning, repositioning, removing or returning to service as required or as directed by the Engineer. The Contractor will receive the day payment for each continuous work period in which the Truck Mounted Attenuator is deployed.

Temporary Illumination for Work Zone will be paid for at the contract unit price per day which shall provide full compensation for all lighting specified for use in lane drops, work areas, and other lighting locations as directed by the Engineer. The work includes the lighting plan, delivery, removal, setting and resetting of all floodlighting equipment, staging or tripods, generators, wiring, the light meter, adjustment, maintenance and any equipment necessary or incidental to the operation of a lighting system.

850.82 Payment Items.

ENGLISH

850.41	Roadway Flagger	Hour
851.1	Traffic Cones for Traffic Management	Day
852.	Safety Signing for Traffic Management	Square Foot
853.1	Portable Breakaway Barricade Type III	Each
853.2	Temporary Barrier (TL-2)	Foot
853.21	Temporary Barrier Removed and Reset	Foot
853.3	Temporary Restrained Barrier	Foot
853.31	Temporary Restrained Barrier Removed and Reset	Foot
853.403	Truck Mounted Attenuator	Day
853.41	Temporary Impact Attenuator for Shoulder, Incapable of Redirection	Each
853.411	Temporary Impact Attenuator for Shoulder, Incapable of Redirection, Remove and Reset	Each
853.42	Temporary Impact Attenuator for Shoulder, Capable of Redirection	Each
853.421	Temporary Impact Attenuator for Shoulder, Capable of Redirection, Removed and Reset	Each
853.43	Temporary Impact Attenuator for Median, Incapable of Redirection	Each
853.431	Temporary Impact Attenuator for Median, Incapable of Redirection, Removed and Reset	Each
853.44	Temporary Impact Attenuator for Median, Capable of Redirection	Each
853.441	Temporary Impact Attenuator for Median, Capable of Redirection, Removed and Reset	Each
853.8	Temporary Illumination for Work Zone	Day
854.	Temporary Raised Pavement Marker	Each
854.016	Temporary Pavement Markings – 6 inch (Painted)	Foot
854.036	Temporary Pavement Markings – 6 inch (Tape)	Foot
854.1	Pavement Marking Removal	Square Foot
854.5	Raised Pavement Marker Removal	Each
856.	Arrow Board	Day
856.12	Portable Changeable Message Sign	Day
859.	Reflectorized Drum	Day
151.	Gravel Borrow	Cubic Yard

METRIC

850.41	Roadway Flagger	Hour
851.1	Traffic Cones for Traffic Management	Day
852.	Safety Signing for Traffic Management	Square Meter
853.1	Portable Breakaway Barricade Type III	Each
853.2	Temporary Barrier (TL-2)	Meter
853.21	Temporary Barrier Removed and Reset	Meter
853.3	Temporary Restrained Barrier	Meter
853.31	Temporary Restrained Barrier Removed and Reset	Meter
853.403	Truck Mounted Attenuator	Day
853.41	Temporary Impact Attenuator for Shoulder, Incapable of Redirection	Each
853.411	Temporary Impact Attenuator for Shoulder, Incapable of Redirection, Remove and Reset	Each
853.42	Temporary Impact Attenuator for Shoulder, Capable of Redirection	Each
853.421	Temporary Impact Attenuator for Shoulder, Capable of Redirection, Removed and Reset	Each
853.43	Temporary Impact Attenuator for Median, Incapable of Redirection	Each
853.431	Temporary Impact Attenuator for Median, Incapable of Redirection, Removed and Reset	Each
853.44	Temporary Impact Attenuator for Median, Capable of Redirection	Each
853.441	Temporary Impact Attenuator for Median, Capable of Redirection, Removed and Reset	Each
853.8	Temporary Illumination for Work Zone	Day
854.	Temporary Raised Pavement Markers	Each
854.016	Temporary Pavement Markings – 150 millimeter (Painted)	Meter
854.036	Temporary Pavement Markings – 150 millimeter (Tape)	Meter
854.1	Pavement Marking Removal	Square Meter
854.5	Raised Pavement Marker Removal	Each
856.	Arrow Board	Day
856.12	Portable Changeable Message Sign	Day
859.	Reflectorized Drum	Day
151.	Gravel Borrow	Cubic Meter

SECTION 860
REFLECTORIZED PAVEMENT MARKINGS

SUBSECTION 860.40 General.

(page 266 English, page II.231 Metric) Delete Thermoplastic Pavement Marking Compound, Alkyd M7.01.20.

(page 266 English) Add the following materials:

Fast Drying White Water-borne Traffic Paint .....M 7.01.23
Fast Drying Yellow Water-borne Traffic Paint .....M 7.01.24

SUBSECTION 860.60 Equipment.
(page 266 English, II.232 Metric) Replace this subsection with the following;

860.60 Equipment.

All equipment used for the application of pavement markings shall be approved by the Engineer and shall be of standard commercial manufacture. All equipment and devices necessary for the protection of the pavement marking and the traveling public shall be approved by the Engineer. The pavement marking equipment shall be operated in accordance with the manufacturer's recommendations.

Truck mounted equipment shall be used 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.

The Contractor shall supply the following equipment for each pavement marking operation;

1) infrared pistol thermometer meeting the requirements of Section 450.42
2) digital thickness gauge for measuring the thickness of thermoplastic lines
3) wet film thickness gauges for painted lines.
4) a retroreflectometer with certification of calibration within the last 6 months.

The above equipment shall remain the property of the Contractor upon completion of the project.

SUBSECTION 860.62 Application of Markings.
(page 267 English, page II.232 Metric) Replace the existing table with the new table and sentence as follows:

Material	Material Application Temperature	Line Thickness above Roadway Surface	Glass Bead Application
M7.01.03 M7.01.04	400º - 425ºF (205º - 220ºC)	125 - 188 mils (3.2 - 4.8 mm)	Drop on 1 pound / 10 Square Feet (0.50 kg/m^2)
M7.01.23 M7.01.24	135º - 150ºF (4º - 50ºC)	15 mils (0.4 mm)	6 pounds/gallon (0.75 kg/l)

Line thickness above the roadway surface shall meet the minimum requirements regardless of the type of surface on which it is applied.

(page 267 English, page II.232 Metric) Add the following after the third paragraph of the Subsection:

Glass beads for water-borne traffic paint and thermoplastic pavement markings shall be applied by the single drop method using AASHTO M247 Type 1 glass beads sprayed or dropped on pavement marking material.

Glass beads for epoxy and polyurea pavement markings shall be both standard gradation beads and large gradation beads. Standard gradation beads shall be applied by the double drop method. Large gradation beads shall be injected into or dropped onto the liquid pavement marking material. Large gradation beads shall be applied first, immediately followed by standard gradation beads. The beads shall adhere to the cured pavement marking material or all pavement marking operations shall cease until corrections are made.

SUBSECTION 860.82 Payment Items.

(page 268 English, page II.234 Metric) Replace this subsection with the following:

860.106	6 Inch Reflectorized White Line (Painted)	Foot
860.112	12 Inch Reflectorized White Line (Painted)	Foot
861.106	6 Inch Reflectorized Yellow Line (Painted)	Foot
861.112	12 Inch Reflectorized Yellow Line (Painted)	Foot
864.	Pavement Arrow Reflectorized White (Painted)	Square Foot
864.01	Pavement Arrow and Legends Reflectorized White - Inlay Tape	Square Foot
864.02	Pavement Arrow and Legends - Tape	Square Foot
864.04	Pavement Arrows and Legends Reflectorized White (Thermoplastic)	Square Foot
866.106	6 Inch Reflectorized White Line (Thermoplastic)	Foot
866.112	12 Inch Reflectorized White Line (Thermoplastic)	Foot
867.106	6 Inch Reflectorized Yellow Line (Thermoplastic)	Foot
867.112	12 Inch Reflectorized Yellow Line (Thermoplastic)	Foot

SECTION 901 CEMENT CONCRETE MASONRY
(page 269 English, page II.235 Metric) Replace this Section with the following:

SECTION 901
CEMENT CONCRETE

901.20 General.

Cement Concrete 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.

Calcium Chloride, or any other admixture containing chloride salts, shall not be used in any Cement Concrete.

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
Silica Fume Modified Cement Concrete M4.06.0
HP Cement Concrete M4.06.1
Reinforcing Steel M8.01.0
Epoxy Coated Reinforcing Bars M8.01.7
Galvanized Reinforcing Bars M8.01.8
Mechanical Reinforcing Bar Splicer M8.01.9
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
Bonded Closed Cell Joint System M9.14.6
Plastic Water Stops M9.07.0
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
Metal Masonry Plate Bearing Pads
- Rubber - Cotton Duck Bearing Pad M9.16.1
- Molded Fabric Bearing Pad M9.16.2

For any project that requires the placement of cement concrete for structural purposes, 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 with plastic covers shall conform to the requirements of AASHTO M 205. The standard concrete cylinder shall be 6 inches in diameter by 12 inches high for regular Cement Concrete. When the nominal maximum size of the coarse aggregate does not exceed 1 inch, 4 inches in diameter by 8 inches high cylinders may be used.
2. One complete set of tools for fabricating concrete cylinders that meet the requirements of AASHTO T 23.
   a. Tamping rod shall be round, straight steel rod with at least the tamping end rounded to a hemispherical tip of the same diameter as the rod. Large rod, 5/8 inch (16 mm) diameter and approximately 2 feet (610 mm) long to prepare 6 inches (150 mm) diameter concrete cylinders; small rod, 3/8 inch (10 mm) diameter and approximately 12 inches (305 mm) long to prepare 4 inches (100 mm) diameter concrete cylinders.
   b. Rubber mallet, shovel, trowel, wood float, metal float, scoop, and wheelbarrow.
3. One complete set of apparatus for measuring the slump of fresh concrete and shall conform to the requirements of AASHTO T 119.
   a. Slump cone.
   b. Tamping rod. A round smooth 5/8 inch (16 mm) steel rod with the tamping end rounded to a hemispherical tip of 5/8 inch (16 mm) diameter. The minimum length shall be 2 feet (610 mm).
   c. Sheet metal pan 2 feet x 2 feet x 3 inches (600 x 600 75 mm).
   d. Cement mold brush, rule, scoop and trowel.
4. One complete set of apparatus for measuring the air content of freshly mixed concrete and shall conform to the requirements of AASHTO T 152.
   a. Air meter (AASHTO T 152, Type B).
   b. Tamping rod. A round smooth 5/8 inch (16 mm) steel rod with the tamping end rounded to a hemispherical tip of 5/8 inch (16 mm) diameter. The minimum length shall be 18 inches (450 mm).
   c. Rubber mallet, scoop, shovel, and a metal straightedge a minimum of 12 inches (300 mm) long.
5. One concrete curing box, equipped with thermostatically controlled cooling and heating device, meeting the moisture and temperature requirements of AASHTO T 23. The box shall be capable of holding a minimum of eighteen 6 x 12 inch (150 x 300 mm) cylinders.
6. Two 4 gallon (15 liter) heavy duty buckets.
7. One complete device for measuring the temperature of freshly mixed concrete. The temperature measuring device shall conform to the requirements of AASHTO T 309.

CONSTRUCTION METHODS

901.60 Footings.

No concrete shall be placed until after the Engineer has approved the depth and dimensions of the excavation, the character of the material and the condition of the foundation. No footing shall be supported partially on rock and partially on soil. The rock shall be excavated as necessary to allow the placement of gravel borrow in accordance with Section 140. The Engineer may direct, in writing, such changes in dimensions or elevations of footings as may be necessary to obtain satisfactory foundations. The Plans will be revised accordingly.

Shallow foundations (i.e., not supported by driven piles, drilled shafts, or other deep foundations) to be constructed under water shall be inspected prior to the placement of tremie concrete by a Diver hired by the Contractor independently and solely for the purpose of the inspection requirements of the Contract. The Diver shall be a Professional Engineer registered in the Commonwealth of Massachusetts.

In general, the Diver's tasks shall include inspection of the excavations for foundations to determine their completeness and suitability for the placement of concrete, inspection of the drilling and grouting operations for any dowels that may be specified, and inspection of the tremie placement operations to insure that the concrete placement is proceeding properly and is completed in accordance with applicable contract documents.

The Diver shall be responsible to report any discrepancies in materials or workmanship to the Engineer. The Diver shall record his/her findings by written and photographic methods and a final report of findings, recommendations and actions taken shall be prepared for the Engineer.

901.61 Forms, Falsework, and Centering.

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 shall be 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 load of the liquid concrete to be 150 pounds per cubic foot (2400 kg/m^3), and in addition thereto a live load allowance of 50 pounds per square foot (2.4 kPa) on horizontal surfaces.

All falsework or centering shall be adequate for the type of construction involved. The Contractor shall submit all shop drawings for falsework and centering, including design computations, formally signed and sealed by the Contractor's Massachusetts registered Professional Engineer.

The Contractor's Professional Engineer shall certify that the falsework system has been assembled and constructed according to the approved falsework drawings, prior to placing loads on such falsework.

When structures are to be constructed over railroad tracks, the centering shall also conform to the requirements of the Railroad Company as to temporary operating clearances, safety and design.

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 any part of a structure that will be at least 2 feet (600 mm) below the surface of adjacent ground in the completed project that will not be coated with bituminous damp-proofing. 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 approved 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 required for form and/or falsework support shall be used in connection with all ties in the region of exposed surfaces on 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 1½ inches (40 mm) to the surface. The inserts shall be truly round, not more than 1½ inches (40 mm) in outside diameter and shall be treated with non-staining 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. All ties and embedded devices required for form and/or falsework support that are to be left in place shall be either epoxy coated or galvanized to match the reinforcement within the concrete placement. Galvanizing of such ties and embedded hardware shall be in accordance with Subsection 960.64.

Form ties of a design with a weakened section 1½ inches (40 mm) 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. Voids and forming accessory holes shall be patched as necessary to match the surrounding texture and color to produce a uniform appearance.

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 construed 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 or 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 ¾ inch (20 mm) on the square 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 concrete specified on the plans of larger size shall be formed and finished as required for other parts of the adjacent forms.

Surfaces of the abutments and wingwalls that are designated to receive striation texturing shall be cast using one of the following fractured fin form liner patterns:

1. GREENSTREAK Architectural Form Liners, pattern number 367, as manufactured by GREENSTREAK, 3400 Tree Court Industrial Blvd., St. Louis, MO 63122
2. SYMONS Form Liner, P/C 30492 pattern, as manufactured by SYMONS Corporation, Des Plaines, IL 60018
3. LITHOTEX Form Liner, T33050 texture, as manufacture by L.M. SCOFIELD Co., Los Angeles, CA 90040
4. An equal fractured fin form liner approved by the Engineer that meets the dimensions as shown on the Plans.

The same form liner pattern must be used exclusively for all textured surfaces on the job. Using form liners of different manufacturers together on the same job will not be permitted. Form liners shall be installed to the limits as shown on the Plans. The Contractor shall ensure that the striation fins are plumb. Horizontal joints are not allowed in the form liner.

Form liners shall be used and installed in accordance with the manufacturer's written instructions and recommendations. Additional job site training in the proper use of the form liner shall be provided by an authorized manufacturer's representative at no additional cost to the project. A test panel with a minimum size of 4 x 4 feet (1.2 x 1.2 meters) shall be erected at the job site for establishing acceptance criteria for the finished surface.

Bridge bearing anchor bolts in piers shall be set accurately by a template prior to placing concrete. Anchor bolts in abutments may be set by a template or by drilling and grouting. Grout shall be a non-shrinking type approved by the Engineer.

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 that 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 that 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 preceding 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 the column and wall forms and near the bottom of all deep members.

The foregoing specifications for forms as regards to 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 diaphragms, 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 forms:

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 (2.4 kPa) 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 (250 MPa).

2. Deflection under the load of the forms, the plastic concrete and reinforcement shall not exceed 1/180 of the form span or ½ inch (13 mm) whichever is less. In no case shall this design loading be less than 120 pounds per square foot (5.75 kPa) total.

The permissible 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 (50 mm) 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. Longitudinal reinforcement shall have minimum concrete cover, as measured from the permanent steel deck form, of 1 inch (25 mm). Main reinforcement shall have minimum concrete cover, as measured from the permanent steel deck form, of 1½ inches (38 mm).

6. The plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete 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. Fabricator's shop and erection drawings shall be submitted to the Engineer for approval. These plans shall indicate the grade of steel 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 (25 mm) 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 permissible welds, bolts, or 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 D1.3 pertaining to fillet welds except that 1/8 inch (3 mm) fillet welds will be permitted.

Any permanently exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned and painted with galvanizing repair paint in accordance with Subsection 960.64 of the Standards. 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 at no additional cost to the project. 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 at no additional cost to the project 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 at no additional cost to the project 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 through the slabs.

The Contractor shall provide all facilities as are reasonably required for the safe and convenient conduct of the Engineer's inspection procedure.

901.62 Reinforcement.

The Contractor shall submit for approval detailed shop drawings and schedules of the reinforcing bars so that the reinforcement may be properly placed and its mass readily computed.

Coated bars shall be either epoxy coated or galvanized, as specified on the plans. Where coated bars are called for without distinction, they may be either epoxy coated bars or galvanized bars, however mixing epoxy coated and galvanized bars will not be permitted. Where coated bars are used in combination with uncoated bars in a reinforcing mat or cage and the coated bars will touch or be tied to uncoated bars with wire ties, only epoxy coated bars shall be used.

All support devices and ties for galvanized bars used in deck reinforcing shall be coated so that there is no electrical continuity either between reinforcing mats or between the reinforcing and the stay-in-place forms or steel beams.

All support devices and ties for epoxy coated bars used in deck reinforcing shall be either epoxy coated or coated with a plastic material compatible with the coating of the reinforcement.

All coated and un-coated reinforcing bars shall be stored above the surface of the ground on platforms, skids, or other supports and shall be protected from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcing bars shall be free from dirt, loose rust or scale, mortar, paint, grease, oil, or other non-metallic coatings that reduce bond. Reinforcing bars shall be free from injurious defects such as cracks and laminations. Any injurious defects of the epoxy coating shall be repaired and allowed to cure completely prior to concrete placement.

Epoxy coated reinforcing bars shall be coated in a certified epoxy coating applicator plant in accordance with the Concrete Reinforcing Steel Institute's Voluntary Certification Program for Fusion-Bonded Epoxy Coated Applicator Plants. Epoxy coated reinforcing steel shall be handled and stored by methods that will not damage the epoxy coating. All systems for handling epoxy coated reinforcing bars shall have adequately padded contact areas. All bundling bands shall be padded and all bundles shall be lifted with a strong back, multiple supports, or platform bridge so as to prevent bar to bar abrasion from sags in the bundle. Bars or bundles shall not be dropped or dragged. Epoxy coated reinforcing bars shall be stored on wooden or padded supports.

Epoxy coated reinforcing steel shall be protected from sunlight, salt spray, and exposure to the weather. Provisions shall be made for continuous air circulation around the coated reinforcing to minimize condensation under the protective covering.

If it is impractical to obtain or use bars of the full length required, the bars shall be lapped for the length shown on the plans or joined with mechanical splicers. If no lap length is provided, the lap length shall be calculated for the type of bar used according to the latest AASHTO Standard Specifications for Highway Bridges for a Class C tension lap splice.

If mechanical splicers are used proper consideration shall be given to the installation sequence and shall be so noted on the reinforcing steel shop drawings. The mechanical splicing system shall be assembled in accordance with the manufacturer's recommendations.

Reinforcement bars to be spliced mechanically shall be marked using indelible ink prior to splice attachment to ensure sufficient embedment in the splicing device. Assembly features shall provide for reasonably error free work under construction conditions. Mechanical reinforcing bar splicers shall be staggered in accordance with the Plans.

The entire splice area of epoxy coated mechanical splicing systems shall be painted with a compatible approved epoxy repair coating after the system is assembled. The entire splice area of galvanized splicing systems shall be painted with a compatible approved galvanizing repair coating after the system is assembled. For mechanical splicer systems that cannot be effectively sealed with an epoxy or galvanizing repair coating, an approved heat shrink tube/sleeving shall be required after installation to seal the system. The mechanical splicer shall not be encased in concrete until the visual inspection and the required testing have been completed and approved by the Engineer.

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 face of bar) ± ¼ inch (5 mm).
2. Horizontal spacing of bars ± 2 inches (50 mm) (however the required number of bars must be placed). The minimum spacing cannot be decreased. The reinforcement shall be placed so as to ensure it remains in the correct position during the placing and hardening of the concrete. The clear distance between spliced bars and/or splicing devices shall not be less than 1-1/2 times the nominal diameter of the bars, 1-1/2 times the maximum size of the coarse aggregate, nor less than 1½ inches (40 mm).

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 4 feet (1.2 m).

Steel reinforcing mats shall be firmly secured against displacement by tying every other intersection point with a maximum of 12 inches (300 mm) 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 between the top and bottom mats of reinforcement shall be placed no farther apart than 4 feet (1.2 m). on center. 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, except for those placed in bridge decks, 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 (75 mm) of an exposed surface of the concrete shall be made of either non-rusting metal, or shall be epoxy coated or galvanized to match the reinforcement. Galvanizing of such parts shall be in accordance with Subsection 960.64. 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 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/her 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 substructure 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.

901.63 Handling and Placing Concrete.

The Contractor shall notify the Engineer at least 24 hours in advance of his/her intention to place concrete in order to provide ample time for inspection of forms, reinforcement, materials, and equipment.

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. 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 placement and consolidation of the concrete shall be conducted so as to not cause segregation of materials nor displacement of reinforcement and shall result in a dense homogeneous concrete that is free of voids.

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.

A. Transportation.

The concrete shall be transported from the mixer and placed in the forms by a method that 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 constructed of aluminum free metal or metal lined and shall extend as nearly as possible to the point of concrete placement. 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. Concrete shall not be permitted to be transported through chutes or pipes composed of aluminum.

Transportation of concrete by pumping will be permitted provided that the required slump or air content can be maintained at the discharge end of the hose and there is no adverse effect to the mix design. Concrete shall be sampled and tested at the end of the chute or if pumping is allowed, from the discharge end of the hose. 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 that there will be no separation of the ingredients.

Pumping through aluminum pipes will not be permitted.

All pipes and chutes shall be kept clean and free from coatings of hardened concrete.

B. Depositing.

The concrete shall be placed in the form in the approved manner to prevent stone pockets, voids or segregation and to reduce handling and flowing in the forms to a minimum. The concrete shall not be dropped more than 3 feet (1m) or dragged more than 10 feet (3m) in the forms. Vibrators shall not be used to transport concrete. Epoxy coated steel reinforcement shall be protected from damage from dropping concrete by limiting the maximum height of concrete drop to 2 feet (600 mm). Points of deposit shall be spaced not more than 20 feet (6 m) apart nor more than 10 feet (3m) 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 (300 mm to 1 m) in depth per hour. 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 structures 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 within the concrete at frequencies of not less than 5500 vibrations per minute nor more than 13500 vibrations per minute. Epoxy coated steel reinforcement shall be protected from damage from exposed steel headed immersion-type vibrators. Immersion-type vibrators used to consolidate concrete that is reinforced with epoxy coated reinforcement shall feature heads covered with rubber or other resilient non-metallic material approved for concrete consolidation.

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 concrete mass at the point and time of deposit and shall be moved throughout the mass continuously from point to point for a sufficient duration to accomplish thorough consolidation. The duration of vibration shall not be prolonged to the point where segregation, serious loss of entrained air, or excessive water bleeding occurs. 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 as 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 that 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 designation 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 has begun.

Concrete deposited under water shall be carefully placed by the tremie method in a compound mass in its final position and shall not be disturbed 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 with sufficient rapidity to prevent the formation of layers or inclined seams. Concrete shall not be placed in water having a temperature below 2°C (35°F). Pumping of water will not be permitted while the concrete is being deposited nor before it is sufficiently hardened.

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 (6m) on centers or 10 feet (3m) from the forms. Tremie tubes shall not be moved horizontally or the seal purposely broken once placing of concrete has started.

The radius of influence of a tremie shall not be assumed to exceed 10 feet (3m). The means of supporting the tremie shall be as 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 pounds per square inch (8.5 MPa).

All laitance and scale shall be removed so that sound, durable concrete is exposed to the area on which the construction is to be based and shall be leveled off with epoxy bonded concrete or mortar.

E. Concrete Exposed to Sea Water.

Concrete structures so located as to be subjected to the action of sea water shall be constructed in a manner to provide a maximum resistance to its disintegrating action.

The concrete shall conform to Subsection M4.06.1. 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/her 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 for at least 30 days after placement.

901.64 Protection from Adverse Weather.

Suitable precautions shall be taken to thoroughly protect the concrete from any damage by adverse weather conditions during and after placement.

A. Hot and Dry Weather Requirements.

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. During concrete placement operations in hot weather, appropriate measures shall be taken to reduce the hazards of increased rate of cement hydration, flash set, loss of water due to evaporation, high concrete ingredient temperatures, and the increased difficulty of concrete placing and finishing. The following requirements shall be met during concrete placement operations in hot weather:

1. Concrete Temperature. The temperature of the concrete at the point of discharge shall not exceed 90°F (32°C).

2. Cooling Materials. The Contractor may reduce the temperature of the concrete by cooling one or more of several ingredients. The aggregates may be cooled by fogging, or other suitable means that will not result in a high variation of moisture content within the stockpile. Chipped or crushed ice may be used in the mix as a portion of the mixing water on a pound for pound basis, provided such measure is determined at the time it is placed in the mix. If used, all ice shall be melted before the batch is discharged from the mixing unit. Water may also be cooled by refrigeration or other means that provide a uniform mixing water temperature.

3. Concrete Placing. Immediately before the concrete is placed, the forms and reinforcement steel shall be cooled by spraying with water. In no case shall there be any standing water in the concrete forms as a result of the spraying procedures. The Contractor shall have sufficient skilled men and adequate equipment to place the concrete without delays which may cause excessive slump loss and evaporation due to over-mixing or exposure before it is placed.

4. Finishing. To prevent shrinkage cracking resulting from moisture loss, the Contractor may be required to furnish windscreens, to use water fogging, or other approved means of supplying moisture. If the use of windscreens is required, the windscreens shall consist of canvas barriers of suitable height erected on the windward side of the concrete placement. Finishing operations shall follow as closely as practicable behind the placing operation so that curing may begin as soon as possible.

B. Rainy Weather Requirements.

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.

C. Cold Weather Requirements.

Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 40°F (5°C) or the ambient temperature at the site drops below 50°F (10°C) for a period of 12 hours or more. Any concrete placed during cold weather shall be placed at the Contractor's risk and any damage or unsatisfactory concrete shall be removed and replaced at the Contractor's expense. When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement, the Contractor shall include as part of their Placement and Curing Plan detailed procedures for the production, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. The Contractor shall include verifiable evidence of satisfactory results obtained by use of his/her proposed methods. Procedures for accommodating abrupt changes in weather conditions shall be included. Placement of concrete shall not commence until the plan is accepted by the Engineer. Acceptance of the plan will take at least one day. All material and equipment required for cold weather placement and curing protection shall be available at the project site before commencing concrete placement. All snow, ice, and frost shall be removed from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. The temperature of any surface that will come into contact with fresh concrete shall be at least 35°F (2°C) and shall be maintained at a temperature of 35°F (2°C) or above during the placement of concrete.

During the curing period, the Contractor shall provide suitable measures to maintain the concrete surface temperature which shall be monitored by continuously recording surface temperature measuring devices that are accurate within 1.8°F (1°C). One temperature measuring device shall be required to be randomly placed in an accessible location for every 1,500 square feet (140 m^2) of concrete surface area being cured.

SECTION 901. (continued)

The minimum concrete surface temperature requirements indicated in the Table below shall be continuously maintained for a curing period of at least 7 days. The 7 day minimum curing period of time will be extended when necessary to develop satisfactory strength in the concrete.

Any day during which the minimum concrete surface temperature requirement is not continuously maintained shall not count as a day contributing to the curing period.

Cold Weather Concrete Surface Temperature Requirements				
	Minimum Section Size Dimension			
	Under 1 foot (Under 305 mm)	1 – 3 feet (305 – 915 mm)	Over 3 up to 6 feet. (Over 915 mm up to 1.830 m)	Over 6 feet (Over 1.830 m)
Minimum temperature of concrete during curing period	57°F (14°C)	54°F (12°C(	50°F (10°C)	50°F (10°C)
Maximum allowable temperature drop in any 24-hour period after end of curing	50°F (28°C)	40°F (22°C)	30°F (16°C)	20°F (11°C)

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 (20°C) nor more than 140°F (60°C). The temperature of the concrete shall not be less than 60°F (15°C) nor more than 90°F (30°C) at the time of placing it in the forms. The heating shall be done in a manner to preclude the occurrence of overheated areas that might result in damage to the materials. Any material containing frost or lumps of hardened material shall not be used.

Insulation shall be approved blanket, batt or board insulation with a thermal conductivity of less than 0.25 BTU per hour per square foot (0.8 W/m^2) for a thermal gradient of 1°F/inch (0.02°C/mm). Insulation shall be applied to the forms in an approved manner. Insulation with breaks or tears shall be rejected unless satisfactorily repaired. Openings for thermometers shall be provided where ordered.

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 concrete temperature of 70°F (20°C) where protection is provided by the surrounding earth, except on top, shall be protected by a tarpaulin placed over the top with an air space between the concrete and the tarpaulin and sufficient added artificial heat shall be provided to maintain the minimum required concrete surface temperature. Mass concrete, when concrete as such is so specified on the plans or so defined by the Engineer, placed at a concrete temperature of 70°F (20°C), shall be protected by enclosure with tight wooden forms at least 5/8 inch (16 mm) in thickness except at corners and edges and sufficient added artificial heat shall be provided to maintain the minimum required concrete surface temperature. Double sheathing, insulation board or tarpaulins with a dead air space between the covering and the forms shall be placed to equally protect such corners and edges. Supplemental enclosures and added artificial heat will be utilized when required to maintain the minimum concrete surface temperature.

As much as possible, 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. 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 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 drying out or other injury due to excessive temperatures.

901.65 Finishing and Curing.

The requirements of this subsection shall be considered applicable to all concrete placements with the exception of bridge deck, bridge sidewalk, bridge safety curb, and bridge median concrete placements. Refer to the requirements specified under Subsection 901.66 for bridge deck, bridge sidewalk, bridge safety curb, and bridge median concrete placements.

A. 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, air pockets, and honeycombing. The use of mortar, cement water mixture, or neat cement for plastering over any concrete surface will not be permitted.

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 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 with 48 hours of notification that rubbing is required, the surface should 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 or marking between form panels.

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 kept wet with clean water for a period of 5 days.

No rubbing will be permitted when the air temperature is below 5°C (40°F).

3. Preparation of Bridge Seat Bearing Areas.

(a) *General.* Bridge seat bearing areas shall be considered to be those areas of the concrete bridge seats of the abutments, piers, and pedestals that support the bridge bearing devices. The limits of the bridge seat bearing area shall extend 3 inches (75 mm) outside of the perimeter of the bearing device component that is in contact with the bridge seat.

Bearing devices shall not be placed upon bridge seat bearing areas that are improperly finished, deformed or irregular. Bearing devices shall be set to the required grade in the exact positions called for on the plans and shall have full and even bearing upon the bridge seat cement concrete. Satisfactory drainage shall be provided as called for on the plans and where necessary to prevent water accumulation at the bridge seat bearing areas.

(b) *Bearing device installations for adjacent precast concrete deck beam bridges with spans 50 feet (15m) or less.* The bridge seat concrete as cast shall be finished to the exact final required elevation and to the roadway profile grade slope in the direction parallel to the centerline of construction and to the cross slope set by the bridge seat elevations in the direction parallel to the centerline of bearings.

(c) *For all other bearing device installations.* The surface of the concrete within the limits of the bridge seat bearing area shall be cast a minimum of ¼ inches (5 mm) higher than the required finished elevation. This additional concrete shall be cast monolithically with the rest of the bridge seat concrete and shall be sound and free of voids and laitance. After the concrete has been cured and thoroughly hardened, these areas shall be machine dressed down using approved methods to provide a true even surface at the following elevations and grades:

(1) *Elevations:* For bearing devices where the elastomeric bearing pad is placed directly onto the as-finished bridge seat concrete surface, the surface of the bridge seat bearing area shall be dressed down to the exact final required elevation.

For bearing devices that utilize a metal masonry plate, the metal masonry plate shall be set on a system of either rubber-cotton duck bearing pads or molded fabric bearing pads and the surface of the concrete shall be dressed down sufficiently below the required finished elevation so that the rubber-cotton duck or molded fabric bearing pad will bring the bottom of the masonry plate to the exact final required elevation.

(2) *Grades:* The bridge seat bearing areas shall be finished level, except that the bridge seat bearing area for adjacent prestressed concrete deck and box beams shall be finished level in the direction parallel to the centerline of construction and shall be finished to follow the cross slope set by the bridge seat elevations in the direction parallel to the centerline of bearings.

4. Bridge Approach Slabs.

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 furnished 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 straightedge, not less than 10 feet (3 m) in length, furnished by the Contractor, as the Engineer may direct. Any irregularities, measuring more than ¼ inch (5 mm) 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 then required shall be performed from approved bridges furnished by the Contractor, which will not rest on the new concrete in any manner.

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 7 days after placing 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 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. Mass Cement Concrete.

Cement concrete placements where all volumetric dimensions of the placement are 4 feet (1.2 m) or greater shall be considered mass cement concrete. Mass cement concrete shall also include cement concrete placements of other dimensions where measures must be taken to mitigate potential cracking caused by heat of hydration when such placements are specifically designated as mass cement concrete on the plans. The Contractor shall perform the following to prevent cracking in mass cement concrete placements:

- Limit the temperature differential between the internal (hottest) and external (coolest) temperature of the cement concrete to 38°F (21°C) and limit the maximum concrete temperature to 154°F (68°C). Heat control shall be accomplished through a combination of proper cement concrete ingredient selection to minimize heat generated, pre-placement cement concrete ingredient cooling, post-placement cooling, cement concrete placement rate control, cement concrete surface insulation to minimize heat loss, and providing supplemental heat to prevent heat loss.
- Submit for review and approval by the Engineer at least 30 days prior to the date of intended cement concrete placement, along with each mix design, a cement concrete heat of hydration analysis and a detailed plan indicating how temperature differential restrictions for mass cement concrete are to be achieved, methods of observing and recording cement concrete temperatures, and methods of applying immediate corrective action should the temperature differential approach 38°F (21°C) so as to limit the temperature differential to 38°F (21°C).

- Measure and record concrete and ambient air temperatures on an hourly basis. Install 2 sets of 3 temperature sensors (thermocouples) prior to placement of concrete. Thermocouples shall be installed so that one is located 2 inches (50 mm) from the top of flat placements or side of vertical placements, one is located 2 inches (50 mm) from the bottom of flat placements or other side of vertical placements, and the third is located midway between the first and second thermocouples. The thermocouples shall be aligned vertically for flat placements or aligned horizontally for vertical placements. For flat placements, one thermocouple set shall be placed in the center of the plan location of the placement and the second set shall be placed in the plan center of one of the quadrants. For vertical placements, one sensor set shall be located at the mid-height of the placement and the other sensor set shall be located at a quarter point. An additional thermocouple shall be placed in a sheltered area that is out of direct sunlight, is protected from weather, and shall be used to monitor the air temperature.

The thermocouples shall operate in a minimum temperature range of -22 - 212°F (-30 to 100°C) with an accuracy of 1.8°F (1°C). The Contractor shall furnish a temperature logger that records the temperatures automatically at intervals not to exceed once per hour, performs digital temperature storage, and prints temperature data to a paper tape. The thermocouples shall be connected to the recording device using Teflon-sheathed wire or shall use wireless technology. The measuring tips of the thermocouples shall be located as far away from the reinforcing steel as is practical. The thermocouple tips shall be supported with wood or plastic dowels. Thermocouple wire, if used, shall be tied to reinforcing steel bars with plastic zip ties. The thermocouple wire, if used, shall be protected from abrasion and concrete tools by securing the wire to the undersides of reinforcing steel. Temperature data shall be furnished to the Engineer as required, with a minimum frequency of once per day.

2. Water Curing.

Curing of concrete shall begin by fog spraying immediately upon the disappearance of free bleed water on concrete surfaces not protected by forms. 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 weighed down, but not directly in contact with the 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 placed as soon after concrete finishing as the Engineer determines will not cause damage to the concrete surface. However, in no case will the foregoing time period exceed 1 hour after placing of concrete. Fog spray or covers shall be used continuously during this period. The burlap shall be completely saturated over its entire area by being submerged in water for at least 8 hours before the scheduled start of the placement. The burlap shall be drained of excess water prior to application. The burlap shall be free from cuts, tears, uneven weaving and contaminants. The burlap shall be placed such that the edges are lapped a minimum of 6 inches (150 mm). Burlap shall be kept continuously wet and protected from displacement for the entire curing period in a manner acceptable to the Engineer.

The materials for the coverings shall conform to the pertinent requirements for the same provided under Subsection M9.06.03. 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 thoroughly 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.

3. Impervious Liquid Membrane Curing.

Immediately after the free bleed 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 application 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 M 148, Type I shall be permitted.

The membrane curing shall be applied in one or more separate coats at the rate recommended by the manufacturer. 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 (600 mm) away from the concrete surface 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 the 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.

4. 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 476.71, except that the length of time for the curing period shall be as specified herein.

b. Other methods of curing may be used only when approved in writing by the Engineer prior to any use in the work.

901.66 Placement, Finishing and Curing of Concrete Bridge Decks.

This work shall consist of the placement of concrete bridge decks by using self-propelled finishing machines, all as indicated on the Plans and in accordance with these Specifications.

A. Placement and Curing Plan Submission Requirements.

At least 30 calendar days prior to the proposed start of placing the concrete bridge deck, the Contractor shall submit to the Engineer for approval, a submission (herein called the Placement and Curing Plan) specifying the method of concrete conveyance, placement, type and number of finishing machines and work bridges, rate of pour, estimated time of completion, screed and rail erection plan, sequence of concrete pours, and the concrete curing procedure. The Placement and Curing Plan shall take into consideration weather conditions. It shall also include details and a complete description of equipment to be used in the handling, placement, finishing and curing the concrete including the number and type of personnel who will be engaged in the operation. The personnel shall consist exclusively of persons with the experience and skill appropriate to their working assignment. Approval of this plan will not relieve the Contractor of the responsibility for the satisfactory performance of his/her methods and equipment. The Placement and Curing Plan shall include, but not be limited to, the following:

1. Proof of the following minimum operator qualifications for the bridge deck finishing machine(s):
   a. Five years experience operating machines or similar type and manufacturer as that proposed.
   b. Proof of no less than five bridge decks of similar size, placed using a machine of the same manufacturer as that proposed.
   or, as a substitute for a. and b.:
   c. A representative of the manufacturer of the bridge deck finishing machine shall be present on the site a minimum of 24 hours in advance of the proposed deck placement to approve the set up of the machine and rail system, and the representative shall be present for the entire duration of the placement of the deck concrete using the bridge deck finishing machine.
2. Curing method.
3. Provisions for enclosures, indicating method of holding down enclosure safely in place.
4. When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement, the Contractor shall include detailed procedures for the production, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather, including a plan of heating devices, types and locations around structure.
5. Method of monitoring temperature of hardened concrete.
6. Backup systems as required.

Before concrete placement operations begin, the Contractor shall make all necessary arrangements and have all materials on hand for curing and protecting the concrete deck. Concrete placement shall not proceed until the Engineer is satisfied that all necessary steps have been taken to insure adequate compliance with these Specifications and that completion of the operation can be accomplished within the required scheduled time. It shall be the Contractor's responsibility to allow sufficient time to permit such an inspection by the Engineer.

B. Limitations on Placement.

In addition to the requirements contained herein, all weather and concrete temperature requirements contained in Subsection 901.64 shall be satisfied. When placing concrete, the Contractor must provide suitable equipment and take appropriate actions as approved by the Engineer to limit the evaporation rate of the exposed concrete surface to less than 0.15 lb/ft^2/hr (0.75 kg/m^2/hr). The deck surface evaporation rate shall be determined in accordance with Figure 1 of these Specifications (obtained from "Plastic Cracking of Concrete" by Delmar Bloem for the National Ready Mixed Concrete Association and published in ACI 305R-89). To maintain the deck surface evaporation rate below 0.15 lb/ft^2/hr (0.75 kg/m^2/hr) the Contractor shall take one or more of the following actions:

1. Misting the surface of the concrete with a triple head nozzle immediately behind the finishing machine and until the curing cover is applied. The nozzle shall be rated at 1 gallon per minute (4 l/min) or less and shall produce a fine fog mist that will maintain a sheen of moisture on the concrete surface without ponding.
2. Construct windscreens or enclosures to effectively reduce the wind velocity throughout the area of placement. If the use of windscreens is required, the windscreens shall consist of canvas barriers of suitable height erected on the windward side of the concrete placement.
3. Reduce the temperature of the concrete.

C. Placement.

Concrete placement shall take place during daylight and shall not begin unless the Contractor is certain that the placement can be completed and finished, to the satisfaction of the Engineer, during daylight hours. The Engineer may waive this requirement if adequate and approved lighting facilities are provided by the Contractor prior to the start of the deck placement. Before concrete placement operations begin substantial bulkheads or headers shall be shaped to the required deck surface cross-section. In the event of unforeseen circumstances should the concrete placement be forced to cease, sufficient bulkheads shall be installed at locations determined by the Engineer and the concrete placement shall be discontinued. All concrete in place beyond the bulkhead shall be removed. Concrete placement will recommence only with the approval of the Engineer. The concrete shall be placed as a monolithic unit in a continuous operation between joints. A minimum rate of placement of 35 cubic yards per hour (27 m^3/hr) shall be maintained at each finishing machine.

D. Consolidation.

The concrete shall be consolidated by means of approved high frequency internal vibrators (9000 – 13500 vibrations per minute in concrete) that shall be applied in a manner to secure maximum consolidation of the concrete and by means of surface vibration from the vibrating pan(s) of the finishing machine. Consolidation shall leave the concrete free from voids and insure a dense surface texture, but not be continued so long as to cause segregation or bleeding. A small uniform quantity of concrete shall be maintained ahead of the screed on each pass. At no time shall the quantity of concrete carried ahead of the screed be so great as to cause slipping or lifting.

In the case where the vibratory action of the finishing machine does not provide consolidation in accordance with the rate of placement, the Contractor shall have in reserve at all times sufficient vibration equipment to guard against shutdown of the work. The Contractor shall take preventive measures to insure that the epoxy coated reinforcement is not susceptible to damage by the vibrators.

E. Finishing.

1. General.

Methods, procedures, and equipment shall be used which will insure a uniform riding surface without over-vibration or segregation of the components of the concrete. The leading edge of freshly placed concrete shall at all times be maintained approximately parallel to the finishing machine.

The weight of the finishing machine(s) shall not cause unaccounted deflection of the bridge members or falsework. The machine shall travel on steel rails, pipe or other approved grade control, which shall be supported by vertical supports securely fastened in place at a maximum spacing of 2 feet (200 mm) to prevent any appreciable deflection between rail supports. Screed rail supports may be located inside or outside of the placement width. Prior to placing the concrete, screed rails shall be completely in place, and accurately set to insure finishing of the concrete deck surface to the elevations shown on the Plans. The supports for the rails, if embedded in the deck concrete, shall be of the type that can be removed without disturbing the concrete.

Screed rails shall be set entirely above the finished surface of the concrete and shall be supported in a manner approved by the Engineer. Where stud type shear connectors are available, welding to the studs will be permitted. Where no studs are available, other means of attaching the screed rail supports shall be provided. No welding will be permitted directly on stringer or girder flanges or cover plates in tension areas, nor in areas subject to stress reversal, for attaching either screed rail supports of any type. Any welding in compression areas shall be approved by the Engineer.

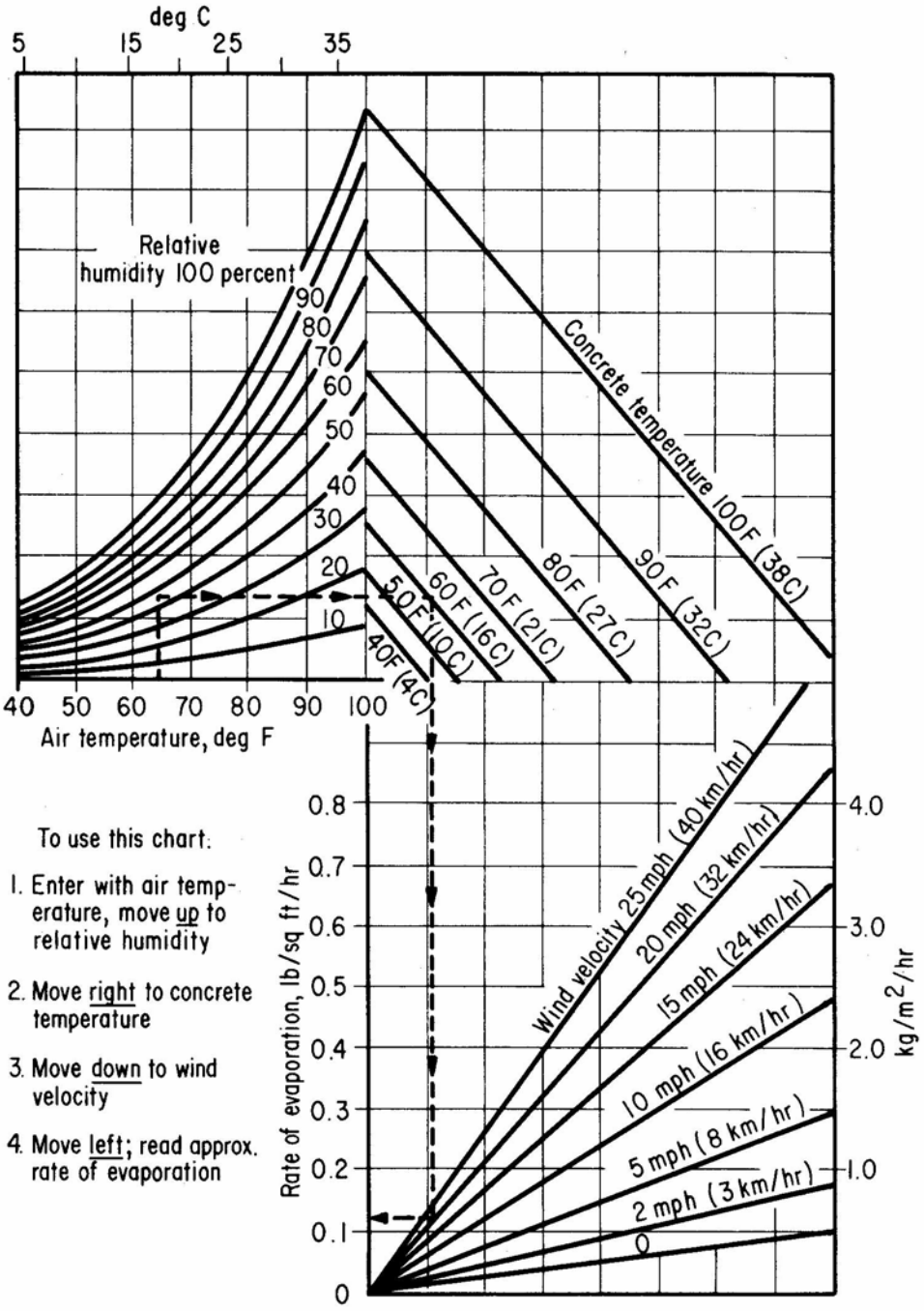

FIGURE 1

Screed rail supports set in the concrete shall be so designed that they may be removed to at least 2 inches (50 mm) below the surface of the concrete. Voids created by removal of the upper part of the screed rail supports shall be filled with mortar having the same proportions of sand and cement as that of the slab or wearing surface. The mortar shall contain an approved additive in sufficient proportions to produce non-shrink or slightly expansive characteristics. Screed rail supports shall not be treated with parting compound to facilitate their removal. Rails for finishing machines shall extend beyond both ends of the scheduled length for concrete placement. The extended length shall be of sufficient distance to allow finishing machine(s) to clear the concrete to be placed.

2. Finishing Machine - Placement Widths Less Than Or Equal To 4.5 Meters (15 Feet) or Bridge Lengths Less Than Or Equal To 15 Meters (50 Feet).

For concrete deck placements specified to be less than or equal to 15 feet (4.5 m) in width, or less than or equal to 50 feet (15 m) in total bridge length, the finishing machine shall be a lightweight vibrating screed with the following features:

a. It shall be portable and easily moved, relocated, or adjusted by no more than four persons.

b. The power unit shall be operable without disturbing the screeded concrete.

c. It shall be self-propelled with controls, that will allow a uniform rate of travel and by which the rate of travel can be increased, decreased, or stopped.

d. It shall have controlled, uniform, variable frequency vibration, end to end.

e. It shall be fully adjustable for flats, crowns, or valleys.

f. The screed length shall be adjustable to accommodate the available work area.

The finishing machine shall be operated over the full length of the bridge segment to be finished prior to beginning of concrete placement operations. The test run of the self-propelled finishing machine shall be performed in the presence of the Engineer at least 24 hours in advance of the concrete placement with the screed adjusted to its finishing position. During the test run, checks shall be made of the deflection due to the finishing machine, adjustment of guide rails and required covers for slab reinforcement. The required concrete cover over the top bars shall be checked by riding the screed over the bars and measuring the cover over the slab reinforcement. Discrepancies so found, which are in excess of the tolerances shall be rectified to secure the required concrete cover. All necessary corrections shall be made before concrete placement is begun.

The rate of concrete placement shall be coordinated with the initial strike-off so that the initial strike-off is never more than 10 feet (3m) behind the concrete placement.

Sufficient depth checks shall be made behind the machine(s) and along the full length of the span to insure achievement of the required section and reinforcement cover.

Improper adjustment or operation of the finishing machine(s) that results in inadequate reinforcement cover or smoothness shall be corrected immediately. Unsatisfactory performance, particularly with respect to the surface smoothness attained, shall be cause for rejection of the equipment and cement concrete placed.

3. Finishing Machine - Placement Widths Greater Than 15 Feet (4.5 Meters) And Bridge Lengths Greater Than 15 Meters (50 Feet).

An approved bridge deck finishing machine(s) complying with the following requirements shall be used for consolidating, striking off, and finishing the concrete deck surface for concrete placements greater than 15 feet (4.5 m) in width and bridge lengths greater than 50 feet (15 m). The finishing machine(s) shall have the necessary adjustments, built in by the manufacturer, to produce the required profile grade, cross-section, and surface smoothness. The supporting frame shall span the section being cast in a transverse direction without intermediate support. The finishing machine(s) 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. The screed device shall be provided with positive control of the vertical position.

The finishing machine(s) shall be self-propelled with two or more rotating cylinder screeds. The rotating cylinder screeds shall rotate in a transverse direction while also traveling in the same direction and shall be operated transversely in overlapping strips in the longitudinal direction not to exceed 6 inches (150 mm). One or more powered augers shall be operated in advance of the screed(s) and a drag (pan type) float shall follow the screed(s). The surface of bridge decks that are to be left exposed without bituminous or cement concrete overlays shall receive an artificial turf drag made of molded polyethylene with synthetic turf blades that are approximately 1/2 inch (13 mm) long and with approximately 65,000 blades per square meter (6,000 blades per square foot) of drag. The artificial turf drag mat shall be removed and replaced with a clean artificial turf drag mat every 10 feet (3 m) measured along the bridge centerline. The transversely operated rotating cylinders of the finishing machine(s) shall be rotated such that the direction of the rotation of the cylinders at the surface of the concrete is in accordance with the manufacturer's recommendations.

The finishing machine(s) shall be operated over the full length of the bridge segment to be finished prior to beginning of concrete placement operations. The test run of the self-propelled finishing machine shall be performed in the presence of the Engineer at least 24 hours in advance of the concrete placement with the screed adjusted to its finishing position. During the test run, checks shall be made of the deflection due to the finishing machine, adjustment of guide rails and required covers for slab reinforcement. The required concrete cover over the top bars shall be checked by riding the screed over the bars and measuring the cover over the slab reinforcement. Discrepancies so found, which are in excess of the tolerances shall be rectified to secure the required concrete cover. All necessary corrections shall be made before concrete placement is begun.

The rate of concrete placement shall be coordinated with the initial strike-off so that the initial strike-off is never more than 10 feet (3 m) behind the concrete placement.

Concrete immediately in front of the power auger(s) of bridge deck finishing machine(s) shall be placed or cut to a depth no higher than the center of the rotating auger(s). The concrete shall be consolidated just prior to the auger strike off. In the case where the vibratory action of the finishing machine does not provide sufficient consolidation in accordance with the rate of placement, the Contractor shall utilize approved high frequency internal vibrators (9000 – 13500 vibrations per minute in concrete) that shall be applied in a manner to secure maximum consolidation of the concrete. Consolidation shall leave the concrete free from voids, but shall not be continued so long as to cause segregation or bleeding. The advance auger(s) shall strike off the concrete to approximately ¼ inch (6 mm) above the final grade and then the concrete shall be finished to final grade.

Improper adjustment or operation of the finishing machine(s) that results in inadequate reinforcement cover or smoothness shall be corrected immediately. Unsatisfactory performance, particularly with respect to the surface smoothness attained, shall be cause for rejection of the equipment and cement concrete placed.

4. Work Bridges.

Work bridges supported on the screed rails shall be provided by the Contractor in order to permit access to the surface of the deck for the purpose of finishing, straight-edging, making corrections, and setting curing materials. The Contractor shall furnish a minimum of two work bridges behind the bridge deck finishing machine, capable of spanning the entire width of the deck and supporting at least a 500 pound (225 kg) load without deflection to the concrete surface. These working bridges shall be available to the Engineer for inspection purposes. Workmen will not be permitted to walk in the fresh concrete after it has been screeded. All finishing work, including application of the fog spray and placement of curing mats, shall be performed from bridges supported above the deck surface.

5. Tolerances.

Verification that the completed surface of the deck has been constructed in accordance with the grades and cross slopes specified on the contract drawings shall be made immediately after finishing and again after the deck has been cured. The Contractor shall check the surface of the concrete with a 10 feet (3 m) long metal straightedge operated parallel and perpendicular to the centerline of the bridge. Deck surfaces that are not to be overlaid with 1 inch (25 mm) or more of wearing surface material shall show no deviation in excess of ¼ inch (6 mm)from the testing edge of the straightedge. For deck surfaces to be overlaid with 1 inch (25 mm) or more of wearing surface material, such deviation shall not exceed 3/8 inch (9.5 mm). The checking operation shall progress by overlapping the straightedge at least one half of the length of the preceding straightedge pass. Any area that requires finishing to correct surface irregularities shall be re-textured which may be performed with a hand-operated texture mat wrapped in a roll or attached to a round or curved shaped base. In the event that the tolerance is not met when tested after the concrete has hardened, variance in excess of 1/4 inch in 10 feet (6 millimeters in 3 meters) for deck surfaces not to be overlaid with 1 inch (25 mm) or more of wearing surface material or 3/8 inch (9.5 mm) for deck surfaces to be overlaid 1 inch (25 mm) or more of wearing surface material shall be marked and corrected at the Contractor's expense in a manner satisfactory to the Engineer. The Contractor shall correct out of tolerance hardened concrete surface irregularities by the use of concrete planing or grinding equipment that does not damage the remaining concrete or violate minimum cover requirements on steel reinforcement.

The straightedges shall be furnished and maintained by the Contractor. They shall be fitted with a handle and all parts shall be made of aluminum or other lightweight metal. The straightedges shall be made available for use by the Engineer when requested.

F. Curing.

All concrete bridge decks shall be kept wet with clean fresh water for a curing period of at least 14 days after placing of concrete.

Curing shall begin by fog spraying during the placing and finishing operations. Fogging shall continue and shall be applied continuously, rather than intermittently, after the finishing operation until wet covering material has been placed over the concrete surface. Deck finishing machine mounted fogging systems shall be augmented by hand-held fogging equipment as needed.

All bridge decks, medians, sidewalks, and safety curbs shall be water cured only and shall be kept continuously wet for the entire curing period by covering with one of the following systems:

a. Two layers of wet burlap,
b. One layer of wet burlap and either a polyethylene sheet or a polyethylene coated burlap blanket.

Curing protection shall be applied within 15 minutes after the concrete is deposited and before the surface of the concrete has lost its surface "wetness" or "sheen" appearance. The burlap shall be completely saturated over its entire area by being submerged in water for at least 8 hours before the scheduled start of the placement. The burlap shall be drained of excess water prior to application. The burlap shall be free from cuts, tears, uneven weaving and contaminants. The burlap shall be placed such that the edges are lapped a minimum of 6 inches (150 mm). Continuous burlap wetting shall commence 10 minutes from the time it is placed and shall be kept continuously wet and protected from displacement for the entire curing period in a manner acceptable to the Engineer.

The covering of bridge decks, medians, sidewalks, and safety curbs shall be kept continuously wet for the entire curing period by the use of soaker hoses. The soaker hoses shall circulate water continuously and shall be located to insure a completely wet surface for the entire curing period.

The Contractor shall make sure that adequate personnel are available at the site to carry out the placement, screeding, finishing, fogging and curing operations simultaneously. To overcome shrinkage problems, the use of wind screens and sun shades shall be used as conditions require.

The application of impervious liquid membrane curing compounds shall not be considered a substitute for achieving the curing of the concrete required by these Specifications. Only in the event of an unavoidable delay during concrete placement shall two coats of an approved curing compound be sprayed on to the concrete that has been deposited and not screeded. The curing compound shall conform to the requirements provided under Subsection M9.06.5, except that only AASHTO M 148, Type I shall be permitted. This curing compound shall later be mixed into the concrete by the finishing machine. Curing compounds shall not be applied to the screeded surfaces of bridge decks.

The Contractor shall limit the maximum concrete temperature to 154°F (68°C), and control the temperature of the concrete to ensure that it does not fall below 57°F (14°C). Heat control shall be accomplished through a combination of proper cement concrete ingredient selection to minimize heat generated, pre-placement cement concrete ingredient cooling, post-placement cooling, cement concrete placement rate control, cement concrete surface insulation to minimize heat loss, and providing supplemental heat to prevent heat loss.

The Contractor shall submit for review and approval by the Engineer at least 30 days prior to the date of intended cement concrete placement, along with each mix design, a plan indicating methods of observing and recording cement concrete temperatures. The Contractor shall measure and record concrete and ambient air temperatures on an hourly basis for at least the first 72 hours after placement or longer during hot or cold weather conditions. The Contractor shall furnish temperature log records of the temperatures that are recorded at a maximum frequency of once per hour. Temperature data shall be furnished to the Engineer as required, with a minimum frequency of once per day.

G. Cold Weather Requirements.

Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 40°F (5°C) or the ambient temperature at the site drops below 50°F (10°C) for a period of 12 hours or more. When cold weather is reasonably expected or has occurred within 7 days of anticipated concrete placement, the Contractor shall include in their Placement and Curing Plan detailed procedures for the production, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. Procedures for accommodating abrupt changes in weather conditions shall be included. Placement of concrete shall not commence until the plan is accepted by the Engineer. Acceptance of the plan will take at least one day. All material and equipment required for cold weather placement and curing protection shall be available at the project site before commencing concrete placement. All snow, ice, and frost shall be removed from the surfaces, including reinforcement, against which the concrete is to be placed. The temperature of any surface that will come into contact with fresh concrete shall be at least 35°F (2°C) and shall be maintained at a temperature of 35°F (2°C) or above during the placement of concrete.

During the curing period, the Contractor shall provide suitable measures to maintain the concrete surface temperature between 57°F (14°C) and 85°F (30°C) which shall be monitored by continuously recording surface temperature measuring devices that are accurate within 1.8°F (1°C). At least one temperature measuring device shall be randomly placed in an accessible location for every 1,500 square feet (140 m^2) of concrete deck surface area being cured.

The minimum concrete surface temperature requirement shall be continuously maintained for the entire 14 day wet curing period. Any day during which the minimum concrete surface temperature requirement of 57°F (14°C) is not continuously maintained shall not count as a day contributing to the curing period.

If the concrete surface temperature falls below 45°F (7°C) during the curing period, the structure shall be enclosed and external heat shall be provided as directed by the Engineer. If external heat is required, the following shall apply:

1. The time required for tenting shall not be counted as curing time.
2. External heat shall be maintained on and below the structure for the entire curing period and then reduced gradually such that the uniform change in temperature does not exceed 5°F (3°C) in one hour or 18°F (10°C) in any 24-hour period.

If at any time during the curing period the concrete surface temperature falls below 35°F (2°C), the concrete will be inspected by the Engineer for possible damage due to exposure to freezing temperatures. Concrete determined by the Engineer to be damaged due to exposure to freezing temperatures will be considered as being unsatisfactory and rejected.

Adequate precautions shall be taken to protect the concrete deck from any damages resulting from severe weather conditions during the curing process.

H. Surface Texturing.

The final finish required shall be as follows:

1. The finished surface of bridge decks to receive bituminous or cement concrete overlays shall be smooth without any projections that could puncture the membrane waterproofing or depressions that could retain water.

2. Bridge decks that are to be left exposed without bituminous or cement concrete overlays shall receive an artificial turf drag finish and shall be grooved using multi-bladed self-propelled sawcutting equipment. Transverse grooves shall be sawcut no sooner than completion of the 14 day wet curing operation provided that the concrete has reached a compressive strength of 3,300 pounds per square inch (23 MPa). The grooves shall be rectangular in shape, 1/8 inch (3 mm) wide (plus 1/16 inch, minus 0 inches) (plus 1.5 mm, minus 0 mm) and 3/16 inch (5 mm) deep (plus or minus 1/16 inch (1.5 mm)). The grooves shall be cut at a variable spacing measured from the centerline of grooves as follows: ¾, 1 1/8, 5/8, 1, 5/8, 1 1/8, and ¾ inch in 6 inch repetitions (19, 29, 16, 25, 16, 29, and 19 mm in 150 millimeter repetitions) across the width to be grooved in one pass of the mechanical saw device. One 6 inch (150 mm) sequence may be adjusted by ¼ sequence increments to accommodate various cutting head widths provided the general pattern is carried out. The tolerance for the spacing of the grooves is plus or minus 1/16 inch (1.5 mm).

The groove sawcutting equipment shall have a depth control device that will detect variations in the surface profile and adjust the cutting head height to maintain the depth of groove specified. The groove sawcutting equipment shall be provided with devices to control the alignment. Flailing type grooving that is uncontrolled and erratic shall not be permitted. Grooves shall be cut continuously across the roadway, perpendicular to the centerline of the roadway, and shall stop 1 foot (305 mm) from the curb line. Grooves shall be continuous across construction joints. At skewed metal bridge deck expansion joints and at the skewed ends of bridge decks, the groove cutting shall be adjusted by using narrow width cutting heads so that all grooves end within 6 inches (150 mm) of the edge of deck joint measured normal to the centerline of joint or end of deck. No un-grooved deck surface greater than 6 inches (150 mm) in width shall remain. A minimum clearance of 1 inch (25 mm) shall exist between the first groove and the end of deck or edge of metal bridge deck expansion joint. No overlapping or repeating of grooving in the same location by the grooving machine shall be permitted. The pattern of grooving shall be discussed and agreed upon with the Engineer before grooving begins. Debris and residue from the grooving operation shall be continuously removed and disposed of off site. Residue from grooving operations shall not be permitted to flow into gutters or drainage facilities. The surface of exposed concrete decks shall be left in a washed clean condition that is free from all slipperiness from the sawcutting slurry.

A 1 foot (305 mm) wide margin shall be finished adjacent to curbs with a magnesium float.

I. Sidewalks and Medians 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.

901.67 Removal of Forms and Falsework and Loading on Structures.

The terms falsework and centering, as used herein, shall include all supports of the actual forms enclosing and supporting the concrete.

No external loads of any kind, except as provided for herein, shall be allowed until the members reach at least the designated strengths.

A. Removal of Forms and Falsework.

The forms, falsework, and centering 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, falsework, and centering shall not be removed or disturbed without the prior approval of the Engineer. Forms, falsework, and centering 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 for the purpose of controlling the timing of form removal operations, the forms shall be left in place until the concrete has attained the minimum percentage of the specified design strength and, regardless of the strength attained, for the minimum period of time with test cylinder testing as designated in the following table. If test cylinders are cast for this purpose, 3 concrete cylinders shall be cast, field cured, and tested by the Contractor at an independent testing laboratory that is certified under the AASHTO Accreditation Program, all at no additional cost to the project. When test cylinders are not taken from the concrete in the members of a structure for the purpose of controlling form removal operations, the minimum days without test cylinder testing designated in the following table shall be used as a guide. The number of days counted shall be measured from the time of the last placement of concrete in the forms or falsework supports and shall exclude days when the surrounding temperature is below 40ºF (4ºC) for a total of 4 hours or more. The complete curing process shall be continued after removal of forms, falsework, or centering as required. 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 type 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.

Structural Member	Minimum Percentage of Specified Design Compressive Strength (f'c)	Minimum Days with Test Cylinder Testing	Minimum Days without Test Cylinder Testing
Free standing walls, columns, and piers	40%	3 days	5 to 7 days
Arches	80%	10 days	14 to 28 days
Beams, pier cap beams, slabs, and girders with under 6.1 meter (20 feet) clear span between supports	80%	10 days	14 to 28 days
Beams, pier cap beams, slabs, and girders with 6.1 meter (20 feet) or greater clear span between supports	90%	14 days	21 to 28 days
Cantilevered beams, slabs, and girders	90%	14 days	21 to 28 days

Where continuous span structures are involved, the forms or falsework shall remain in place until the concrete in every span of the entire group of continuous spans has attained the minimum percentage of the specified design compressive strength.

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 show excessive voids or form joint marks that 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.

Any proposal by the Contractor to remove forms, falsework, and centering prior to the concrete attaining the specified minimum percentage of the design compressive strength must satisfy each of the following requirements:

The Engineer has reviewed and approved the Contractor's justifying calculations. The calculations must be based upon the concrete strength from the time of the proposed early removal until the concrete has attained its design strength. The calculations shall demonstrate that the capacity of the structure shall not be exceeded by computing the loads, resultant stresses, and deformations to which the concrete and reinforcing steel will be subject to at the time of the proposed removal.

The Contractor has had 3 field cured concrete cylinders tested by an independent testing laboratory immediately prior to the start of removal of forms, falsework, and centering, and all of the test results equal or exceed the anticipated strength used in the Contractor's calculations. The Engineer must accept the field curing of the 3 test cylinders as being representative of the field curing of the production concrete in order for this approval to occur.

B. Application of External Loads.

Loads shall not be applied to concrete structures until the concrete has, as determined by the Engineer, attained sufficient strength so that damage will not occur.

Nothing, except for curing materials and related curing equipment and devices, may be carried on bridge decks until the entire 14 day wet curing operation is completed. A live load not exceeding 5,500 pounds (2,400 kg), operated at a speed not to exceed 5 miles per hour (8 km/h), may be allowed on bridge deck concrete no sooner than completion of the 14 day wet curing operation provided that the concrete has reached a compressive strength of 3,300 pounds per square inch (23 MPa). Full traffic loading shall not be allowed on bridge deck concrete until completion of the 14 day wet curing operation and until the concrete has reached its specified strength.

Precast concrete or steel beams or girders shall not be placed on substructure elements until the substructure concrete has attained 70% of its specified strength.

When the placement of backfill will cause flexural stresses in the concrete, the placement shall not begin until the concrete has reached not less than 80% of its specified strength.

901.68 Joints.

A. Construction Joints.

Construction joints not shown on the plans shall not be permitted except in case of emergency as specified in subsection D hereinafter.

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.

All concrete placed between construction joints shall be placed in a continuous operation.

In order to allow for initial shrinkage, concrete shall not be placed against the second side of the construction joint for at least 3 days after that on the first side has been placed.

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 pressurized water blast and 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 course 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 that has been cleaned as specified above shall be thoroughly pre-wetted for a minimum duration of 12 hours. 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 (75 mm) from the face of concrete and shall extend a minimum of 2½ inches (65 mm) into the concrete.

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 ¼ inch (5 mm) smaller along all surfaces that will be exposed in the finished work. 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 ¼ inch (5 mm) 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 insulation nails 3 inches (75 mm) long and 12 inches (300 mm) 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 (75 mm) from the face of the concrete and shall extend a minimum of 4½ inches (115 mm) into the concrete, measured from the center line of the joint.

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 the manufacturer's instructions. Application shall be made only when air temperature is 50°F (10°C) or over. The sealant shall be installed in a 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 inch (3 mm) 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.

Bonded closed cell joints shall be consist of a watertight wear resistant joint system located within the joint gap as shown on the plans. The joint system shall be installed after the adjacent concrete structures have cured for a minimum of 14 days. The joint seal shall be installed in widths which are 20% to 25% wider than the joint gap defined on the plans. The joint seal shall be uncoiled from the shipping packaging and shall be allowed to reach a relaxed condition prior to installation. The following installation procedure shall be followed:

1. The joint seal shall be precut to the proper lengths with splices only at the corners. Corner splices shall be made by cutting the seals on a 45º miter, bonding adjoining sections together by applying an epoxy based adhesive to the mitered faces and holding together for one minute, and letting the spliced section remain undisturbed for one hour prior to installation;
2. The ribbed or grooved areas of the seal shall be vigorously scrubbed with a conditioning agent using a stiff nylon brush;
3. The ribbed or grooved areas of the seal shall then be cleaned using clean absorbent white cotton rags;
4. All oil, grease, dirt, wax, curing compounds, and laitance shall be removed from the surfaces of the previously cast concrete prior to installation of the joint seal;
5. The two-components of an epoxy based adhesive shall be thoroughly mixed in accordance with the manufacturer's recommendations;
6. The sidewalls of the joint interface shall be coated with the adhesive to a depth necessary to engage the lowest rib or groove of the joint seal;
7. The ribs or grooves of the joint seal shall be completely covered with the adhesive;
8. The joint seal shall then be inserted into the joint gap using a blunt tool to position the seal at the proper depth.

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 for load bearing applications may be used. The epoxy adhesive shall conform to AASHTO M 235 Type V and 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 construct a construction joint to the approval of the Engineer at no additional expense to the project. When such a joint occurs at a section on which there are shearing or flexural stresses, 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.

901.69 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 ¼ inch (6.35 mm) mesh galvanized wire screen 23 gauge and not less than one cubic yard (m^3) of screened gravel or crushed stone conforming to Subsection M2.01.1.

Drains shall be provided for bridge superstructures as indicated on the plans.

901.70 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 used shall be the latest year of contract completion as of the date placement. The same date shall be used when placed at multiple locations on a given bridge. The date shall be cast or cut in masonry as directed. Detail drawings of the date will be furnished by the Department upon the request of the Contractor.

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 Penetrant/Sealer.

Concrete penetrant/sealer shall be applied to cement concrete surfaces if shown on the plans. 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 or discolor the concrete. 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 and safety precautions.

The preparation process shall not cause any damage to the concrete surface, remove or alter the existing surface finish, or expose the coarse aggregate of the concrete.

The Engineer shall approve the prepared surface prior to application of the penatrant/sealer.

The Contractor shall prevent the penetrant/sealer from coming in contact with any joint sealers.

901.80 Method of Measurement.

Cement Concrete will be measured by the cubic yard (m^3) 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 (100 mm) on the square sides, or for the volume of pipes less than 18 inches (500 mm) in diameter, drainage inlets, or for anchor bolts or reinforcing bars. The volume occupied by pipe culverts in headwalls shall be deducted.

Underwater Foundation Inspection shall be measured by the Unit Day of Underwater Foundation Inspection ordered by the Engineer and actually performed at the work site by each Diver that is a Professional Engineer registered in the Commonwealth of Massachusetts. Each eight hour period for which Underwater Foundation Inspection is performed as described above shall be measured as one Unit Day. Underwater Foundation Inspection that is performed as described above for less than four hours on a given work day shall be measured as one half of one Unit Day. Underwater Foundation Inspection that is performed as described above for more than four hours, but less than eight hours, on a given work day shall be measured as one Unit Day. Underwater Foundation Inspection that is performed as described above for more than eight hours on a given work day shall be measured by the quantity of Unit Days determined by the actual number of hours during which Underwater Foundation Inspection is performed divided by eight hours for each Unit Day.

Reinforcement for Cement Concrete structures shall be measured by the pound (kg). The mass (weight) of bars shall be the product of the length as shown on the approved shop drawings and schedules and the standard weight per foot (mass per meter) of length as adopted by the Concrete Reinforcing Steel Institute. Mechanical splicers will be measured by the product of the weight per foot (mass per meter) of the bar being joined and the length of an AASHTO Class C lap splice. 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 mass (weight) of wire mesh (incorporated in the structure) shall be the computed weight (mass) in accordance with the plans based on the standard weight (mass) accepted by the trade for the unit area of the particular mesh.

901.81 Basis of Payment.

Cement Concrete will be paid for at the contract unit price per cubic yard (m^3) under the particular item of Cement Concrete of the Class required, as shown on the plans or as directed, complete 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/her 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 designation of Cement Concrete specified or directed.

Underwater Foundation Inspection shall be paid at the contract unit price per unit day of Underwater Foundation Inspection ordered by the Engineer and performed by a Professional Engineer registered in the Commonwealth of Massachusetts. Written records, final reports, recommendations, travel time, and photographic documentation shall be considered incidental to Underwater Foundation Inspection and shall not be measured for payment.

Steel reinforcement including wire mesh will be paid at the contract unit price per kilogram (pound) complete in place including mechanical splicers, lap splices and proper coating of the bars and splices. Fastening devices, and supports for keeping the reinforcement in the correct position are considered incidental to the steel reinforcement and shall not be measured for payment.

Galvanized steel curb bars and steel dowels will be paid for at the contract unit price per kilogram (pound) under the item for Steel Reinforcement for Structures.

The work specified under Subsections 901.69, 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 foot 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.

English:

901.	4000 psi, 1.5 in., 565 Cement Concrete	Cubic Yard
901.3	4000 psi, 1½", 565 Cement Concrete for Post Foundation	Cubic Yard
902.	3500 psi, 1.5 in., 520 Cement Concrete	Cubic Yard
903.	3000 psi, 1.5 in., 470 Cement Concrete	Cubic Yard
904.	4000 psi, 3/4 in., 610 Cement Concrete	Cubic Yard

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904.1	5000 psi, 3/4 in., 705 Cement Concrete	Cubic Yard
904.2	5000 psi, 3/4 in., 685 Silica Fume Modified Cement Concrete	Cubic Yard
904.3	5000 psi, 3/4 in., 685 HP Cement Concrete	Cubic Yard
905.	4000 psi, 3/8 in., 660 Cement Concrete	Cubic Yard
905.1	5000 psi, 3/8 in., 710 Silica Fume Modified Cement Concrete	Cubic Yard
905.2	5000 psi, 3/8 in., 710 HP Cement Concrete	Cubic Yard
906.	5000 psi, 1.5 in., 660 Cement Concrete	Cubic Yard
909.9	Underwater Foundation Inspection	Unit Day
910.	Steel Reinforcement for Structures	Pound
910.1	Steel Reinforcement for Structures - Epoxy Coated	Pound
910.2	Steel Reinforcement for Structures - Coated	Pound
910.3	Steel Reinforcement for Structures - Galvanized	Pound

Metric:

901.	30 MPa - 40 mm - 335 kg Cement Concrete	Cubic Meter
901.3	30 MPa - 40 mm - 335 kg Cement Concrete for Post Foundation	Cubic Meter
902.	25 MPa - 40 mm - 310 kg Cement Concrete	Cubic Meter
903.	20 MPa - 40 mm - 280 kg Cement Concrete	Cubic Meter
904.	30 MPa - 20 mm - 390 kg Cement Concrete	Cubic Meter
904.1	35 MPa - 20 mm - 420 kg Cement Concrete	Cubic Meter
904.2	35 MPa - 20 mm - 405 kg Silica Fume Modified Cement Concrete	Cubic Meter
904.3	35 MPa - 20 mm - 405 kg HP Cement Concrete	Cubic Meter
905.	30 MPa - 10 mm - 425 kg Cement Concrete	Cubic Meter
905.1	35 MPa - 10 mm - 425 kg Silica Fume Modified Cement Concrete	Cubic Meter
905.2	35 MPa - 10 mm - 425 kg HP Cement Concrete	Cubic Meter
906.	35 MPa - 40 mm - 400 kg Cement Concrete	Cubic Meter
909.9	Underwater Foundation Inspection	Unit Day
910.	Steel Reinforcement For Structures	Kilogram
910.1	Steel Reinforcement For Structures - Epoxy Coated	Kilogram
910.2	Steel Reinforcement For Structures - Coated	Kilogram
910.3	Steel Reinforcement For Structures - Galvanized	Kilogram

SECTION 930
PRESTRESSED CONCRETE BEAMS

SECTION 930 PRECAST CONCRETE BEAMS

(page 287 English, page II.254 Metric) Replace this Section with the following:

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 Standard Specifications for Highway Bridges, supplemented by the relevant provisions of "*The Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products*", PCI publication MNL-116-85, 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 (3 mm) per each 15 foot (5 m) of beam length nor shall it exceed ½ inch (12 mm) maximum for butted precast members.

MATERIALS

930.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III:

Protective Sealcoat Emulsion.....M3.03.3
Bitumen for Expansion End Anchor Rod.....M3.05.1
Cement Mortar.....M4.02.15
Prestressed Concrete Beams.....M4.03.00 thru M4.03.14
Mortar for Filling Keyways.....M4.04.0
Anchor Rods.....M8.01.6
Strand Chuck.....M8.15.0
Elastomeric Bridge Bearing Pads.....M9.14.5

The transverse ties shall be single ½ inch (13 mm) low-relaxation strands meeting the requirements of AASHTO M 203. The ties shall be supplied with a seamless polypropylene sheath which has corrosion inhibitor grease between the strand and sheath. The location of all strands, both pretensioning and transverse tie, shall be as shown on the plans.

CONSTRUCTION METHODS

930.60 General.

Prestressed concrete beams shall be installed to the line and grade shown on the plans in accordance with the Contractor's approved erection procedures and in accordance with relevant provisions of these Standard Specifications.

The prestressed concrete beams shall not be shipped for a minimum of 14 days from casting.

Beams shall not be stacked on top of each other either at the fabricator's yard, during transit or at the site. At all times blocking shall be located at the center line of bearing of the beam. The bridge seats for the bearing devices shall be prepared in accordance with Section 901.65, A., 3. *Preparation of Bridge Seat Bearing Areas.* If inserts are cast into the beams for support of form work on the outside face of the exterior beams, the inserts shall be recessed a minimum of 1 inch and shall be plugged after use with a grout of the same color of the precast cement concrete.

930.61 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 detailed procedures which include drawings and calculations sufficient to enable the Engineer to determine the adequacy of the proposed method.

The preparation and submission of this erection procedure, including the information and calculations to be provided, shall be in accordance with the relevant requirements of *Section 960.61, D. Erection*, for beams and girders.

The prestressed concrete beams shall be lifted only by the lifting hooks, and the utmost care shall be taken to prevent distortion of the beams during handling, transportation or storage. Under no circumstances are the beams to be handled in other than an upright position. The design of the lifting hooks shall be the responsibility of the Fabricator of the beams. The lifting hooks shall be designed to meet the requirements for lifting devices as specified under *Section 960.61, D. Erection*.

Suitable spreaders shall be used during lifting so that only a vertical pull will be made on the hooks. A non-vertical lifting force may be permitted if prior written approval is given by the Engineer. This approval will be contingent on the Contractor demonstrating by calculations, prepared by a Professional Engineer registered in Massachusetts, that the beams will not be damaged by the non-vertical lifting force and by documentation that the capacity of the lifting hooks is adequate for the non-vertical lifting force.

930.62 Butted Prestressed Concrete Deck and Box Beams.

A. Beam Layout

Prior to erection, the location of the beams on the abutments and piers shall be laid out according to the nominal width of the beams as shown on the plans. Each beam will be erected such that the distance from its edge to the corresponding nominal width line shall be as shown on the plans. After erection, the beam shall lie entirely within the horizontal lines defined by its nominal width for its entire length and shall not infringe on the space allocated for any adjacent beam.

After all beams are erected, the actual overall width of the butted deck assembly shall not deviate from the nominal dimension shown on the framing plan by more than +0, -1 inches (+0, -30 mm).

B. Preparation and Mortaring of Keyways.

The surfaces of the keyways cast in the sides of the beams shall be sand blasted at the fabricator's yard prior to shipment to the job site. The sand blast shall be oil free. After sand blasting, the profile of the keyway surfaces shall be similar to that of 60 grit sand paper. Immediately prior to erection at the job site, the keyway surfaces shall be cleaned of all dust, dirt, and carbonation using a high pressure water blast.

The keyways shall not be filled until 28 days have elapsed from casting of the youngest beam in the butted assembly except under the following condition. If the beams have been cast in a continuous sequence and adjacent beams are not more than two days different in age, then keyways may be filled after 14 days have elapsed since casting of the youngest beam.

Mortar (M4.04.0) shall be placed in strict accordance with the manufacturer's recommendations and instructions.

The keyways shall be filled flush to the top of the beams and any vertical misalignment between beams shall be feathered out on a slope of 1 to 12. Curing shall be performed in strict accordance with the manufacturer's recommendations. The keyways shall not be filled in cold weather when either the ambient temperature or the precast member's temperature is below the mortar manufacturer's recommendation. No localized heating of either the precast members or of the air surrounding the keyway will be permitted in an attempt to reach application temperatures.

No vehicular or construction traffic will be allowed on the bridge until the mortar has attained its full strength.

C. Transverse Tie Tensioning

The ties shall be tensioned to 5,000 pounds (20 kN) before the keyways are filled. After the keyways are filled with mortar (M4.04.0) and the mortar has cured, the ties shall be tensioned to 30,000 pounds (135 kN).

If the plans show that the ties are to be tensioned before mortaring, then the strands shall be tensioned to 30,000 pounds (135 kN) with multipolymer (plastic) shims in place as shown on the plans to maintain a uniform joint width. If excessive time elapses between the tensioning of the ties and the mortaring of the keyways, the Contractor shall verify that the 30,000 pound (135 kN) post tensioning force is still in the strand.

D. Closure Pour for Continuity

Prior to erecting the beams, the restraint key cast into the top of the pier cap shall be lined with closed cell foam to the limits and thickness shown on the plans.

The concrete for the closure pour shall not be placed until after the keyway mortar has cured and the transverse ties have been fully tensioned. The pier cap restraint key shall be cleaned of all loose and extraneous material prior to placing the concrete. Styrofoam shall be placed outside of the restraint key as shown on the plans to prevent the closure pour concrete from coming in contact with the pier cap itself.

E. Final Deck Assembly Work

After the final deck assembly has been accepted by the Engineer, the lifting hooks shall be cut off below the top of the beam, and the recesses shall be filled with mortar (M4.02.15). The Contractor shall also remove projections and fill all depressions in the tops of the beams with mortar (M4.02.15).

After all mortar has cured, the Engineer shall inspect and approve the surface of the deck assembly before the Contractor will be permitted to apply the membrane waterproofing in accordance with the requirements of *Section 965, System 3 - Preformed Sheet Membranes*.

F. Backwalls, Curtain Walls and Keeper Blocks

The backwalls, the curtain walls at the abutment bridge seats, and the keeper blocks shall be cast only after the deck assembly has been accepted. Closed cell foam shall be attached to the bridge structure to the limits and thickness as shown on the plans and the backwall / curtain wall / keeper block concrete shall be placed directly against it.

The sidewalk, safety curb or barrier sections may be cast after the curtain walls and exterior pier keeper blocks have been cast. In this case, the curtain walls and keeper blocks shall be accurately formed above the beams to the shape and dimensions of the coping, including the thickness of the closed cell foam, as shown on the plans. Closed cell foam will be attached to the curtain wall/keeper block prior to placing the coping concrete.

930.63 Prestressed I-Beam, Bulb Tee, and Spread Box Beam Sections.

Anchor bolts, where called for on the plans, shall be set as follows: in piers, anchor bolts shall be accurately set by template prior to placing concrete; in abutments, anchor bolts may be set by template or by drilling and grouting. Grout shall be a non-shrink type.

Keeper blocks on the abutments and pier caps, where called for on the plans, shall be cast after the beams have been erected. Closed cell foam of the thickness shown on the plans shall be attached to sides of the beam within the limits of the keeper blocks prior to placing the concrete.

As the beams are being erected, temporary blocking or bracing shall be installed at the ends of the beams to prevent the beams from accidentally rotating and tipping over. The detail for this bracing shall be included with the erection procedure submittal.

After the reinforced concrete diaphragms have been poured and allowed to reach a minimum of 70% of the required 28 day strength, the temporary bracing may be removed. In addition, the placement of the deck concrete will not be permitted until these concrete diaphragms have been installed and have reached this minimum strength.

The top of the beam shall be clean, free of all laitance and shall have a rough surface raked across the width of the beam. Deck concrete shall be placed against the beam concrete without the use of any bonding agents.

COMPENSATION

930.81 Basis of Payment.

The above work shall be paid for at the contract unit price per foot for the respective items of Prestressed Concrete Deck Beams, Prestressed Concrete Beams (I or Bulb Section), and Prestressed Concrete Box Beams complete in place and accepted.

Bearing pads shall be paid complete in place and accepted. Item 932. Elastomeric Bridge Bearing Pad shall be paid by the square foot. Item 933. Elastomeric Bridge Bearing Pad shall be paid by each bearing.

930.82 Payment Items.

930.3*	Prestressed Concrete Deck Beam (S*)	Foot (m)
930.4*	Prestressed Concrete Box Beam (B*)	Foot (m)
930.5*	High Performance Prestressed Concrete Box Beam (B*)	Foot (m)
931.*	Prestressed Concrete Bulb-Tee Beam (NEBT*)	Foot (m)
931.1*	High Performance Prestressed Concrete Bulb-Tee Beam (NEBT*)	Foot (m)
932.	Elastomeric Bridge Bearing Pad	Square Foot (m^2)
933.	Elastomeric Bridge Bearing Pad	Each

* = as per MHD Standard Nomenclature.

SUBSECTION 940.61 Driven Pile Capacity.

(page 293 English, page II.261 Metric) Replace the first paragraph with the following:

For piles with proposed capacities greater than 50 tons (450 kN), the Ultimate Pile Capacity 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 Ultimate Pile Capacity may be determined by the following formula.

*(page 293English, page II.261 Metric) Under **A. Formula Method.**, replace the first paragraph after paragraph (b) beginning with "A design safety factor ..." with the following:*

On projects designed using the Service Load Design Method (Allowable Stress Design), a Design Safety Factor of 3.5 is to be used when using this formula to determine the required Ultimate Pile Capacity. For example, if a Design Capacity of 50 tons (450 kN) is required, then an Ultimate Pile Capacity of 175 tons (1575 kN) should be used in the formula to determine the necessary hammer blow count. On projects designed using the Strength Design Method (Load Factor Design), the Performance Factor and Factored Design Capacity specified on the plans shall be used when using this formula to determine the required Ultimate Pile Capacity. For example, if a Factored Design Capacity of 35 tons is required and the Performance Factor specified on the plans is 0.35, then an Ultimate Pile Capacity of 100 tons should be used in the formula to determine the necessary hammer blow count.

SUBSECTION 940.62 Pile Load Tests.

*(page 296 English, page II.264 Metric) Add the following to the end of **B. Static Tests** (immediately above **C. Dynamic Load Tests.**):*

7. Static-Cyclic (Express) Load Test.

This load test can apply to a compression test, tension test, or both, on a pile and provide the ultimate capacity of the pile. The load test is carried out in four "loading-unloading" cycles, at a constant loading rate, conducted continuously without allowing for settlement stabilization.

The loading frame should be designed to handle at least two times the estimated ultimate pile capacity. The displacement and load readings from the top of the pile are to be taken continually by a data acquisition system.

The load sequence shall be as follows:

a) For a compression test; apply continuously a load at a rate between 20 to 40 kips/minute (100 to 200 kN/minute) until failure is observed and an additional settlement equal to 0.1 inches (2.5 mm) is achieved with total pile settlement equal or exceeding 1 inch (25 mm). A failure is defined when displacement increases without an increase in the pile's load at or below the ratio of 0.1kips/0.1 inches/foot (0.67 kN/mm/meter) pile embedment for all compression tests. Unload the pile at a constant rate between 60 to 80 kips/minute (300 to 350 kN/minute) until zero load. Carry out additional three load-unload cycles to the maximum load that was achieved in the first cycle.

b) For a tension test, apply a load at a rate of 15 to 30 kips/minute (75 to 150 kN/minute) and unload at a rate of 30 to 60 kips/minute (150 to 300 kN/minute). Failure is defined when displacement increases without an increase in the pile's load at or below the ratio of 0.05 kips/0.1 inches/foot (0.33 kN/mm/meter) pile embedment for all tension tests.

c) For all tests, pile top load and displacement are measured at intervals of loads equal to 1/10 of the estimated ultimate pile capacity but no more than 20 kips (100 kN) for a compression test and 10 kips (50 kN) for a tension test. The readings need to allow for accurate definition of the load-unload interception. The use of electronic data acquisition is recommended. If dial gages are used, the gages should not be adjusted at the end of the first cycle and the zero load reading at the end of the first cycle (first zero reading of the second cycle) will be subtracted from the readings of the second cycle.

The pile design load on this test is based on the measured ultimate capacity of the pile. The ultimate capacity of the pile is defined as the average of the three intersection points formed by the load-unload curves.

SUBSECTION 940.65 Procedure for Driving.

*(page 299 English, page II.267 Metric) Delete the second sentence of the first paragraph under the heading **B. Accuracy of Driving.**.*

*(page 300 English, page II.268 Metric) Under **C. Obstruction.** delete paragraph 6., delete "and (6)" from paragraph 7., and renumber paragraph 7. to 6..*

SUBSECTION 940.82 Payment Items.

(page 302 English, page II.271 Metric) Add the following payment item in numerical order:

948.31	Static - Cyclic (Express) Load Test	Each

(page 302 English, page II.271 Metric) Replace payment item 946. with the following:

946.12	Precast-Prestressed Concrete Pile - 12 Inch	Foot
946.14	Precast-Prestressed Concrete Pile - 14 Inch	Foot
946.16	Precast-Prestressed Concrete Pile - 16 Inch	Foot
946.18	Precast-Prestressed Concrete Pile - 18 Inch	Foot
946.20	Precast-Prestressed Concrete Pile - 20 Inch	Foot
946.12	Precast-Prestressed Concrete Pile - 300 Millimeter	Meter
946.14	Precast-Prestressed Concrete Pile - 350 Millimeter	Meter
946.16	Precast-Prestressed Concrete Pile - 400 Millimeter	Meter
946.18	Precast-Prestressed Concrete Pile - 450 Millimeter	Meter
946.20	Precast-Prestressed Concrete Pile - 500 Millimeter	Meter

SECTION 945 DRILLED SHAFTS

(page 303 English, page II.271 Metric) Add this Section.

SECTION 945
DRILLED SHAFTS

DESCRIPTION

945.20 General.

This work shall consist of excavating and constructing drilled, cast-in-place reinforced concrete shafts installed in accordance with these specifications and the details and dimensions shown on the plans.

Drilled shafts shall consist of reinforced concrete sections that are cast-in-place against in situ soil or rock or a casing. Permanent casings are designed as part of the drilled shaft and shall remain in place after concrete placement is completed. Temporary casings shall be installed to facilitate drilled shaft construction and removed during or after concrete placement. The embedment length of the drilled shafts may be modified by the Engineer, pending results of any subsurface investigation taken and/or load testing performed as an initial part of the work, as approved by the Engineer.

MATERIALS

945.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Cement Concrete	M4.02.00
Reinforcing Steel	M8.01.0
Epoxy Coated Reinforcing Bars	M8.01.7
Galvanized Reinforcing Bars	M8.01.8
Mechanical Reinforcing Bar Splicer	M8.01.9
Steel Casings	M8.05.6
Cross Hole Sonic Testing Access Pipes	M8.22.0
Drilling Slurry	M9.40.0

CONSTRUCTION METHODS

945.50 Personnel Qualifications.

Drilled shaft construction personnel must be experienced in this type of work. Experience shall be relevant to anticipated subsurface materials, water conditions, shaft size, and special construction techniques required. Prior to the Preconstruction Conference, the Contractor shall submit the following information to verify the firm's experience and the qualifications of personnel scheduled to perform the drilled shaft construction:

1. Submit a list of at least three projects successfully completed in the last five years, which used drilled shaft construction. Include a brief description and reference for each project listed.
2. Provide the names and detail the experience of the on-site supervisors and drill operators for the Project. On-site supervisors shall have at least two years of experience in drilled shaft construction, and drill operators shall have at least one year of experience.
3. A signed statement that the Contractor has inspected both the project site and all the subsurface information including any soil or rock samples made available in the contract documents.

Work on any drilled shafts shall not begin until the qualifications have been approved. The Engineer may suspend the drilled shaft construction if the Contractor substitutes unapproved personnel during construction. Requests for substitution of field personnel shall be submitted to the Engineer for approval. Additional costs resulting from the suspension of work will be the Contractor's responsibility, and no extension in contract completion date resulting from the suspension of work will be allowed.

The Contractor shall have on site during all drilled shaft construction activity a minimum of one person who has fulfilled the qualifications required for drilled shaft field inspector certification. The representative will be responsible for the Contractor's Quality Control (QC) of the drilled shafts during all phases of construction. The Contractor's QC representative shall have proof of certification as a Drilled Shafts Inspector by the NorthEast Transportation Training and Certification Program (NETTCP) or an equivalent certification program approved by MassDOT.

945.51 Drilled Shaft Installation Plan.

The Contractor shall submit an installation plan for review and approval of the Engineer at least 30 days prior to the anticipated date of beginning drilled shaft work. This plan shall provide the following:

1. The sequence of drilled shaft construction as it relates to the overall construction plan and the sequence of shaft construction in bents or groups.
2. A review of equipment suitability based on the Contractor's understanding of the site subsurface conditions. Include a project history of the drilling equipment that demonstrates the successful use of the equipment for drilled shafts of equal or greater size in similar subsurface conditions. List proposed equipment with manufacturer's specification and catalog data including cranes, drills, augers, bailing buckets, casing oscillators, casing twisters, vibratory hammers, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casing, etc.
3. Details of shaft excavation methods in soils and rock, including sloping bedrock and methods of removing any obstructions such as boulders or foundations, including a disposal plan for excavated material. Include details of methods used to perform final cleaning of the excavation and checking the cleanliness and soundness of the rock socket sidewalls and bearing surface.
4. Include details of the methods and materials used to fill or eliminate all voids between the plan shaft diameter and excavated shaft diameter, or between the casing and surrounding soil, if permanent casing is specified. Include a disposal plan for any water or contaminated concrete expelled from the top of the shaft (if applicable).
5. Details of the proposed method(s) for ensuring drilled shaft stability during excavation and concrete placement.
6. Method of monitoring plumbness and location of the shaft during construction.
7. Details for the use of drilling slurry including methods to mix, circulate, de-sand, maintain and dispose of the slurry (if applicable). Include a discussion of the suitability of the proposed drilling slurry in relation to the anticipated subsurface conditions.
8. A plan for quality control of drilling slurries, if their use is proposed. In the quality control plan, include property requirements, required tests and test methods to ensure the synthetic slurry performs as intended. Submit to the Engineer the name and current phone number of the synthetic slurry manufacturer's representative who will provide technical assistance during construction.
9. Reinforcing steel shop drawings and details of reinforcement placement, including bracing, centering and lifting methods and the method for supporting the reinforcement on the bottom of the shaft excavation. Include details for ensuring the reinforcing cage position is maintained during construction. Include details for attaching the crosshole sonic logging test access tubes to the reinforcing cage.
10. Evidence that the proposed materials and concrete mix design conform to all applicable Specifications.
11. Details of concrete placement, including proposed operational procedures for pumping and/or tremie methods and methods of curing and protecting the concrete. Include details for grout placement in the crosshole sonic logging test access tubes after testing is completed (if applicable).
12. Detailed procedures for permanent casing installation and temporary casing installation and removal, including casing dimensions.
13. Two copies of "Drilled Shaft Inspector's Manual" (latest edition), available from International Association of foundation Drilling (ADSC) at www.adsc-iafd.com and the Deep Foundation Institute (DFI) at www.dfi.org, shall be supplied to the Resident Engineer. These manuals shall become the property of the Department.

The Engineer shall approve or reject the drilled shaft installation plan after receipt of all submissions. The Contractor shall provide any additional information and submit a revised plan, if requested, for review and approval. All procedural approvals given by the Engineer will be subject to trial in the field and will not relieve the Contractor of the responsibility to satisfactorily complete the work. The Contractor shall submit requests for modification of adopted procedures to the Engineer.

All portions of proposed construction shall be described on shop drawings and submitted to the Engineer for approval. No work shall commence prior to receiving the written approval of the proposed methods and equipment by the Engineer. This approval shall be considered in no way as relieving the Contractor of the responsibility to satisfactorily complete the work in accordance with the Plans and Specifications.

A Preconstruction Meeting shall be conducted when so requested by the Engineer. Such meeting is held among the Department, the Contractor and the Drilled Shaft Subcontractor to review special requirements for the drilled shaft work, including installation plans, acceptance and rejection criteria, and project documentation.

945.52 Borings.

When required in the contract documents, soil borings and/or rock cores shall be conducted at the specified locations and to the indicated size and depth, as approved by the Engineer. The boring logs shall be reviewed by the Contractor and shall be submitted to the Engineer for approval prior to mobilizing drilled shaft equipment. All work shall be performed in accordance with Section 190, Borings.

945.53 Trial Drilled Shaft.

When required in the contract documents, a trial shaft shall be constructed by the Contractor. A trial shaft may be required on projects where unusual and variable subsurface conditions exist, when the dry method of construction is proposed, and/or when excavations are performed in open water areas.

The Contractor shall demonstrate the adequacy of his methods, techniques and equipment by successfully constructing a trial shaft in accordance with the plans and these requirements. This trial shaft shall be drilled to the maximum depth of any production shaft and away from production shafts as shown on the plans or as directed by the Engineer. Failure by the Contractor to demonstrate the adequacy of methods and equipment shall be reason for the Engineer to require modifications in equipment and/or method by the Contractor to eliminate unsatisfactory results. Any additional trial holes required to demonstrate the adequacy of altered methods or equipment shall be at the Contractor's expense. The same methods and equipment used to construct the approved trial shaft shall be used to construct the production shafts.

The trial shaft holes shall be filled with unreinforced concrete in the same manner that production shafts will be constructed and shall be cut off 2 feet (600 mm) below finished grade and left in place. The disturbed areas at these shafts shall be restored as nearly as practical to their original condition.

945.54 Protection of Existing Structures.

The Contractor shall control his operations to prevent damage to existing structures and utilities. Preventive measures shall include, but are not limited to, selecting construction methods and procedures that will prevent caving of the shaft excavation, monitoring and controlling the vibrations from construction activities such as the driving of casing or sheeting, drilling of the shaft, or from blasting, if permitted. The Contractor shall be responsible for selecting and using equipment and procedures that keep deformations of adjacent structures within acceptable levels as determined by the Engineer.

945.55 General Methods and Equipment.

The Contractor's methods and equipment shall have adequate capacity including power, torque and down thrust to excavate a hole of both the maximum diameter and to a depth of 25% beyond the depths shown on the plans. The permanent casing method shall be used only at locations shown on the plans or when authorized in writing by the Engineer. The Contractor shall provide all equipment and tools as necessary to construct the shaft excavation to the size and depth required. Drilling tools should contain vents to stabilize hydrostatic pressure above and below the tool during insertion and extraction.

A. Dry Method.

The dry method shall be used only at sites where conditions are suitable to permit construction of the shaft in a relatively dry excavation and where the sides and bottom of the shaft can be visually inspected by the Engineer during the excavation and prior to placing the concrete. The dry method shall only be approved when a trial shaft excavation demonstrates that: less than 6 inches (152 mm) of water accumulates above the base over a one-hour period without pumping; the sides and bottom of the hole remain stable without caving and sloughing over a four-hour period following completion of excavation; any loose material or water can be removed prior to inspection and concrete placement.

B. Wet Method.

The wet method consists of using water or slurry (mineral or polymer) to maintain stability of the drilled hole while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft.

Slurry should be introduced when the depth of the drilled hole is still above the piezometric level and not after the inflow of water is detected and/or sloughing has begun. This method may involve desanding and cleaning the slurry and final cleaning of the excavation by means of bailing bucket, air lift, submersible pump or other approved devices.

The wet method may also be used in combination with the casing method.

C. Casing Construction Method.

The casing method may be used at sites where the dry or wet methods are inadequate to prevent hole caving or excessive deformation of the hole. The casing may be either placed in a predrilled hole or advanced through the ground by twisting, driving, or vibration before being cleaned out. When the casing is placed in a predrilled borehole, the temporary stability of the hole may need to be assured by using drilling slurry. The rising column of fluid concrete must force the slurry that is trapped in the annular space behind the casing out as the casing is being pulled.

The casing method may not be permitted at specified depths that are designated for mobilization of side resistance.

945.56 Drilled Shaft Excavation.

A. General.

The Contractor shall use excavation techniques that are technically adequate and cost effective to meet the geologic conditions encountered at the site. Excavation for drilled shafts shall be made so that the sidewalls of the hole are stable at all times.

Drilled shafts shall be excavated to the dimensions and elevations shown or as directed. Materials removed from the shaft excavations and slurry shall be disposed of according to the applicable federal, state and local regulations and shall not be discharged into any stream, waterway, or storm water drainage system.

If approved by the Engineer, a partially excavated shaft may be left open overnight, provided that the excavation:

- Is stabilized at the bottom, sides and surface to prevent soil caving or swelling or a reduction of soil strength, and
- Is covered at the surface to protect the public.

Excavation shall not commence immediately adjacent to a concreted drilled shaft for a minimum of 24 hours after completing the shaft concrete pour.

The Contractor shall extend the drilled shaft tip elevations when so indicated by the results of the load test and/or the Engineer determines that the material encountered during excavation is unsuitable or differs from that anticipated in the design of the drilled shaft.

Drilled shaft excavation is excavation accomplished with conventional tools such as earth augers, casing twisters, drilling buckets, and overreaming (belling) buckets attached to drilling equipment of the size, power, torque, and down thrust (crowd) approved for use by the Engineer.

Should the Engineer have reason to believe that the drilled shaft excavation techniques or workmanship have been deficient, so that the integrity of any excavation is in question, work on that drilled shaft shall be stopped. Drilled shaft excavation will not be allowed to resume until the deficient excavation techniques or workmanship have been changed to the satisfaction of the Engineer.

B. Clean Out.

Appropriate means, such as a cleanout bucket or air lift, shall be employed to clean the bottom of the drilled shaft excavations. No more than 1 inch (25 mm) of loose or disturbed material will be allowed at the bottom of the excavation for end-bearing drilled shafts. No more than 3 inches (75 mm) of loose or disturbed material will be allowed at the bottom of the excavation for skin friction drilled shafts. All drilled shafts shall be assumed to be end-bearing shafts. Shaft cleanliness will be determined by the Engineer.

The Engineer shall be notified of completion of each drilled shaft excavation to permit inspection before proceeding with construction.

The drilled shaft dimensions and alignment shall be verified with approved methods. Final shaft depths shall be measured with a suitable weighted tape or other approved method after final cleaning. The drilled shaft excavation may be extended if the Engineer determines that the subsurface materials encountered are not capable of providing the required bearing capacity or differ from those anticipated in the design of the drilled shafts.

If caving occurs during any construction procedure, the construction operation shall be stopped, the Engineer shall be notified, and the shaft excavation shall be stabilized by approved methods.

C. Rock Socket Excavation.

Rock socket excavation is excavation that requires rock-specific tools and/or procedures to accomplish hole advancement, such as rock augers and core barrels. All excavation, performed below the depth where rock socket excavation is authorized shall be considered rock socket excavation regardless of the density, strength, hardness, or changes in type or character of materials encountered.

D. Obstruction Excavation.

Obstructions are defined as impenetrable objects that cannot be removed or excavated using conventional rock or soil augers, drilling buckets, casing twisters, and cause a significant decrease in the rate of excavation advancement as compared to before the obstruction was encountered or shafts in close proximity advanced using the same techniques and equipment. The Engineer will consider the equipment, techniques, and level of effort by the Contractor and shall be the sole judge of the significance of any reduced rate of shaft advancement and the classification of obstruction excavation. Special procedures/tools needed to remove obstructions may include: core barrels, chisels, boulder breakers, downhole hammers, hand excavation, temporary casing, and increasing the hole diameter. Blasting shall not be permitted. The Contractor shall specifically log the depth and rate of removal of the obstruction.

Those obstructions located within 5 feet (1.52 m) of the top level of the ground surface during shaft drilling at shaft locations shall be removed at the expense of the Contractor. Such obstructions may include man-made materials such as old foundations, utilities, tunnels, and natural materials such as boulders and wood.

Drilling tools that are lost in the excavation shall not be considered obstructions and shall be promptly removed by the contractor without compensation. All costs due to lost tool removal shall be borne by the Contractor including but not limited to, costs associated with the repair of hole degradation due to removal operations or an excessive time that the hole remains open.

The rate of occurrence of obstruction encounters during the excavation and construction of drilled shafts may vary considerably from what is inferred from the boring logs due to sampling limitations of the boring(s), sampling bias due to the diameter differences between the drilled shaft and the boring(s), and spatial variability of the soil deposit.

The Engineer shall be present to evaluate the occurrence of obstructions, to authorize, and to approve the designation of such. Sloping bedrock and/or higher than anticipated bedrock, as inferred from the borings, shall not be considered obstruction excavation.

E. Casings.

Casings shall be steel, clean, watertight, and of ample strength to withstand handling and installation induced stresses and the pressure from both concrete and surrounding earth materials. The outside diameter (O.D.) of casings shall not be less than the specified size of shaft. Casings may be either placed in a predrilled hole or advanced through the ground by twisting, driving or vibration before being cleaned out.

Permanent casings shall be used only at locations shown on the plans or upon approval by the Engineer. The casing shall be continuous between top and bottom elevations.

Temporary casings shall be provided to aid shaft alignment and position, to prevent sloughing of the shaft excavation, and to prevent excessive deformation around the hole unless the Contractor demonstrates to the satisfaction of the Engineer that the casing is not required.

As the temporary casing is withdrawn, the level of concrete (and drilling fluid/slurry, if used) shall be maintained with a sufficient head to prevent any water and/or other extraneous materials from entering the drilled shaft. In addition to the foregoing, the level of concrete in the temporary casing shall be maintained a minimum of 5 feet (1.52 m) from the bottom of the casing. As the casing is withdrawn, care shall be exercised to maintain an adequate level of concrete within the casing so that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.

F. Drilling Slurry Installation.

If synthetic drilling slurry is selected, a manufacturer's representative shall be available to provide technical assistance at the site prior to use of the slurry. The manufacturer's representative shall remain available during construction to adjust the slurry mix for the specific site subsurface conditions.

All in-hole drilling slurry shall meet the required Specifications prior to concrete placement. The slurry shall be cleaned, re-circulated, de-sanded or replaced to maintain the required slurry properties. The level of slurry in the excavation shall be maintained at not less than 5 feet (1.52 m) above the groundwater level for all slurries. The slurry level shall be maintained a sufficient distance above all unstable zones to prevent bottom heave, caving or sloughing.

Slurry shall feed continuously into the shaft excavation as drilling progresses so that a stable excavation is maintained. A self-priming pump shall be used to reclaim the slurry. A functioning standby pump shall be kept on-site and available during the drilling operation.

G. Drilling Slurry Inspection and Testing.

All drilling slurries shall be mixed and kept thoroughly hydrated in an appropriate storage facility. Sample sets shall be collected from the storage facility and tests shall be performed to ensure the slurry conforms to the specified material properties before introduction into the drilled shaft excavation. A sample set shall be composed of samples taken at mid-depth and within 24 inches (610 mm) of the bottom of the storage facility. All slurry shall be sampled and tested in the presence of the Engineer. Final cleaning of the excavation and placement of concrete will not be allowed until the test results indicate the slurry properties are as specified.

A minimum of two sets of slurry tests shall be performed per eight-hour work shift, the first test being done at the beginning of the shift. Field conditions may require more frequent testing to ensure acceptable slurry properties. Copies of all slurry test results shall be provided to the Engineer on request.

945.57 Construction Quality Control.

A. Location and Survey.

Drilled Shafts shall be located and staked by the Contractor who shall maintain and be responsible of all location and elevation stakes.

The Contractor shall maintain a construction method log during shaft excavation and concreting of each drilled shaft. This record shall be available for the Engineer's inspection as directed. The log shall contain for each shaft the following information:

- Shaft number, date and time of installation.
- Description and approximate top and bottom elevation of each soil or rock material, and final tip elevation.
- Level and variation of the piezometric surface.
- Excavation procedures and method used to stabilize the sides of shaft and any seepage of groundwater.
- Quantity, type of obstruction material, and drilling rate.
- Diameter of the as-built shafts.
- Plumbness and deviation of shaft location.
- Type, diameter, and length of any casing left in place.
- Time, method, and duration of placement of concrete.
- A chart showing quantity of concrete placed versus depth or elevation of top of concrete in shaft during placement.
- Other pertinent data relative to the installation.

B. Construction Sounding.

The Contractor shall provide to the Engineer access and equipment for checking the dimensions and alignment of each permanent shaft excavation. After excavation is complete, the bottom of the shaft shall be measured and sounded with a steel rod (AW) and/or a weighted tape. A check of the bearing surface by sounding shall be made in the presence of the Engineer, who shall determine if the drilled shaft excavation is acceptable. The bearing surface shall be sounded again immediately before placing concrete.

No more than 1 inch (25 mm) of loose or disturbed material will be allowed at the bottom of the excavation for drilled shafts designated as end-bearing and no more than 3 inches (75 mm) of loose or disturbed material will be allowed at the bottom of the excavation for drilled shafts designated as deriving their capacity from skin friction. Shaft cleanliness will be determined by the Engineer, based on visual inspection for dry shafts and other methods deemed appropriate for wet shafts. In addition, for dry excavations the maximum depth of water shall not exceed 3 inches (75 mm) prior to concrete placement.

C. Construction Tolerances.

The following construction tolerances apply to drilled shafts:

1. The drilled shaft shall be within 3 inches (75 mm) of plan position in the horizontal plane at the plan elevation for the top of the shaft.
2. The vertical alignment of a shaft excavation shall not vary from the plan alignment by more than 1/4 inch per foot (20 mm) of depth or 2% of plumb for the total length of shaft.
3. After all the concrete is placed, the top of the reinforcing steel cage shall be no more than 6 inches (150 mm) above and no more than 3 inches (75 mm) below plan position.
4. The top elevation of the shaft shall be within 2 inches (50 mm) of the plan top of shaft elevation.
5. The bottom of the shaft excavation shall be perpendicular to the axis of the shaft within 1 inch per foot (80 mm) of shaft diameter.

6. When the shaft steel reinforcement is to extend into the structural column or cap, all plan, vertical, and elevation tolerances shall meet the structural column or cap requirements.

Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances are unacceptable. Correction methods shall be submitted by the Contractor for the Engineer's review and approval before continuing with any drilled shaft construction. Correction procedures are dependent on analysis of the effect of the degree of misalignment and improper positioning.

D. Scheduling and Restrictions.

Drilled shaft excavation and cement concrete placement shall be scheduled so that each drilled shaft is cast immediately after drilling operations are complete. After the first drilled shaft on a project has been accepted, no significant change in construction methods, equipment, or materials used shall be made in the construction of subsequent shafts. Construction of subsequent shafts shall not proceed until the first drilled shaft has been approved by the Engineer. Drilling may commence on a subsequent shaft at an approved location provided that the cement concrete placement operation on the previous drilled shaft is in progress and there are sufficient workers present to complete all required operations.

For a minimum period of 24 hours after completion of the cement concrete placement operation in a newly constructed shaft, including withdrawal of casing if applicable, none of the following operations shall be permitted within 15 feet (4.57 m) of the newly constructed shaft:

- Excavation for adjacent shafts;
- Construction of footings;
- Application of equipment loads;
- Introduction of vibrations with a peak particle velocity of greater than 1/4 inch (6 mm) per second.

945.58 Steel Reinforcement Configuration and Placement.

Steel reinforcement shall not be placed until the Engineer has approved the results of all borings and load tests for drilled shafts.

The clear spacing between bars of the steel reinforcement cage shall be at least 5 times the size of the maximum coarse aggregate size of concrete. Hooks at the top of the steel reinforcement cage shall not be bent outward if there is any chance that temporary casing will be used. Similarly, interior hooks must be designed to permit adequate clearance for a concrete tremie pipe, i.e., 12 inches (305 mm) minimum.

The assembled steel reinforcement cage outside diameter must be at least 10 inches (250 mm) smaller than the drilled hole diameter. This clear space is necessary both to permit free flow of concrete up the annular space between the cage and the hole perimeter and to provide adequate concrete cover over the steel reinforcement cage.

The steel reinforcement in the shaft shall be tied and supported so that the steel reinforcement will remain within the allowable tolerances given above. Concrete spacers or other non-corrosive durable spacing devices shall be used at sufficient intervals not exceeding 10 feet (3 m) up the shaft to insure concentric spacing for the entire steel reinforcement cage length. The spacers shall be of adequate dimension to insure a minimum 5 inches (125 mm) annular space between the outside of the steel reinforcement cage and the side of the excavated hole or casing. The spacing of the spirals and/or ties may be adjusted slightly to accommodate the rotation of the centering devices. Cylindrical concrete feet, or approved alternate bottom supports, shall be provided to ensure that the bottom of the cage is maintained 3 inches (75 mm) above the base.

The steel reinforcement cage, consisting of longitudinal bars, spirals and/or ties, cage stiffener bars, spacers, centralizers, and other necessary appurtenances, shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted. The steel reinforcement cage shall be supported by positive methods to prevent its displacement during concrete placement.

945.59 Cement Concrete Placement.

A. General.

Cement concrete placement shall be performed in accordance with the applicable portions of Section 901 and in accordance with the requirements herein. Cement concrete quantities over the theoretical amount required to fill any excavations for the shafts dimensioned on the plans shall be furnished at the Contractor's expense.

The bottom of the shaft shall be sounded immediately before placing concrete. Cement concrete placement for a drilled shaft shall start within 2 hours after the excavation has been completed and approved and the steel reinforcement has been placed and approved. If cement concrete placement is not begun within 2 hours, then the steel reinforcement cage shall be removed and inspected. The Contractor shall remove any caked slurry or soil from the steel reinforcement cage before returning the cage to the shaft, re-clean the bottom, re-circulate, and test the slurry prior to resetting cage. Cement concrete shall be placed in a manner to prevent segregation. Cement concrete placement shall be a continuous operation except for the time interval necessary to remove temporary casings, tremie pipe sections, and to change concrete trucks.

The cement concrete shall remain in a workable plastic state through the placement period. Prior to cement concrete placement the Contractor shall provide test results of both a trial mix and slump test conducted by an approved testing laboratory to demonstrate that the cement concrete meets the above requirements.

If the drilled shaft excavation cannot be pumped free of seepage water at the time of cement concrete placement, the cement concrete shall be placed under water with a tremie pipe or pump hose. Cement concrete placement shall proceed continuously from the bottom of the shaft to the top of shaft elevation shown.

Shaft cement concrete may be placed without mechanical vibration in those areas of the drilled shaft that are not formed or are below the ground line or the water surface.

If caving occurs during concrete placement, the shaft will be rejected and a repair plan shall be submitted by the Contractor to the Engineer for approval.

Should a delay in cement concrete placement occur because of a delay in cement concrete delivery or other factors, the placement rate shall be reduced to maintain a flow of fresh concrete into the shaft excavation. A maximum of 60 minutes shall be allowed between cement concrete placements. No cement concrete older than 90 minutes from batch time shall be placed. Procedures for cement concrete placement shall ensure that the cement concrete within the shaft becomes a monolithic, homogeneous unit. The exposed top of concrete shall be cured a minimum of 7 days by covering with wet burlap overlain with plastic sheets. The burlap shall be kept continuously wet during the entire 7 day cement concrete cure period.

B. Tremie Cement Concrete.

Tremies may be used for cement concrete placement in either wet or dry holes. Tremies used to place cement concrete shall consist of a tube of sufficient length, weight, and diameter to discharge cement concrete at the shaft base elevation. The tremie shall not contain aluminum parts that will have contact with the concrete. The tremie inside diameter shall be at least 6 times the maximum size of aggregate used in the cement concrete mix but shall not be less than 8 inches (200 mm) for tremie pipe or 4 inches (100 mm) for pump hose. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of cement concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or shear bends that restrict cement concrete placement. An alternate delivery system that can be used in case of failure of the primary delivery system shall be provided.

Tremie cement concrete shall be placed so that mixing with groundwater or slurry is avoided. The tremie tube shall be fitted with a valve or plug to prevent the cement concrete placed initially from contacting water before a sufficient head of concrete has been obtained. The bottom of the tremie tube shall be kept a minimum of 5 feet (1.52 m) below the top of the in-place concrete at all times once the cement concrete has reached a depth of 5 feet (1.52 m). The initial placement of the tremie pipe shall be within 12 inches (305 mm) from the bottom of the shaft.

The tremie used for wet excavation concrete placement shall be watertight. Underwater placement shall not begin until the tremie is placed to the shaft base elevation. Plugs shall either be removed from the excavation or be of material approved by the Engineer that will not cause a defect in the shaft if not removed. The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations.

If concrete is placed under water, all displaced water shall be disposed of in an approved manner. When groundwater, the drilling water or slurry in the shaft excavation is to be removed by pumping during concrete placement, a standby pump shall be kept available on-site.

C. Pumped Cement Concrete.

Concrete pumps and lines may be used for concrete placement in either wet or dry excavations. All pump lines shall have a minimum 4 inches (100 mm) diameter and be constructed with watertight joints. Cement concrete placement shall not begin until the pump line discharge orifice is at the shaft base elevation.

Cement concrete shall be placed in a continuous operation so that the cement concrete always flows upward within the shaft. The delivery hose or pipe shall be withdrawn slowly as the elevation of the fresh concrete rises in the shaft. The discharge end of the pipe or hose shall be kept at least 5 feet (1.52 m) below the surface of the cement concrete after the cement concrete has reached a depth of 5 feet (1.52 m). When lifting the pump line during concreting, the Contractor shall temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation. During cement concrete placement, markings on the tremie pipe or pump hose or a sounding device or other appropriate method shall be provided and maintained to determine the relative elevations of the fresh cement concrete surface and the bottom end of the pipe or hose.

For wet excavations, a plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material, approved by the Engineer, which will not cause a defect in the shaft if not removed.

If for any reason, the tremie/pump line is removed during concrete placement, the line must be resealed at the bottom and once again embedded sufficiently below the level of concrete at which the tremie pipe was removed prior to continuation of the pour. Concrete placement can then be continued until fresh uncontaminated concrete has overflowed the top of the shaft. All contaminated concrete must be removed exposing the clean concrete in the shaft.

D. Free Fall Concrete.

The free fall placement of cement concrete shall only be permitted in dry holes. The maximum height of free fall placement shall not exceed 25 feet (7.62 m).

Drop chutes shall be used to direct placement of cement concrete to the base of the excavation, where the maximum depth of water shall not exceed 3 inches (75 mm), without hitting either the steel reinforcement cage or hole sidewall. Drop chutes shall consist of a smooth tube of either one-piece construction or sections that can be added and removed. Cement concrete may be placed through either a hopper at the top of the tube or side openings as the drop chute is retrieved during concrete placement. The drop chute shall be supported so that the free fall of the concrete measured from the bottom of the chute is less than 25 feet (7.62 m) at all times.

If placement cannot be satisfactorily accomplished by free fall in the opinion of the Engineer, the Contractor shall use either tremie or pumping to accomplish the placement of cement concrete.

E. Casing Removal.

If a temporary casing is used during drilled shaft construction, casing removal shall not start until the level of fresh cement concrete within the casing has reached a depth of 10 feet (3 m).

As the temporary casing is withdrawn, a minimum 5 feet (1.52 m) head of concrete above the bottom of the casing shall be maintained.

The elevation of the top of the steel reinforcement cage and the elevation of the top surface of the shaft cement concrete shall be checked before and after temporary casing extraction. Any upward or downward movement of the steel reinforcement cage or any large downward movement of the surface of the concrete during casing extraction shall be cause for rejection of the shaft. A slight downward movement of the casing while exerting downward pressure, or hammering or vibrating the casing will be permitted to facilitate extraction. Casing that cannot be extracted during or immediately after the cement concrete placement operation shall also be cause for rejection of the shaft. A repair plan (or a structural evaluation for temporary casing not extracted from the shaft excavation) for all rejected shafts shall be submitted to the Engineer for approval.

The tops of permanent casings shall be removed to the top of the drilled shaft or the finished ground line, whichever is lower. The tops of permanent casings for shafts constructed in a permanent body of water shall be removed to the low water elevation.

945.60 Inspection.

A. General.

Nondestructive Evaluation (NDE) tests shall be performed on all completed drilled shafts as directed by the Engineer. Such tests may include cross-hole acoustic tests, sonic echo tests, and other specified NDE tests.

B. Cross-hole Sonic Testing.

Cross-hole sonic logging (CSL) is a down-hole ultrasonic test method used to evaluate the condition of the concrete within drilled shafts. The test shall meet ASTM D6760 requirements as modified herein.

This method involves using a piezo-electric transducer (emitter), to generate a signal that propagates as a sound wave (sonic) within the concrete, and another transducer (receiver) is used to detect the signal. Both transducers are placed into a vertical steel pipe filled with water that acts as a coupling medium between the transducer and the tube. These pipes are attached to the reinforcement cage.

The transducers are lowered to the bottom of their respective pipes and placed in the same horizontal plane. The emitter transducer generates a sonic pulse that is detected by the receiver in the opposite pipe. While the pulses are generated, the two transducers are simultaneously raised within the pipes until they reach the top of the drilled shaft. This process is repeated for each possible pipe combination.

The existence of a flaw or defect (void, soil inclusion, or necking within the shaft) will slow down the signal. The signal arrival times are plotted with depth to generate a log for the particular pipe combination. In addition, the energy of each signal (integration of the amplitude with time) is also plotted with depth. Lower energy or longer arrival times would indicate the occurrence and location of the defects.

1. Requirements.

Provisions for sonic testing shall be made for all shafts. The testing subcontractor and test method to be used for sonic testing shall be approved by the Engineer. A record of experience of the testing subcontractor shall be submitted to the Engineer along with written description of the testing procedures, operation manuals for the testing equipment, and samples of previous test results indicating both sound and defective shaft.

2. Installation of Pipes.

The Contractor shall furnish and install a minimum of four 1.5 to 2 inch (38 to 50 mm) internal diameter steel pipes to provide access for sonic testing in each drilled shaft. The pipes shall be installed such that all internal joints are flush.

If the number and placement of the pipes are not called out in the construction drawings, then the following guidelines shall be used:

Shaft Diameter $\leq$ 5 feet (1.52 m)	4 Pipes (Minimum)
5 feet (1.52 m) $<$ Shaft Diameter $\leq$ 8 feet (2.44 m)	6 Pipes (Minimum)
Shaft Diameter $>$ 8 feet (2.44 m)	8 Pipes (Minimum)

The steel pipes shall be connected so that the transducers can pass through unobstructed. The tubes shall be clean from any corrosion or dirt to ensure a good bond between the tube and concrete. The pipes shall be watertight (including at joints) and capped at the bottom and the top. The top cap must be removable (i.e. threaded) for access of the transducers during testing.

The pipes shall be attached to the interior of the reinforcement cage or as specified in the contract documents. However, if the clear spacing between longitudinal bars is less than 5 inches (125 mm), the pipes shall be offset from the rebar cage by 3 inches (75 mm) toward the center of the shaft. The pipes shall be located in a symmetric pattern depending on the size of the shaft and the number of pipes. Tie wire or spacers shall be used to attach the pipes to the reinforcement cage so that they remain as vertical and parallel as possible during cage installation. The pipes shall extend from 6 inches (150 mm) above the bottom of the shaft to 3 feet (915 mm) above the top of the shaft, or ground surface, whichever is higher. The pipes shall not be placed on the bottom of the shaft.

The pipes shall be full of clean water prior to cement concrete placement. The caps must be sealed to prevent debris from entering the pipes after the water is placed. The pipes must be handled with care during installation and capping (i.e. no twisting or impacting). After completion of CSL testing and upon approval of the Drilled Shaft by the Engineer, the water shall be removed from the pipes to be completely filled with a cement or sand-cement grout.

3. Sonic Logging Equipment.

The Sonic Logging equipment furnished by the Contractor shall consist of the following components:

- Ultrasonic emitter and receiver probes capable of producing records with good signal amplitude and energy through concrete.
- A measurement wheel or other suitable linear measuring device to record the depth of the transducers.
- A microprocessor based system, with data filtering/amplification and synchronized triggering of records with pulses, that is capable of permanent recording of data, display of individual records, and printing of logs.
- The Contractor shall also furnish all necessary supplies, support equipment, power, and provide reasonable access to the shaft top for performance of the sonic logging.

4. Sonic Logging Test Procedure

Completed drilled shafts shall be tested between 1 and 7 days after placing of cement concrete. Information on the drilled shafts to be provided to the CSL consultant shall include: Shaft bottom and top elevations, pipe lengths and positions, and construction dates including cement concrete placement.

Sonic Logging shall be performed between all possible tube combinations. Tests shall be performed in the same horizontal plane in all pairs of pipes directly across from each other. Tests involving different horizontal planes would be conducted if requested by the Engineer or when necessary to further evaluate defects.

The probes shall be raised simultaneously from the bottom of the pipes by winch ensuring that all slack is taken out of the cables before the analyzer is switched on. The speed of ascent should be less than 1 foot (305 mm) per second. A depth wheel or similar measuring device shall be used to provide accurate depth measurements. Measurements shall be taken at 0.2 feet (60 mm) intervals or as otherwise directed by the Engineer.

5. Results of Testing.

The Contractor shall provide a CSL Report signed by a Professional Engineer providing the results and recommendations for acceptance or correction of each shaft tested. The report shall include the following:

- The cross-hole sonic logs with potential defects indicated.
- Records of the initial pulse arrival time and energy/amplitude vs. depth for each pipe combination.
- Related interpretation and discussion of the results.

Defects identified by longer arrival times or lower energy signals shall be promptly reported to the Engineer. Any further tests required by the Engineer to evaluate the extent of the defects shall be duly carried out.

6. Acceptance.

Any indicated drilled shaft defects shall require further integrity testing. The Engineer may require other non-destructive tests upon evaluation of the data. These tests may include cross-hole tomography, Single-hole Sonic Logging, Pulse Echo Method, or others.

If the additional tests and records are inconclusive, the Engineer may require coreholes of the defective shaft, at the expense of the Contractor. If the cores show defects in the shaft, these defects shall be repaired at the Contractor's expense by methods acceptable to the Department.

945.61 Drilled Shaft Load Tests.

A. General.

When the contract documents include load testing of shafts, the load test shall be completed before construction of any production drilled shafts. The Contractor shall construct a test shaft in accordance with the provisions of the specifications. The Department's Geotechnical Engineer shall be notified at least 2 working days prior to the start of the load test.

The load test can be performed when 75% of the design compressive strength of the concrete for the drilled shaft is achieved as determined from cylinder breaks. The Contractor shall allow 10 working days for analysis of the load test data by the Engineer before estimated drilled shaft tip elevations are provided for production shafts.

Static load tests shall conform to the requirements of ASTM D1143 (vertical load testing-quick test method) and ASTM D3966 (lateral load testing) or as modified herein.

Other types of Load Tests may be included in a project's Special Provisions. A detailed Testing Plan, in conformance with the specification requirements, shall be submitted to the Engineer for review and approval.

The number and locations of load tests shall be shown on the plans and/or as designated by the Engineer. The load test shafts shall be loaded to a load equal to 3 times the test shaft design load, or to plunging failure, whichever occurs first. Plunging failure is defined as a deflection of the shaft head equal to 5% of the shaft diameter.

B. Osterberg Cell (O-cell) Load Test.

1. Description.

This work shall consist of furnishing all materials and labor necessary for conducting an Osterberg Cell Load Test and reporting the results of the test. The Osterberg Cell, herein called the O-cell, is a calibrated bi-directional loading device capable of applying loads upward and downward, when embedded in a drilled shaft. The drilled shaft used for the load test shall be instrumented by the Manufacturer of the O-cell as directed by the Engineer.

2. Manufacturer's Representative. The Contractor may obtain the services of a licensed Professional Engineer, with O-cell load testing experience, to conduct the test in compliance with these specifications, record all data and furnish reports of the test results to the Engineer. If so, the Manufacturer's Representative shall be present on site during the initial installation and testing of the shaft.

3. Instrumentation and Materials. The Contractor shall supply all instrumentation and materials required to install the O-cell, conduct the load test and remove the load test instrumentation and apparatus as required. Instrumentation and materials include, but are not limited, to the following:

a. One 1 or more O-Cell with appropriate capacity and diameter for the test shaft.
b. Two 2 circular steel base plates, which shall be 2 inches (50 mm) thick and welded to the top and bottom of the cell. Also, a beam or pipe, as required by the manufacturer, to support its placement in the test shaft.
c. High strength pumpable grout with a minimum compressive strength of 4,000 psi (30 MPa) at the time of testing. The quantity necessary to place a 1 to 3 inches (25 to 75 mm) bed below the bottom of the cell will be required. Type III cement may be substituted upon approval of the Engineer.
d. Materials sufficient to construct a stable reference beam system, for monitoring deflection of the shaft, supported at a minimum distance of 3 shaft diameters from the center of the shaft.
e. Materials sufficient to construct a protected work area (such as a tent or shed for protection from direct sun and inclement weather) of sufficient size to accommodate the entire load test apparatus, instrumentation and personnel performing the test.
f. Electric power, as required for lights, welding, instrumentation, etc.
g. Tell-tale extensometers connected to the upper and lower plates of the O-cell, and strain gages applied in pairs at approved intervals throughout the shaft length. The instrumentation shall be able to provide the distribution of stresses along the shaft length and to distinguish bottom displacement from top displacement of the tested shaft.
h. Clean water from an approved source to mix with a water-soluble oil to be provided by the manufacturer's representative, to form the hydraulic fluid pressure used to pressurize the O-cell.

4. Equipment.

The Contractor shall supply equipment required to install the O-cell, conduct the load test, and remove the load test apparatus. Equipment includes but is not limited to:

a. Welding equipment and certified welding personnel, as required to assemble the test equipment, attach pipes, plates and fittings to the O-cell.
b. A suitable pressurized gas source consisting of either an air compressor or of compressed nitrogen.
c. Equipment and operators for handling the O-cell and piping during the installation of the cell and during the conducting of the test, including but not limited to a crane or other lifting device(s) for the cell piping, manual labor, and hand tools as required by the manufacturer's representative.
d. Equipment and labor sufficient to erect the protected work area and monitoring reference beam system, to be constructed to the requirements of the Engineer and the manufacturer’s representative.

5. Procedures.

The O-cell, piping and other attachments will be assembled and made ready for installation under the direction of the manufacturer of the load cell in a suitable area, adjacent to the test shaft, to be provided by the Contractor.

When a reinforcing steel cage is required for the test shaft, the O-cell assembly shall be welded to the bottom of the cage in conjunction with the construction of the cage. If a rebar cage is not required, the load cell and piping shall be supported during installation by suitable means such as two channel beams attached on each side.

When excavation for the test shaft has been completed, inspected, and accepted by the Engineer, a seating layer of concrete or grout shall be placed, by an approved method, at the base of the shaft. The Contractor shall then install the O-cell under the direction of the manufacturer and the Engineer such that the cell is resting firmly in the bed of grout or concrete. The Contractor shall use utmost care in handling the test equipment assembly so as not to damage the instrumentation during installation. Alternatively, the O-cell and its support system can be lowered to near-bottom of the shaft and the center pipe from the cell can be used to grout the space between the cell and the bottom of the shaft so as to firmly seat the cell.

After installation of the cell, the drilled shaft shall be concreted in a manner specified above. However, the Contractor may use high early cement (Type III) in the mix to reduce the time between concreting and testing, when approved by the Engineer.

The load sequence shall be as follows:

a. Apply 5% of the anticipated ultimate capacity of the test shaft, in load increments at 5-minute intervals until the maximum capacity of the cell is reached or until the shaft has failed as determined by the Engineer.
b. At the maximum load or failure load (as determined by the Engineer), maintain the load for a minimum of ½ hour.
c. Remove the load in 10% load increments at 5-minute intervals until zero load is reached.
d. At each load increment, or decrement, movement indicators shall be read at a minimum of 1, 2 and 4-minute intervals while the load is held constant.

During the period required to perform the load test, no drilling or excavation operations on any shaft may be performed. If test apparatus show signs of negative effects due to other construction activities, such activities shall be halted for the duration of the test. After completion of the load test the contractor shall remove any equipment, material, waste, etc., which are not to be part of the finished structure.

6. Report. The contractor will supply 3 copies of a report for each load test detailing the load-movement curves and test data. The report shall be reviewed and approved by the Geotechnical Engineer.

945.62 Defective Drilled Shafts.

Defective drilled shafts are defined as exhibiting flaws that result in inadequate performance (deflections criteria) or unsafe performance (capacities criteria) under the shaft design loads, as determined by the Engineer, based on the shaft construction records, NDE, and load test data.

The Contractor shall submit a plan for remedial action to the Engineer for acceptance. Modifications to the structural integrity and/or load transfer mechanism caused by the remedial action shall require that calculations and working drawings stamped by a Professional Engineer registered in the Commonwealth of Massachusetts for all elements affected, be provided. All labor and materials necessary to complete the remedial work shall be furnished without cost to the Department.

COMPENSATION

945.80 Method of Measurement.

Drilled shaft excavation will be measured for payment on a length basis by the foot (m) of completed drilled shaft excavation of the diameter shown on the plans measured along the centerline of the shaft from the bottom to the top of the completed shaft excavation or to the mud line if under water, less the measured length of obstruction excavation and less the measured length of rock socket excavation. Measurement shall be to the nearest 1/10 of a foot (m).

Rock socket excavation will be measured for payment on a length basis by the foot (m) of completed rock socket excavation of the diameter shown on the plans measured from the highest point of encountered rock within the rock socket to the bottom of rock socket. Measurement shall be to the nearest 1/10 of a foot (m).

Obstruction excavation, after designation as obstruction excavation by the Engineer, will be measured for payment on a length basis by the foot (m) of completed obstruction excavation of the shaft diameter indicated on the plans. Measurement shall be to the nearest 1/10 of a foot (m).

Trial drilled shafts that are accepted, including backfill when required, will be measured for payment by the foot (m) of completed trial drilled shaft of the diameter shown on the plans measured along the centerline of the trial shaft from the bottom of completed trial shaft to the top of the completed trial shaft or to the mud line if under water. Measurement shall be to the nearest 1/10 of a foot (m).

Drilled shafts, of the cement concrete and steel reinforcement as shown on the plans, will be measured for payment on a length basis by the foot (m) of completed drilled shaft of the diameter shown on the plans measured along the centerline of the shaft from the bottom of the rock socket or shaft excavation to the top of the completed shaft or to the mud line if under water. Measurement shall be to the nearest 1/10 of a foot (m).

Permanent casing will be measured for payment on a length basis by the foot (m) of permanent casing of the diameter shown on the plans measured along the centerline of the shaft from the bottom to the top of the permanent casing. Measurement shall be to the nearest 1/10 of a foot (m).

Cross-hole sonic logging (CSL) access pipes will be measured on a length basis by the number of feet (m) of pipes installed and grouted (upon acceptance of testing) regardless of whether sonic testing is performed.

Cross-hole sonic logging (CSL) sonic testing shall be measured on an each basis per shaft tested.

Osterberg load cell axial load testing shall be measured on an each basis per shaft tested.

Conventional axial load testing shall be measured on an each basis per shaft tested.

945.81 Basis of Payment.

Drilled shaft excavation will be paid at the contract unit price per foot (m) of completed drilled shaft excavation of the diameter shown on the plans. Payment for drilled shaft excavation shall be considered complete compensation for temporary casing, water control, removal from the site and disposal of excavated materials, using slurry as necessary, tools and drilling equipment to excavate the shaft, and furnishing all other labor, materials and equipment necessary to complete the drilled shaft excavation. If larger diameter drilled shaft excavation than that specified on the plans is performed at the Contractor's option, no additional compensation will be provided to perform this oversized drilled shaft excavation.

Rock socket excavation will be paid at the contract unit price per foot (m) of completed rock socket excavation of the diameter shown on the plans. Payment for rock socket excavation shall be considered full compensation for water control, removal from the site and disposal of excavated materials, drilling equipment, procedures to excavate the rock socket to the required depths, and all labor, materials, equipment, and tools necessary to complete the rock socket excavation. If larger diameter rock socket excavation than that specified on the plans is performed at the Contractor's option, no additional compensation will be provided to perform this oversized rock socket excavation.

Obstruction excavation, after designation as obstruction excavation by the Engineer, will be paid at the contract unit price per foot (m) of completed obstruction excavation of the shaft diameter indicated on the plans. Payment for obstruction excavation shall be considered full compensation for water control, removal from the site and disposal of excavated materials, drilling equipment, procedures to excavate the obstruction to the required depths, and all labor, materials, equipment, and tools necessary to complete the obstruction excavation. If larger diameter obstruction excavation than that specified on the plans is performed at the Contractor's option, no additional compensation will be provided to perform this oversized obstruction excavation.

Trial drilled shafts that are accepted will be paid at the contract unit price per foot (m) of completed trial drilled shaft of the diameter shown on the plans. Payment for trial drilled shafts shall be considered full compensation for the excavation of the trial shaft hole through whatever materials are encountered to the authorized bottom of trial shaft, including obstructions, temporary casings, backfilling the hole with unreinforced concrete, restoring the site as required, and all other incidentals necessary to complete the trial drilled shaft. If larger diameter trial drilled shaft than that specified on the plans is performed at the Contractor's option, no additional compensation will be provided to perform this oversized trial drilled shaft.

Drilled shafts, of the diameter, cement concrete and steel reinforcement as shown on the plans, will be paid at the contract unit price per foot (m) of completed drilled shaft. Payment for drilled shafts shall be considered full compensation for all cement concrete, steel reinforcement, labor, materials, equipment, and all other incidentals necessary to complete the drilled shaft. This payment shall include all cement concrete and steel reinforcement that extends into rock sockets, if any, and all steel reinforcement that is embedded in the shaft and extends above the top of the shaft to the point where it connects to any steel reinforcement that is not embedded in the drilled shaft. Bracing, centering devices, and support devices for the steel reinforcement cage shall be considered incidental to the work. If a larger diameter drilled shaft than that specified on the plans is constructed at the Contractor's option, no additional compensation will be provided to perform this oversized drilled shaft construction.

Permanent casing shall be paid at the contract unit price per foot (m) of permanent casing of the diameter shown on the plans furnished and installed in the drilled shafts. Payment for permanent casing shall be considered full compensation for all labor, materials, equipment, and all other incidentals necessary to complete the permanent casing.

Cross-hole sonic logging (CSL) access pipes shall be paid at the contract unit price per foot (m) of access pipe installed. Payment for cross-hole sonic logging (CSL) access pipes shall be considered full compensation for the supply and installation of the pipe and the grouting of the pipes after testing.

Cross-hole sonic logging (CSL) sonic testing shall be paid at the contract unit price per shaft tested. No payment shall be made for supplementary sonic logging testing required to further evaluate any shaft defects detected by the initial cross-hole sonic logging (CSL) sonic test. Payment for cross-hole sonic logging (CSL) sonic testing shall be considered full compensation for the performance of the test, including all labor, equipment, and materials incidental to the test instrumentation, data collection, and report.

Osterberg load cell axial load testing shall be paid for at the contract unit price per each Osterberg load cell axial load test completed and accepted. Payment for Osterberg load cell axial load testing shall be considered full compensation for the performance of the load test, including all labor, equipment, and materials incidental to the test instrumentation, data collection and report (and subsequent removal of test apparatus and appurtenances) prepared under the direction of the Engineer and the manufacturer's representative.

Conventional axial load testing shall be measured on an each basis per shaft tested.

945.82 Payment Items.

945.1*	Drilled Shaft Excavation * Feet Diameter	Foot
945.2*	Rock Socket Excavation * Feet Diameter	Foot
945.3*	Obstruction Excavation * Feet Diameter	Foot
945.4*	Trial Shaft * Feet Diameter	Foot
945.5*	Drilled Shaft * Feet Diameter	Foot
945.6*	Permanent Casing * Feet Diameter	Foot
945.1*	Drilled Shaft Excavation * Millimeter Diameter	Meter
945.2*	Rock Socket Excavation * Millimeter Diameter	Meter
945.3*	Obstruction Excavation * Millimeter Diameter	Meter
945.4*	Trial Shaft * Millimeter Diameter	Meter
945.5*	Drilled Shaft * Millimeter Diameter	Meter
945.6*	Permanent Casing * Millimeter Diameter	Meter
945.71	Cross Hole Sonic Testing Access Pipes	Foot
945.72	Cross Hole Sonic Test	Each
945.81	Osterberg Load Cell Axial Load Test	Each
945.82	Conventional Axial Load Test	Each

* = as per MHD Standard Nomenclature

SECTION 950
SHEETING

SUBSECTION 950.80 Method of Measurement.

(page 304 English, page II.273 Metric) Replace the last sentence of the first paragraph with the following:

Otherwise the Contractor may remove or abandon the sheeting, but only to the extent permitted by the Engineer.

(page 304 English, page II.273 Metric) Replace the second paragraph with the following:

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 board foot measure (MBF) 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.

SUBSECTION 950.81 Basis of Payment.

(page 304 English, page II.273 Metric) Replace the second paragraph with the following:

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 board foot measure (MBF) for Lumber Sheeting or Wood Sheeting.

SUBSECTION 950.82 Payment Items.

(page 304 English, page II.273 Metric) Change Cubic Meter and MBM where encountered to MBF.

SECTION 955
TREATED TIMBER

SUBSECTION 955.40 General.
(page 305 English, page II.274 Metric) Replace this Subsection with the following:

Material shall meet the requirements specified in the following Subsections of Division III, Materials:

Wood Products	M9.05.1
Wood Preservative	M9.05.5
Fastenings	M8.01.5
Tar Paper	M9.06.2

SUBSECTION 955.60 General.
(page 305 English, page II.274 Metric) Replace the first two paragraphs of this Subsection with the following:

Treated timber shall be carefully handled, stored, and fabricated in accordance with AWPA M4 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. Borings, cuts, holes and other machining of wood shall be done prior to preservative treatment whenever possible. All cuts, holes, and injuries such as abrasions which occur after preservative treatment shall be field treated in accordance with AWPA M4. The Contractor shall provide the Engineer with a written copy of AWPA M4 Treatment Specification before any field treatment work is performed.

SUBSECTION 955.80 Method of Measurement.
(page 305 English, page II.274 Metric) Replace the first paragraph of this Subsection with the following:

All treated timber used will be measured by the thousand board foot measure (MBF), in place.

SUBSECTION 955.81 Basis of Payment.
(page 305 English, page II.275 Metric) Replace this Subsection with the following:

Treated timber will be paid for at the contract unit price per thousand board foot measure under the item for Treated Timber complete in place.

SUBSECTION 955.82 Payment Items.
(page 305 English, page II.275 Metric) Replace this Subsection with the following:

955.	Treated Timber	MBF

SECTION 960
STRUCTURAL STEEL

SECTION 960 STRUCTURAL STEEL
(page 306 English, page II.275 Metric) Replace the existing Section with the following:

SECTION 960
STRUCTURAL STEEL AND MISCELLANEOUS METAL PRODUCTS

DESCRIPTION

960.20 General.

This section shall apply to the furnishing, fabrication, erection and coating of all structural steel and metal work in the contract.

MATERIALS

960.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III - Materials:

Structural Steel M8.05.0
Stud Shear Connectors M8.04.1
Steel Pins M8.04.2
High 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

If a Contractor proposes to use steel from sources other than a mill, the source must be approved by the Engineer. The Contractor shall supply 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 the specifications. All sources must supply the actual mill test reports prior to the start of fabrication. Material shall be identified with the MassDOT contract number, material specification, and heat number.

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 that contain more than one bridge, each bridge will be considered separately in submitting shop drawings. Shop work may commence on each bridge when the entire set of shop drawings for that bridge are approved.

On projects which contain complicated steel structures such as a 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 may commence on each section as the shop drawings for that section are approved.

Fabrication shall not begin until the drawings are approved. Work performed prior to shop drawing approval is at the contractor's risk and may require additional inspection, NDT, or partial disassembly/reassembly to satisfy the Verification Inspector.

960.61 Design, Fabrication and Erection.

All structural steel and appurtenant material shall be designed, fabricated, coated 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)*. All aluminum material shall be designed, fabricated and erected in accordance with these specifications, the *AASHTO Standard Specifications for Highway Bridges*, and the *AWS Structural Welding Code - Aluminum (ANSI/AWS D1.2)*. All stainless steel material shall be designed, fabricated, and erected in accordance with these specifications, the AASHTO Standard Specifications for Highway Bridges, and the AWS Structural Welding Code – Stainless Steel (ANSI/AWS D1.6). All steel tubular material shall be designed, fabricated, and erected in accordance with these specifications, the AASHTO Standard Specifications for Highway Bridges or the AASHTO Standard Specifications for Highway Signs, luminaries, and Traffic Signals, and the AWS Structural Welding Code - Steel (ANSI/AWS D1.1).

FABRICATION.

Fabricators.

Fabricators shall be approved for work in one or more of the following three categories; *Major Bridge Structures*, *Simple Bridges and Miscellaneous Steel Fabrication*, or *Poles, Sign Supports, Etcetera*. Fabricators approved to perform work in the *Major Bridge Structures* category are also approved to perform work in the *Simple Bridges and Miscellaneous Steel Fabrication* category. Fabricators of major bridge structures including rolled beams with coverplates, girders, and more complex work shall meet the requirements of AISC Category *Major Steel Bridges* with the *Fracture Critical Endorsement* if applicable. Fabricators of simple bridges and miscellaneous steel, which includes rolled beams without coverplates, steel products such as expansion joints, bridge rail, etcetera shall meet the requirements of AISC Category *Simple Steel Bridges*. Fabricators of poles and sign supports shall meet the requirements of AISC Category *Simple Steel Bridges*. A list of approved fabricators may be obtained from the MassDOT website at www.mass.gov/dot.

Fabricators wishing to be approved by the Department 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 Welder 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 Quality Program Certificate.

After receiving the material listed above, the Engineer shall review it and conduct a shop inspection before approval may be granted.

The Contractor shall submit a shop schedule to the Engineer. The shop schedule shall be provided sufficiently in advance for the Engineer to determine the level of verification inspection required and to arrange for the inspector's attendance. The shop schedule shall include the date fabrication will begin, the approximate date it will be completed, and hours of operation including time and date work is to be performed on all shifts. A revised schedule may be submitted at any time. No material shall be fabricated until the shop schedule has been reviewed. No work shall be performed on second and third shifts unless specifically indicated on the shop schedule.

The Contractor will be required to submit to the Department's Inspector, for approval, three certified copies of the mill test reports for each heat number of steel and aluminum furnished. These certificates shall certify compliance with the specifications and shall give the chemical and physical analysis of the metal. Any cost involved in furnishing the certificates shall be considered incidental to the work . These reports shall be given to the Verification Inspector in advance of shipping so that this inspector has sufficient time to properly review the reports. No material shall be shipped until the reports are reviewed and approved by the Verification Inspector.

Written procedures shall be submitted by the Contractor and approved by the Engineer for the following fabrication processes: material traceability; hot bending; welding; cambering and heat curving; shop assembly/laydown; postheat and stress-relieving; shop installation of fasteners; and blast cleaning and coating. These procedures may be standardized and are not required to be resubmitted for each project.

Inspection.

Quality Control inspection and testing is the responsibility of the fabricator and shall be performed by a sufficient number of qualified inspectors to guarantee product integrity. Quality control inspection shall be performed throughout the entire fabrication process from receiving material to shipping the final product.

Quality Control Inspectors at the fabricating shop shall be certified by the American Welding Society in accordance with the provisions of the Standard for Qualification and Certification of Welding Inspectors (AWS QC1). At least one inspector on each shift shall be a Certified Welding Inspector (CWI). The Engineer, upon written request from the fabricator, may accept other certifications or experience and training consistent with AWS QC1. Assistant inspectors may be used to perform specific inspections under direct supervision of a Quality Control Inspector. For projects requiring greater than 1,500 square feet (140 m^2) of steel surface to be painted, the inspector shall have completed, as a minimum, NACE Level I certification or received other formal training acceptable to the Engineer.

Verification Inspectors will be employed by, and act on behalf of, the Department. The inspector has the authority to act for the Engineer on matters relating to quality including inspection and testing, within the scope of the contract. Verification Inspectors will be assigned at the discretion of the Engineer. The presence or absence of the Verification Inspector does not relieve the Contractor of Quality Control responsibility.

The fabricator shall provide facilities, for the Verification 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 square feet (12 m^2). The office shall contain a telephone with an outside line suitable for modem communication and a system of heating and cooling that will maintain a temperature of 68 to 72°F (20 to 22°C). The fabricator shall also supply ready access to fax and copy machines and adequate parking.

The fabricator shall maintain adequate inspection records. Such records shall be signed by the Quality Control Inspector and provided to the Verification Inspector. No material shall be shipped to the job site 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/her stamp on the material. The Verification Inspector shall affix his/her stamp only when the material is ready for shipment and properly loaded on trucks or rail cars. Material delivered to the job site without such stamp affixed will be considered rejected and immediately returned to the Contractor.

Process.

Steel shall be blast cleaned prior to starting fabrication. Fabrication includes, but is not limited to, drilling, cutting, and welding. The blast cleaning shall conform to the SSPC SP10 "Near-White Blast Cleaning".

Heat numbers shall be transferred, in the presence of the Verification Inspector, to all pieces that are to be major component parts of a main member. Main members are considered to be all webs, flanges, coverplates, floorbeams, stringers and diaphragms on horizontally curved girders as well as any other members as specified on the drawings. Heat numbers are not required to be transferred to component parts of secondary members or to minor components of a main member, i.e. stiffeners, clip angles, etc..

For primary members, the plate components and splice plates shall be cut with the direction of rolling parallel to the direction of primary stresses. For those plates thicker than 5/8 inch (15 mm), plane 3/16 inch (5 mm) off sheared edges that remain exposed after fabrication.

Welding shall not commence until the welding procedures and welder certifications have been approved by the Engineer. All welding procedures shall conform to the applicable welding code, (i.e. AASHTO/AWS Bridge Welding Code, the AWS Structural Welding Code - Aluminum, AWS Structural Welding Code - Reinforcing Bars, etc.) as determined by the Engineer. Shop welders shall be certified in accordance with the applicable AWS Welding Code as determined by the Engineer. All field welders shall be certified by the Department and possess the Department's Welder Qualification Test Record and the Welder Qualification Certificate.

Material fabricated that does not meet the plans and specifications will not be incorporated into the work. Repair procedures, other than those allowed under the Bridge Welding Code, shall be submitted by the Contractor to the Engineer for approval.

Structural rolled beams shall be cambered to the amount shown on the plans with a tolerance of -0, +½ inch (-0, +12 mm) for beams 50 feet (15 m) or less. For beams greater than 50 feet (15 m), the plus tolerance of ½ inch (12 mm) shall be increased by 1/8 inch (3 mm) for each 10 feet (3m) or fraction thereof in excess of 50 feet (15 m).

Plate girders shall be cambered to the amount shown on the plans with a tolerance as specified in the AASHTO/AWS Bridge Welding Code.

The beams and girders shall be handled and stored in such a manner that they will have the required camber after erection.

When steel beams or girders are to be spliced in the field, they shall be assembled in the no load position in order that the assembly, including camber, alignment, accuracy of punched holes and fit of beam or girder ends may be done in accordance with the requirements of the type of splice. When members are assembled with the webs vertical, they shall be supported at intervals no greater than 20 feet (6 m). The requirements of AASHTO for shop assembly shall apply. Reaming of holes shall be performed in accordance with AASHTO. Hand held reamers shall not be used.

All detrimental material, such as oil, grease, dirt, slag, etc. shall be removed from unpainted portions of all weathering steels prior to shipping. Fascia beams/girders shall be reblasted to remove staining and heat marks.

All structural parts shall be provided with adequate drain holes at points where water could otherwise accumulate.

Dimensions indicated at expansion joints and similar construction are determined for a temperature of 50°F (10°C). 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, after coating, 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.

Storage and Shipping.

Fabricated material shall be handled with chain softeners, and stored in a manner that protects it from damage, facilitates subsequent inspections, and does not compromise the safety of personnel. Proper consideration shall be given to guard against lateral buckling of unsupported beams and girders. Material shall be stored above the ground on skids or other supports. Fabricated material shall be kept free of dirt, grease and other foreign matter and shall be stored in a way to facilitate drainage when stored outside.

Marking and shipping shall conform to AASHTO Division II Section 11. Hold down softeners shall be used to prevent chain marks on the material during shipment. Structural members shall be shipped in the upright position. Structural members shipped on truck beds or supported on dollies shall not cantilever behind same in excess of 25 percent of their length. Other shipping configurations shall require calculations by a licensed professional engineer that demonstrate that the member will not be overstressed during shipment. The calculations shall use a load, including impact, of not less than 300 percent of the dead load.

Connections Using High Strength Bolts.

The certification, testing, installation and inspection for all high strength bolts shall conform to the requirements of the current edition of the AASHTO Standard Specifications for Highway Bridges, except as amended herein.

A. Documentation

Mill Test Reports shall be furnished for all mill steel used in the manufacture of bolts, nuts or washers. These reports shall indicate the place where the material was melted and manufactured.

The manufacturer shall furnish Manufacturers Certified Test Reports for the items supplied. These reports shall show the relevant information required. The manufacturer performing the rotational-capacity test shall include in the test report:

1. The lot number of each item tested.
2. The rotational-capacity lot number.
3. The results of all tests.
4. The location and date of tests.
5. A statement that the Manufacturer's Certified Test Report for the items are in conformance to this specification and the appropriate AASHTO specifications.
6. The location where the bolt assembly components were manufactured.

The Distributor shall include the Manufacturer's Certified Test Reports for the various bolt assembly components. The rotational-capacity test may be performed by the distributor (in lieu of the manufacturer) and reported on a Distributor Certified Test Report. This report shall show all the information required on the Manufacturers Certified Test Report. The Distributor shall certify that the manufacturer's reports are in conformance to this specification and the appropriate AASHTO specifications.

B. Installation.

All bolting shall be performed using the calibrated wrench method or the turn of the nut method in accordance with the current edition of AASHTO. Regardless of the tightening method used, particular care should be exercised so that the snug tight condition is achieved. In addition, the rotational-capacity tests described in Section M8.04.3 shall be performed at the job site on each rotational-capacity lot number prior to the start of bolt installation. Hardened washers are required as part of the test even though they may not be required in the actual bolt assembly.

A Skidmore-Wilhelm Calibrator or an acceptable equivalent tension measuring device shall be required at each job site during erection. The Contractor shall submit to the Engineer a certification that the calibration device has been checked by qualified personnel acceptable to the Engineer within the previous thirty days. The device must also be checked for accuracy upon completion of the work on the project and proof of this certification must be submitted to the Engineer.

C. Shipping.

Bolts, nuts and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation. Bolts, nuts and washers shall remain in their original container(s) until installation. If it is necessary to place the bolts in a different container, these new containers shall be labeled with all appropriate information and be shipped with a copy of the original documentation. The new containers shall be stamped by the Verification Inspector prior to shipping to the job site.

Nondestructive Testing.

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 these tests.

When ultrasonic testing is required, it shall be performed by technicians who meet the Level II qualifications above and who shall be qualified by a written examination and performance test administered by the Engineer. The Engineer, at his/her discretion, may accept other properly documented certifications and tests.

Nondestructive testing shall be performed by the Contractor in accordance with the procedures and standards set forth in the AASHTO/AWS Bridge Welding Code or other applicable code. The Department reserves the right to perform additional testing at its own cost during fabrication and up to final acceptance of the project. All welding must meet acceptable quality standards which are defined by the acceptance criteria for the particular test method.

All nondestructive testing shall be witnessed by the Department's Verification Inspector. Certification that all tests were performed in the presence of the Inspector shall be furnished to the Engineer. In addition to that required by the Bridge Welding Code, all radiographs shall be identified as to date, bridge number and girder or beam number. All costs for these tests, including necessary rework and repair, shall be at the Contractor's expense. A copy of all NDT reports shall be given to the Verification Inspector.

Heat Cambering and Curving.

A. General

The Maximum allowable temperatures when applying heat to the steel is 1200°F 650°C () for AASHTO M 270M/M 270 Grades 250, 345 and 345W (Grades 36,50 and 50W) steels and 1100°F (600°C) for AASHTO M 270M/M 270 Grades HPS345W and HPS485W (HPS50W and HPS70W) steels.

Bending and curving may be accelerated by the use of external forces (preload). The stresses induced due to the preload (including loads induced by the member weight) shall be limited to 25 ksi (172 MPa). Calculations showing the maximum external force to apply shall be submitted to and approved by the Engineer. The Contractor shall show the relationship between the maximum allowable external force and the maximum allowable stress. The external force shall be applied before heating and not increased by external means during heating or cooling. Jacks shall not impede contraction during the cooling phase and they shall not produce local buckling.

Heat patterns shall be marked on the steel prior to heating. The steel shall be brought to the appropriate temperature as rapidly as possible. Heating torches shall be manipulated to avoid overheating of the steel. Care shall be taken to avoid the buckling of relatively thin, wide plates.

The temperature of the steel shall be monitored with temperature sensitive crayons, pyrometers or infrared non-contact thermometers. The temperature shall be measured 5 to 10 seconds after the heating flame leaves the area to be tested. After the steel has cooled to 600°F (315°C), rapid cooling with dry compressed air or a water mist is permitted. Care shall be taken to avoid burns when using the water mist.

The steel shall be cooled to below 250°F (120°C) before applying another set of heat patterns. When using V-heat patterns, a location may be reheated after applying at least three sets of heating patterns at other locations.

B. Heat Curving for Sweep

When the radius is less than 1000 feet (300 m), heat curving shall be performed with the web in the horizontal position or preload to induce stress prior to heating when curving with the web in the vertical position. When heating with the web vertical, the member shall be sufficiently supported so that the member will not deflect laterally, overturn or twist. Intermediate safety catch blocks shall be provided to prevent buckling or excessive local deformations.

C. Heat Curving for Camber

The member shall be supported when heating with the web in the vertical position. The supports shall be spaced to take maximum advantage of the dead load of the member and shall be placed prior to heating. If the web is in the horizontal position, care shall be taken when applying the external force and safety catch blocks shall be used to prevent sudden spring back of the beam in case the jacks slip.

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, who is familiar with these Specifications, AASHTO, the work, and experienced in this technical field. All submitted sheets shall be stamped by the supervising Engineer.

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. The manufacturer's rated capacity of the crane and of all lifting and connecting devices shall be adequate for 125% of the total pick load including spreaders and other material except that in the areas within the potential influence area of the crane where railroad, vehicular or pedestrian traffic has access, the rated capacity shall be adequate for 150% of the total pick load. The limits of the potential crane influence area shall be taken as circular areas with radii matching the boom length and radius points located at the boom pivot point. Crane capacity rating charts and the rated capacity of all lifting and connecting devices shall be clearly shown in the submittal. The 125% or 150% factors of safety are to be used in addition to any factors of safety used by the manufacturer to calculate the rated capacity.
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 counterweights, 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.

The stresses shall be investigated at each stage of erection with allowance for wind pressure determined by the table shown below.

Height of Members Above Ground * Feet (m)	Wind Pressure Pounds per Square Foot (kPa)	
	Beams & Girders	Trusses
15 (5)	21.0 (1.0)	31.5 (1.5)
30 (10)	25.5 (1.3)	38.5 (1.9)
50 (15)	28.0 (1.4)	42.0 (2.0)
100 (30)	32.0 (1.6)	48.0 (2.3)
300 (90)	39.0 (1.9)	58.5 (2.8)

* For heights not given wind pressures shall be interpolated.

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 cross frames connected to provide necessary lateral stability. All trusses shall be erected on falsework. The falsework shall provide for proper camber and alignment and shall be properly designed, constructed, and maintained for the loads that 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. 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. Plans, details, and calculations shall be submitted to the Engineer in those instances where changes in an existing structure are necessary to maintain traffic

The Contractor shall keep a full record of piles driven for falsework. 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 least 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 stringer lines as the work progresses.
4. Dimensions indicated at expansion joints and similar construction are determined for a temperature of 10°C (50°F). Proper adjustments must be made when the structure is placed at any other temperature.

After the erection of beams and girders has been completed, expansion bearing sole plates shall be re-aligned so that they will be centered at 50°F (10 °C).

960.62 Preparation of Bridge Seats.

The bridge seats for the bearing devices shall be prepared in accordance with Section 901.65, A., 3. *Preparation of Bridge Seat Bearing Areas.*

960.63 Painting.

General.

The paint system used shall be approved by the Northeast Protective Coating Committee (NEPCOAT). A copy of the NEPCOAT Qualified Products List may be obtained from the MassDOT website at www.mass.gov/dot. Prior to the start of painting, each batch of paint shall be sampled, tested and approved in accordance with Section M7.

For contracts requiring greater than 1,500 square feet (140 m^2) of painted steel surfaces, the contractor or subcontractor performing surface preparation, and field coating of structural steel in the field must be pre-qualified by the Department in the Painting (Structural) category. For surface preparation and painting in the shop a current AISC Sophisticated Paint Endorsement (SSPE) or SSPC QP3 certification is required.

The prime coat shall be applied in the shop. The remaining coats may be applied in the shop or in the field at the Contractor's option.

Structural steel meeting AASHTO M 270/M 270 M Grade 345W (50W), Grade 485HPS (70HPS) and other weathering steels shall not be painted except when and where specifically called for on the plans. When weathering steel is painted, the finish coat color shall conform to Federal Standard 595B, "Colors Used in Government Procurement", color chip no. 30045.

All structural steel surfaces excluding the surfaces of weathering steel that is to remain uncoated, shall receive three coats of paint. All surfaces of this steel that come in contact with concrete shall be painted with the prime coat only. If the entire paint system is applied in the shop, the steel surfaces in contact with concrete shall receive all three coats. Surfaces not in contact but inaccessible after assembly erection shall be painted in the shop with the prime coat followed by one coat of coal tar epoxy polyamide paint (M7.05.21) having after application a minimum dry film thickness of 200 micrometers (8 mils).

The flange surfaces to which shear studs are to be field welded shall receive a mist coat of the prime coat, having after application a minimum dry film thickness of 25 to 40 micrometers (1 to 1½ mils).

The faying surfaces of all field bolted splices and other faying surfaces, except weathering steel in areas where no paint is specified, shall have the faying surfaces painted with the prime coat only. This prime coat shall have a slip coefficient of Class B.

Application of organic zinc, epoxy, and urethane systems shall not be done when the relative humidity is above 85% or when the surface temperature of the steel is less than 5°F above the Dew Point. Paint shall not be applied when the surface temperature is below 40°F or when the surface temperature is above 125°F.

Paint shall not be applied when, in the Engineer's judgment, conditions are or will become unsatisfactory for application and proper cure. All changes as to the application parameters other than specified must be the manufacturer's and presented in writing and approved by the Engineer. Ambient conditions should be closely monitored so that proper cure/drying is achieved prior to recoat. In no case shall a succeeding coat of paint be applied before the previous coat has cured/dried sufficiently for recoat as per manufactured data sheet.

Measurement of the ambient conditions shall be done in accordance with ASTM E337 Test Method for "Measuring Humidity with a Psychrometer" (the Measurement of Wet and Dry bulb Temperatures).

All coats of paint shall be from the same manufacturer. The colors of the shop coat, second coat, and the top coat shall have a definite color contrast between them. The prime coat shall be tinted red or green so as to contrast with the blast cleaned steel.

The application contractor is required to conduct and document quality control inspection of the cleaning and painting operations including, at a minimum, measurements of ambient conditions, surface profile, surface cleanliness, coating material acceptability, dry film thicknesses, and visual inspection for coating defects. The data shall be recorded in an applicator log maintained at the painting site and be available for the Owner's review during working hours. This applies to the application of all three coats.

The Contractor shall supply mechanical paint mixers on the job. Paints shall be mixed in clean containers and agitated thoroughly before drawing off paint through a strainer into the painter's buckets 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 shall not produce a dry film thickness less than that specified. The method used to thin the paint and the thinner used

The steel shall not be shipped from the shop to the field in less than 2 days after the application of the last coat of paint.

Bolts nuts and washers shall be solvent cleaned and dried prior to painting.

The contractor shall take appropriate precautions to avoid damaging the coating during erection.

After erection and after the finish coat of paint has been applied, the date (year, month) of painting and the bridge and BIN numbers shall be stenciled on the bridge as directed by the Engineer. The characters shall be 3 inches (75 mm) in height and be furnished by the Contractor at his/her expense.

Prime Coat.

Steel shall not be painted until shop fabrication is complete. All welds shall be cleaned thoroughly in accordance with good practice and shall have a suitable surface to accept the primer. There shall be no evidence of oil, grease, dirt or other foreign matter on the steel. All surfaces shall be returned to an SSPC SP10 condition. The steel shall have a surface profile of 25 micrometers (1 mil) minimum and 75 micrometers (3 mils) maximum measured with a profile depth tape and micrometer. Profile depth tape measurements shall be retained and submitted for the Engineer's approval. The abrasive cleaning material shall meet the requirements of SSPC-AB 1, "Mineral and Slag Abrasives", SSPC-AB2, "Cleanliness of Recycled Ferrous Metallic Abrasives", or SSPC-AB 3, "Newly manufactured or Re-Manufactured Steel Abrasives", and the condition and cleanliness of the recycled abrasives shall be checked daily or as directed by the Engineer.

All sharp corners shall be broken prior to final cleaning (profiling) and prime painting. Sharp corners may usually be removed by a single pass with a grinder. Thermal cut edges (TCE) to be painted shall be ground before final cleaning (profiling).

To provide adequate film thickness in areas or places prone to breakdown, edges, corners, bolts, nuts, and welds shall be striped by brush painting. The paint when applied, shall be so manipulated under the brush as to produce a uniform even coating, conforming to the dry film thickness, as specified by the manufacturer on the surface being painted. Stripe coating of the primer shall be completed prior to the application of the full prime coat The steel shall then receive one shop coat having after application a minimum dry film thickness of 75 micrometers (3 mils). Paint shall not be applied to shop contact surfaces. . Machined finished surfaces, except abutting joints and base plates, shall be coated with a material suitable to the Engineer.

Intermediate and Finish Coat.

The steel painted in the shop or field shall receive an intermediate coat having after application a minimum dry film thickness of 100 micrometers (4 mils). Within 24 hours of the application of the intermediate coat, the steel shall receive the finish coat having after application a minimum dry film thickness of 75 micrometers (3 mils). The manufacturers' recommendations for recoating shall be followed.

When the erection of the steel is fully complete and the intermediate and finish coats are to be put on in the field, all adhering rust, scale, concrete, dirt, laitance, grease, welding flux and slag, white rust or other foreign matter shall be removed from the steel. 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 (bolts, welds, etc.); the base metal that has become exposed; or any surface from which the shop coat has become defective shall be thoroughly covered with one coat of the same paint used in the shop. The minimum dry film thickness after application shall be 75 micrometers (3 mils).

When the erection of the steel is fully complete and the intermediate and finish coats were put on in the shop, all adhering rust, scale, concrete, dirt, laitance, grease, and other foreign matter shall be removed from the steel. Damaged coating shall be touch-up with the same finish coat that was used in the shop. Exposed steel surfaces including but not limited to bolts and weld metal shall be thoroughly cleaned as stated above and painted in the field with the primer, intermediate and finish coats. The minimum dry film thickness shall be 75 micrometers (3 mils) for the primer.

Minor coating defects, handling damage and other occasional nonconformances, and destructive test sites shall be repaired in accordance with SSPC-PA 1 and/or the manufacturer's recommendations. The applicator shall submit repair procedures for substantial damage, significant defects, or widespread (gross) nonconformances in the coating for the Engineer's approval. Repairs to the topcoat must result in an acceptable, uniform gloss and color. The Engineer shall have final authority concerning the coating's uniformity and acceptable appearance.

In order to avoid subsequent discoloring or staining due to dripping or running of concrete, the field coats of paint shall not be started 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 the painting operations. Full protection shall be provided in the field for all private property.

Environmental Protection Requirement For Field Painting.

The Contractor shall design, install, and maintain a containment system in accordance with Subsection 961.67 Containment for a containment Class 3A, Coating Application.

960.64 Galvanizing.

The following shall be hot dipped galvanized in accordance with Section M7 of these Specifications:

1. Diaphragms, cross frames, utility supports and bottom lateral bracing elements that are composed of non-weathering steels or weathering steels designated to be coated.
2. All sole plates and masonry plates (except sole plates for sliding elastomeric bearings).

Galvanized members requiring shop fabrication and assembly shall be cut, welded, and/or drilled prior to galvanizing. Members to be milled shall be galvanized prior to milling. A thin layer of a rust inhibitor shall be applied to the milled surface.

Galvanized members that are to be welded after galvanizing shall be masked 1 inch (25 millimeters) on either side of the weld line prior to galvanizing. After welding, the weld areas shall be cleaned in accordance with the SSPC-SP3 "Power Tool Clean" and coated with "High Zinc Dust Content" paint meeting M7.04.11. The galvanizing shall be repaired in accordance with ASTM A780 "Repair of Hot Dip Galvanizing". The paint shall be applied such as to achieve a dry film thickness of a minimum of 3 mils (76.2 micrometers) and not more than 5 mils (127 micrometers). Application methods shall be in accordance with the manufacturer's recommendations.

960.65 Metallized Sole Plates for Sliding Elastomeric Bearings.

This work shall consist of surface preparation and the application of thermal sprayed metal coating (metallizing) on structural steel sole plates for sliding elastomeric bearings. The metallizing process shall consist of melting metal and spraying it on to a prepared surface by means of compressed gas. All steel surfaces shall be metallized with the exception of the area over which the stainless steel mating surface is to be welded to the sole plate and the 1 inch (25 mm) wide strips where the sole plate is to be welded to the flange.

The surface preparation shall be accomplished in accordance with the requirements of the SSPC SP1 for Solvent Cleaning and SP10 for Near White Blast Cleaning. The surface preparation shall result in a 50 to 100 micrometer (2 to 4 mils) blast profile as determined by the Engineer. The average surface profile produced by the contractor's surface preparation procedures will be determined at the beginning of the work and as required by the Engineer using a profile depth tape and micrometer. Profile depth tape measurements shall be retained and submitted for the Engineer's approval. Single measurements less than 50 micrometers (2 mils), or greater than the specified maximum for the metallizing system used will be considered unacceptable. Areas having unacceptable measurements will be further tested to determine the limits of the deficient area. If unacceptable profiles are provided, work will be suspended. The Contractor shall submit a plan for the necessary adjustments to ensure the correct surface profile on all surfaces. The contractor shall not resume work until authorized by the Engineer.

The abrasives used shall be hard and sharp in order to produce an angular surface profile. Acceptable abrasives include but are not limited to, angular aluminum oxide, angular steel grit and angular crushed slag. Silica sand shall not be used. Steel shot and other abrasives producing a rounded surface profile are not acceptable. However, the steel can be preblasted with shot provided that the entire surface is reblasted with angular abrasives. All metallizing shall occur within 4 hours of completion of blast cleaning.

The thickness of the metallizing shall be 200 to 250 micrometers (8 to 10 mils), measured as specified by SSPC-PA2. All metallizing work shall be performed by a company with at least five years of experience in the field of metallizing structural steel.

The spray requirements shall be according to the SSPC CS-Guide 23.00 "Guide for Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, and Their Alloys and Composites for the Corrosion Protection of Steel" and the ANSI/AWS C2.18 "Guide for the Protection of Steel with Thermal Sprayed Coatings of Aluminum and Zinc and their Alloys and Composites" .

To produce the required thickness and uniformity, a minimum of two passes are required, overlapping and at right angles to each other. The gun shall be held at such a distance from the work surfaces that the metal is still plastic on impact, 5 to 9 inches (125 to 230 mm). The coating shall be firmly adherent and free from uncoated spots, lumps, or blisters, and have a fine sprayed texture.

The contactor is required to provide facilities to protect the finished metallized surface from damage during the blasting and thermal spraying work operations on adjacent areas. All damaged areas shall be properly repaired and remetallized by the contractor. Surfaces not intended to be metallized shall be suitably protected from the effects of cleaning and metallizing operations. To the maximum extent practicable, metallizing shall be applied as a continuous film or uniform thickness free of pores. All thin spots or areas missed in the application shall be remetallized.

After field welding the sole plate to the flange the weld shall be cleaned and painted with a high zinc content paint in accordance with Subsection 960.64.

960.66 Stud Shear Connectors.

General.

Welding of stud shear connectors shall conform to the latest edition of the AASHTO/AWS Bridge Welding Code.

All stud shear connectors applied to flanges of beams or girders shall be field installed.

Workmanship.

At the time of welding, the studs shall be free from any rust pits, scale, oil or other deleterious material that would adversely affect the welding. The area of the beams or girders to which the studs are welded shall be free of rust and scale.

The arc ferrules shall be kept dry. Any ferrules that show signs of moisture shall be oven dried at 250°F (120°C) for two hours before use.

After welding, the studs shall be free of any discontinuities that would interfere with their intended function.

Longitudinal and lateral spacing of studs with respect to each other and to edges of beam or girder flanges may vary a maximum of 1 inch (25 mm) from the location shown on the drawings. The clear distance between studs shall not be less than 4 diameters center to center.. The minimum distance from the edge of a stud base to the edge of a flange shall be the diameter of the stud plus 1/8 inch (3 mm) but preferably not less than 1½ inches (40 mm).

Preproduction Testing.

Before production welding begins and at the beginning of each shift thereafter, testing shall be performed on the first two studs that are welded for each particular set-up, size and type of stud. All test studs shall be welded in the same position as required in production.

The test studs shall be visually examined and shall exhibit a full 360 degree flash.

The test welds shall also be mechanically tested by bending the studs approximately 30 degrees. The weld or stud shall not fail.

If either of the above tests fail, two more studs shall be welded to separate material and tested again.

Technique.

Stud shear connectors shall be welded to steel beams or girders with automatically timed stud welding equipment connected to a suitable power source of direct current electrode negative (DCEN) power. 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.

While in operation the welding gun shall be held in position without movement until the weld metal has solidified.

When the temperature of the base metal is below 32°F (0°C), one stud in each 100 studs welded shall be bent 15 degrees in addition to the first two bent. Welding shall not be done when the base metal temperature is below 0°F (-20°C).

Operator Qualification.

The equipment operator is qualified by passing the preproduction test.

Production Welding.

Studs on which a full 360° weld is not obtained may be repaired, at the option of the contractor, by adding the minimum size fillet weld in place of the missing flash. The repair shall extend at least 3/8 inch (10 mm) beyond each end of the discontinuity being repaired.

Removal of unacceptable studs in tension areas

1. Base metal from which an unacceptable weld is removed shall be ground smooth.
2. If the base metal has been pulled out during removal of the stud, the area shall be repaired using an approved SMAW welding procedure and ground smooth.

Removal of unacceptable studs in compression areas

1. If the failure is in the shank or weld fusion zone, a new stud may be welded adjacent to it in lieu of repair or replacement.
2. If the base metal is pulled out, the repair is the same for tension areas except that if the depth of the discontinuity is less than 1/16 inch (2 mm)), the discontinuity may be faired by grinding.

Base metal shall be preheated to: 50°F (10°C) for base metal thickness up to and including 3/4 inch (20 mm); 70°F (20°C) for base metal thickness up to and including 1½ inches (40 mm); 150°F (65°C) for base metal thickness up to and including 2½ inches (60 mm).

If the reduction in the height of the studs as they are welded becomes less than normal, welding shall be stopped immediately and not resumed until the cause has been corrected

Inspection.

If visual inspection reveals any stud which does not show a full 360° flash or which has been repaired by welding, such stud shall be bent 15° off the vertical. For studs showing less than a 360° flash, the direction of bending shall be opposite to the lack of weld. Studs that crack either in the weld or shank shall be replaced.

Studs that are tested and show no sign of damage may be left in the bent position.

The Engineer, at his/her option, may select additional studs to be subject to the bend test specified above.

If during the progress of work, inspection and testing indicate, in the judgment of the Engineer, that the stud shear connectors are not satisfactory, the Contractor will be required at his/her expense to make such changes in the welding procedure, welding equipment and type of stud as necessary to secure satisfactory results.

COMPENSATION

960.80 Method of Payment.

Payment will be based only on computed weights (masses) of steel complete in place in the structure. No additional allowance in mass will be made for the shop coat of paint or for any other coat of paint or other protective covering.

The weight (mass) of the rolled shapes and of the plates, regardless of the width of the plates, shall be computed on the basis of their nominal mass 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 mass 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 (kg) as structural steel, with no additional compensation for the galvanizing.

The computed mass (weights) shall not include the mass (weight) of welds. The density of the various metals shall be assumed as follows:

Steel (Structural, Cast, Galvanized).....490 pounds per cubic foot (7850 kg/m^3)
Cast Iron .....450 pounds per cubic foot (7210 kg/m^3)
Bronze .....542 pounds per cubic foot (8680 kg/m^3)

The weight (mass) of the nuts and heads of bolts shall be included in the computed weight (mass), assuming the weight (mass) to be as shown below.

Payment for bolt heads and nuts will be made by the pound (kg). Where rivets are used in the permanent construction, the heads of the rivets shall be considered, for purpose of payment, as bolt heads for bolts equal in diameter to the rivets, regardless of the material of which they are composed or the materials to which they fasten.

All permanent washers will be paid for by the pound (kg). The shank of a bolt will be considered as part of the material through which it passes and will be paid for as that material. No allowance or payment will be made for that part of a bolt shank that extends through and past the nut.

Diameter of Bolt (inches)	Mass Per 100 Bolts (heads and nuts) (pounds)
½	4
5/8	7
¾	12
7/8	18
1	26
1-1/8	36
1-1/4	48

Diameter of Bolt (millimeters)	Mass Per 100 Bolts (heads and nuts) (kilograms)
14	1.8
16	3.2
20	5.4
22	8.2
24	11.8
27	16.3
30	21.8

960.81 Basis of Payment.

The furnishing, fabricating, erecting and coating 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 (kg) under the item for structural Steel, complete in place.

To avoid delay in computation of the weight (mass) 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.

English

960.	Structural Steel	Pound
960.1	Structural Steel – Coated Steel	Pound
960.11	Structural Steel – Uncoated	Pound
960.12	Structural Steel - M270 Grade 70HPS & 50HPS	Pound
999.960	Structural Steel on Hand	Pound

Metric

960.	Structural Steel	Kilogram
960.1	Structural Steel – Coated Steel	Kilogram
960.11	Structural Steel – Uncoated	Kilogram
960.12	Structural Steel - M270 Grade 485HPS & 345HPS	Kilogram
999.960	Structural Steel on Hand	Kilogram

SECTION 961 MAINTENANCE PAINTING OF STEEL BRIDGES
(page 312 English, page II.283 Metric) Add this Section.

SECTION 961
MAINTENANCE PAINTING OF STEEL BRIDGES

DESCRIPTION

961.20 General.

This work consists of the surface preparation and painting of all steel, including but not limited to, the beams (girders), bearings, diaphragms, cross frames, hand railings, drainage systems, utility supports and lamp posts. The work also includes environmental protection and waste disposal.

The Contractor shall implement and maintain programs and procedures that comply with the requirements of this specification and all applicable standards and regulations. The Contractor shall comply with all applicable regulations even if the regulation is not specifically referenced herein. If a Federal, State or local regulation is more restrictive than the regulation of this specification, follow the more restrictive requirements.

Work shall also consist of the removal of all graffiti from concrete surfaces and the removal and disposal of debris on abutments and pier caps.

The Contractor shall provide the Engineer safe access and support to all parts of the structure for interim and final inspection of the bridge during cleaning and painting operations. This support shall include the necessary traffic controls, scaffolding, fall protection and lighting.

All Contractors and Subcontractors performing lead-based paint removal, containment and collection, surface preparation, and coating of structural steel must be pre-qualified by the Department in the Painting (Structural) category.

961.40 Materials.

Coatings systems shall conform to the requirements of M7.02 Structural Paints.

961.41 Inspection Equipment.

Prior to the start of any cleaning or painting operations, the contractor shall furnish the following inspection equipment to the Engineer:

4 Wet Film Thickness Gauges (notch type, as specified in ASTM D4414, procedure *A*)
1 Dry Film Thickness Gauge - type two, with memory and download capabilities (Posi-Tector 6000, Elecometer 345, Quanix or approved equal)
1 Sling Psychrometer with two replacement thermometers (Bacharach, Taylor, Ertco or approved equal)
1 National Weather Bureau psychrometric tables
1 Magnetic Surface Temperature Thermometer, calibrated/certified, range -20º – 65º C (0º – 150ºF)
1 Spring loaded micrometer for reading surface profile tape
* Course and x-course profile replica tape
1 Surface Profile Comparator, comprised of, 10x flash light magnifier and 1 grit/slag disc or coupon, Keane-Tator, Elcometer, Clemtex or approved equal.
* Quantitative soluble contaminates test kit (Bresle, Chlor*Test, or approved equal)
1 Inspection mirror, telescopic with a mirror surface of approximately 6400 square millimeters (10 square inches)
* Blotter Paper for compressed air testing
9 volt lantern
1 High/Low Recording Thermometer (for paint storage area)
Incline Manometer
Velometer
1 Light Meter
1 SSPC VIS 1 Standards
1 SSPC VIS 3 Standards

* A quantity sufficient for required testing.

All equipment shall be in usable condition and complete with all necessary components and instructions for the proper calibration and function. Equipment found to be incomplete or unable to be field calibrated, shall be immediately replaced. All equipment shall remain the property of the Contractor upon completion of the project.

CONSTRUCTION METHODS

961.60 Surface Precleaning.

Pressure washing is required for all surfaces of the structure that are to be painted. Prior to pressure washing, the Contractor shall remove all accumulated debris from abutments, pier caps, girder flanges and other areas of collection. Debris may include but are not limited to, sand, gravel, bituminous materials and bird droppings. The method of removal shall allow for the collection and proper disposal of the debris.

All water used for pressure washing shall be potable and supplied by the Contractor.

Water from pressure washing operations shall be collected, filtered, and tested for toxic metals.

Pressure washing shall not be performed more than seven days prior to the start of surface preparation. Prior to the start of surface preparation, the Engineer will inspect the cleaned surface to insure that it is acceptable. The Contractor shall reclean unacceptable surfaces in the specified manner.

Portable pressure washing equipment shall be operated at a minimum of 21 Mpa (3000psi), a water temperature of 95ºC (200ºF) and a minimum consumption of 23L/m (6 gpm) shall be used to clean all surfaces to be painted of visible and non-visible contaminants. Pressure washers shall be equipped with gauges to ascertain operating pressure and temperature. The use of an oscillating or rotary type nozzle is recommended for all washing.

The Contractor shall use a water-based, phosphate free, biodegradable cleaner, which has a pH of 9 to 11. The cleaner shall also be, non-flammable and non-reactive. MassDOT's Research and Materials Laboratory shall approve all cleaning solutions. Each pressure washing unit shall have a cleaning compound supply tank with the ability to control the amount of solution being supplied to the feed water. Cleaning solutions shall be used in strict accordance with the manufacturer's written recommendations.

All dirt, oil, grease, tar, road salt, bird dropping residue, chalky paint and other dissolvable debris and contaminates shall be removed by pressure washing. Excessive deposits of cleaning liquids remaining on surfaces that will not drain shall be flushed off with clean, fresh water without detergent. In as much as a certain amount of liquid will remain on horizontal surfaces after cleaning, the cleaning process shall be followed through systematically from top to bottom. The last pass on any surface shall be made with clean fresh water without detergent to remove surplus solution.

The Contractor shall be solely responsible for damages arising from pressure washing operations. Expansion joints or open areas that will allow debris or water to pass shall be covered or sealed to protect vehicle and/or pedestrian traffic.

Under no circumstances will surface preparation or painting be started over cleaned surfaces until the surface is free of standing water and dry to the touch, and then only after the approval of the Engineer.

961.61 Surface Preparation.

All equipment, materials and vehicles brought to the site by the Contractor shall be clean and free of debris. A visual assessment of cleanliness shall be made by the Engineer prior to locating equipment at the contract location(s).

All portions of the structure that could be damaged by surface preparation, abrasive residue, and painting operations, (e.g., utilities, bearings, machined surfaces, electric motors, wiring, and neoprene pads) shall be protected prior to the start of cleaning and painting operations. Any damage or reduced service life caused by the failure to protect areas or components of the structure shall be repaired or replaced at the Contractor expense.

The Contractor shall immediately report to the Engineer any cracks, section loss or other potential problems found during surface preparation.

After surface preparation all surface imperfections/discontinuities (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs. slivers, laminations, etc.) that remain shall be completely removed by grinding to the satisfaction of the Engineer. The Contractor shall restore surface profile if degraded by grinding.

Alternate methods of surface preparation that will provide the specified surface cleanliness and profile may be submitted to the Engineer for review for approval.

Prior to full operation of surface preparation, an acceptance standard for the preparation method(s) shall be prepared by the Contractor and approved by the Engineer. The surface for the standard (or control) should be a flat portion of the surface actually to be cleaned and shall be located by the Engineer. The Engineer shall be the final authority in regard to determining whether or not a prepared surface meets the requirements of this specification.

To establish this standard, SSPC VIS-1 and VIS-3, shall be used as guides. An area not less than 600mm x 600 mm (2 feet x 2 feet) shall be prepared to meet the requirements of the surface preparation method(s) to be utilized. After approval and at the option of the Engineer, the prepared standard will be sealed with a clear protective paint to preserve its appearance. Upon completion of the surface preparation and application of the primer, the standard will be re-prepared and coated in accordance with these specifications.

All laminar and stratified rust that has formed on the existing steel surfaces shall be removed. Pack rust formed along the perimeter of mating surfaces of connected plates or shapes of structural steel shall be removed to the extent feasible without mechanically detaching the mating surface. Extensive pack rust, buckled plates, loose or missing bolts shall be brought to the attention of the Engineer before painting. Any pack rust remaining shall be tight and intact when examined after scraping with a dull putty knife.

A best effort with the specified methods of cleaning shall be performed in limited access areas. The equipment being used for the majority of the cleaning may need to be supplemented with other commercially available equipment, such as angle nozzles, to properly clean the limited access areas. The acceptability of the best effort cleaning in these areas is at the sole discretion of the Engineer.

961.62 Surface Cleaning Requirements for Overcoating.

All steel except as defined under section entitled “Cleaning of the Bearing Areas” shall be spot cleaned SSPC SP-3 Power Tool Cleaning or SSPC SP-14 Industrial Blast Cleaning, the method of surface preparation shall be chosen by the Contractor. Regardless of the method used for cleaning, remaining old paint shall be feather edged so that the repainted surface will have a reasonably smooth appearance.

All steel within the width of the pier caps and abutments and a length from the end of the stringer to a distance 1.5 meters (5 feet) beyond the centerline of the bearing (from the top of the pier caps and abutments to the bottom of the bridge deck) shall be abrasive blast cleaned to meet the requirements of SSPC SP-10 “Near White Metal Blast”. This requirement is waived at bearing areas located at intermediate piers where there are no deck joints directly above.

961.63 Surface Cleaning Requirements for Full Removal.

All surfaces to be painted shall be abrasive blast cleaned to meet the requirements of SSPC SP-10 “Near White Metal Blast” using recyclable steel abrasives.

A. Surface Profile.

Abrasive blast cleaned surfaces shall have a uniform profile of 25.4 to 76.2μm (1 to 3 mils). Verification of the profile height will be performed in accordance with ASTM D4417 Method C. If surface profile requirements of the coating manufacturer differ from those specified, the Contractor shall comply with the coating manufacturers requirements. Profile replica tape shall be filed with the project inspection records. The profile shall be measured three times in random locations at least every 48 square meters (500 square feet) of prepared surface or as directed by the Engineer. The measured profile shall be approved by the Engineer.

B. Abrasives.

All abrasives brought to the site shall be stored in a clean and dry environment. The Contractor shall select the type of abrasive. Expendable abrasives shall be in accordance with SSPC AB-1, class “A”. Recycled steel grit shall be in accordance with SSPC AB-2, and recyclable steel abrasives shall be in accordance with SSPC AB-3.

The selected abrasive shall be sufficient to produce a profile within the range specified. The profile shall be uniform and of sufficient angularity as to be acceptable by the paint manufacturer for the application of primer. The Engineer with the use of a surface profile comparator will randomly inspect angularity of the profile.

All abrasives will be maintained clean, dry and uncontaminated. The abrasive shall be tested daily for grease, oil or non-abrasive residue with a “vial test” using the following method:

A sealable jar is filled with distilled water, a sample of abrasive taken from the storage hopper or pressure vessel and is then added to the jar. The vial is shaken for one minute and allowed to set for five minutes. The vial is observed. If any oil or grease is floating on the top of the water or a cloudy condition exists the abrasive will be considered contaminated.

Contaminated abrasives will not be used for surface preparation. Abrasive found to be contaminated shall be disposed of or recycled.

The use of proprietary additives to water or abrasive to generate a non-hazardous waste is not permitted.

C. Compressed Air.

All compressed air sources shall have properly sized and operational oil and moisture separators. Prior to the connection of the air to the blast pot(s), a desiccant filter drying unit or air dryer shall be installed. They shall allow air at the nozzle for blast cleaning, painting, or blow off to be oil free and moisture free. Compressed air shall have sufficient volume and pressure to accomplish the associated work effectively and efficiently.

A blotter test will be performed at the start of each day or shift by the Engineer to ensure that compressed air is free of oil and moisture. The Contractor shall supply all blotter paper. The compressed air will be tested for contaminants in accordance with ASTM D4285 "Detecting Oil or Water in Compressed Air".

D. Substrate Cleanliness.

Upon completion of blast cleaning and prior to inspection, the Contractor shall vacuum and/or blow down under full ventilation and containment all surfaces to be inspected, providing areas for testing and to aid visual inspection of the substrate.

The prepared surface will be tested by the Engineer for chloride contamination using the required test kit and the manufacture's instructions for extracting and quantifying chloride levels. All test areas will be recorded for re-testing purposes.

A minimum of 5 tests per 1000 square feet (93 m^2) or fraction thereof completed in a given day shall be conducted at project start up. If results greater than 7 $\mu g/cm^2$ are detected, the surface shall be recleaned as specified and retested at the same frequency. If acceptable results are achieved on three consecutive days in which testing is conducted, the test frequency may be reduced to one test per 1000 square feet (93 m^2) providing the preparation method remains unchanged. If unacceptable results are encountered, or the methods of preparation are changed, testing shall resume at a frequency of 5 tests per 1000 square feet (93 m^2). After testing and approval, the test areas shall be blast cleaned to the specified level of cleanliness and profile.

961.64 Paint.

Paints and solvents are hazardous due to their flammability and potential toxicity. Proper safety precautions shall be observed to protect against these recognized hazards. Proper ventilation and handling shall be employed during mixing and application to insure that vapor concentrations do not exceed the published Permissible Exposure Limits (P.E.L.) and the Lower Explosion Limit (L.E.L.).

Prior to the application of any coating, all dust and debris shall be removed by vacuuming and/or blowing down under full ventilation and containment. Painting of the approved area will not be allowed until the area has been properly ventilated to remove all airborne dust.

Surface preparation and subsequent paint application shall be so programmed that dust and other contaminants from the cleaning process will not fall on surfaces about to receive paint, or on wet, newly painted surfaces.

Approved surfaces will not be allowed to stand uncoated longer than eight hours unless some form of protective environmental procedure is utilized, e.g., dehumidification. If substrate is found to have degraded, it will be recleaned in the specified method at the Contractors expense.

All surface preparation will be reviewed and approved by the Engineer prior to painting operations.

The finish coat shall be Federal Standard Color # 14223, green.

The colors of the prime, intermediate and finish coats shall have a definite color contrast between them and be subject to the approval of the Engineer.

Minimum and maximum dry film thickness shall be in accordance with the latest manufacturer's data sheet for each product applied.

A. Storage, Testing and Sampling.

The Contractor shall provide a suitable facility for the storage of paint that will be in accordance with the latest requirements of OSHA. This facility must provide protection from the elements and insure that the paint is not subjected to temperatures outside the manufacturer's recommended extremes. Storage of the paint must be located in reasonable proximity to the painting location. The Contractor's facility for the storage of paint and its location at the site are subject to the approval of the Engineer.

Before the Contractor will be permitted to use any paint, the material provided for application shall have been sampled, tested and approved in accordance with Section M7. MassDOT's Research and Materials Laboratory needs a minimum of fourteen days after the receipt of samples to test and approve.

B. Mixing and Thinning.

Before the paint is applied, each component shall be mechanically mixed to ensure complete disbursement of the pigment. Mixing of components shall be accomplished by mechanical mixing or agitation, boxing or hand mixing of components will not be allowed. Any special precautions or requirements for mixing by the manufacturer shall be followed. Paint shall be kept thoroughly mixed in spray pots or containers during application. The pot life shall not be exceeded or attempts made to extend pot life with the addition of solvent.

If it is necessary for any reason to thin paint it will be done in the presence of the Engineer, in accordance with the manufacturer's recommendations. Thinning must be performed using a measuring cup marked in ounces or milliliters. Other methods, such as eyeballing, are not acceptable. Thinner shall be supplied from the same manufacturer as the paint system.

For multi-component paints, the mixing of half or partial kits is not allowed. If the need for small quantities of paint is anticipated, the contractor should order materials accordingly.

C. Application.

All necessary precautions shall be taken to protect pedestrians, vehicles, concrete areas, and any other areas not to be painted. All paint overspray, mist and or dust shall be collected and filtered with collection equipment.

Prior to the application of any coating material, the Engineer’s approval must be obtained. All surfaces painted prior to the Engineer’s approval, shall require the complete removal of the coating applied. All labor, materials, and associated costs with the removal of any unapproved coating shall be done at the Contractor’s expense to the satisfaction of the Engineer in accordance with these specifications.

Applied coatings shall not exhibit, runs, sags, holidays, wrinkling, pinholes, nap hair, topcoat gloss or color variations, or other film discontinuities.

Repair of unacceptable areas that involve removal of the coating system or part of it, shall require surface preparation and coating equal to that specified. Repair procedures used for any unacceptable coating shall be those supplied by the paint manufacturer and approved by the Engineer.

Application of full coats of paint shall be accomplished by spray equipment. Spray equipment shall meet the requirements of the coating manufacturer and be in proper working order.

Application by brush and roller will be limited to stripe coating, inaccessible areas and the application of the spot coat of primer. Brushes and roller covers recommended by the coating manufacturer shall be used. Areas brushed and rolled will have a uniform thickness and be free of defects and excessive coating thickness.

All coating shall be applied according to the latest manufactures written requirements. The maximum recoat times of the primer, intermediate and finish coats shall not be exceeded.

Application of organic zinc, epoxy, and urethane systems shall not be done when the relative humidity is above 85% or when the surface temperature of the steel is less than 5°F above the Dew Point. Paint shall not be applied when the surface temperature is below 40°F or when the surface temperature is above 125°F.

Application of moisture cure urethane systems shall not be done when the relative humidity is above 95% or when the surface temperature of the steel is less than 3°F above the Dew Point and rising. Paint shall not be applied when the surface temperature is below 35°F or when the surface temperature is above 125°F.

If requested by the Engineer, the Contractor shall provide written instructions from the coating manufacturer indicating the length of time that each coat must be protected from cold or inclement weather (e.g., exposure to rain) during its curing or drying period.

Paint shall not be applied when, in the Engineer’s judgment, conditions are or will become unsatisfactory for application and proper cure. All changes as to the application parameters other than specified must be the manufacturer’s and presented in writing and approved by the Engineer. Ambient conditions should be closely monitored so that proper cure/drying is achieved prior to recoat. In no case shall a succeeding coat of paint be applied before the previous coat has cured/dried sufficiently for recoat as per manufactured data sheet.

If required, contaminated surfaces, e.g., bird droppings, road debris shall be cleaned in accordance with SSPC- SP 1 Solvent Cleaning method 4.1.1.

Measurement of the ambient conditions shall be done in accordance with ASTM E337 Test Method for “Measuring Humidity with a Psychrometer” (the Measurement of Wet and Dry bulb Temperatures).

After Full Removal

The primer will be applied at a coverage rate that will result in a minimum dry film thickness recommended by the manufacturer, when measured in accordance with SSPC PA-2.

The primer shall not be cleaned of over spray or debris by wire brushing or methods that would burnish the surface. When the primer has cured sufficiently for recoat, all bridge components to be painted shall receive a full intermediate coat.

To provide adequate film thickness in areas or places prone to breakdown, edges, corners, rivet heads, bolts, nuts, and welds shall be striped by brush painting. Stripe coating of the intermediate coat shall be completed prior to the application of the full intermediate coat.

Prior to the application of the finish coat, bearing areas as defined shall receive an additional intermediate coat at 3 mils Dry Film Thickness (DFT), spray applied. The additional coating will be applied from the end of the beam to a distance of 1.5 meters (5 feet) including all steel between the abutment cap and the bottom of the bridge deck and including end diaphragms.

All steel within the width and length of the intermediate pier(s) from the center of the pier to a distance of 1.5 meters (5 feet) in each direction on the stringers including all steel between the pier cap and the bottom of the bridge deck shall also receive additional second spray applied intermediate coating at 3 mils DFT, with the exception of the intermediate piers where there are no deck joints directly above..

When the intermediate coat has cured sufficiently for recoat, all bridge components to be painted shall receive the finish coat by spray application.

All prepared surfaces shall receive three full coats of paint (primer, intermediate, finish)and the additional (bearing area) intermediate coat of a system selected from the NEPCOAT “B” list, Protective Coatings for New and 100% Bare Existing Steel for Bridges

All areas prepared by spot cleaning shall be spot primed with the selected systems primer. Spot priming shall be completed by brush and roller to provide complete coverage of irregular or pitted surfaces.

Areas spot cleaned in accordance with Subsection 961.62 “Surface Cleaning Requirements for Overcoating” shall be painted with an approved 2 or 3 coat NEPCOAT system selected from the “M” list, Protective Coatings for Previously Painted Existing Steel Bridges.

Overcoat - Two Coat Systems

When the primer has cured sufficiently for recoat, all bridge components to be painted shall receive a full finish coat by spray application.

Overcoat - Three Coat Systems

When the primer has cured sufficiently for recoat, all bridge components to be painted shall receive a full intermediate coat by spray application and when sufficiently cured a full finish coat by spray application.

Bearing areas cleaned in accordance with Subsection 961.62, A., Cleaning of the Bearing Areas shall receive three full coats of paint. Application shall be in accordance with the Full Removal portion of this section. The coating system shall be selected from the NEPCOAT “B” list, Protective Coatings for New and 100% Bare Existing Steel for Bridges. Interface between different paint systems shall be vertically masked during the final coat to provide a neat edge on the fascia girders.

D. Measurement of Paint Thickness.

The Engineer will measure wet and dry film thickness with the following methods and standards.

Wet Film Thickness: Will be measured during application with a notch type wet film thickness gauge every 5 m^2 (50 sq. ft.), in accordance with, ASTM D4414 Standard Practice for Measurement- Wet Film Thickness by V Notch Gages, procedure A

Dry Film Thickness: Will be measured using a type II gauge. The prime, intermediate and the finish coats, shall be measured in accordance with SSPC PA-2, Measurement of Dry Coating Thickness with Magnetic Gages. The Engineer has the option to measure the dry film thickness of overcoated surfaces with the use of a Tooke gage or similar type instrument. Repair to areas cut to determine the DFT of new coatings will be done at the Contractor’s expense.

E. Bridge Identification Markings.

After the application of the finish coat of paint, the Contractor shall stencil the 3-character bridge identification number (BIN), completion date (month and year), and the letter “F” to designate full clean and paint or “O” to designate clean and paint (overcoat). The information shall be applied on the steel in black on a white base measuring 75 x 13 cm^2 (30 x 5 $in.^2$), utilizing 6cm (2 in.) numbers, when and as directed by the Engineer.

961.65 Worker Protection.

The Department of Environmental Protection (DEP) and the Federal Environmental Protection Agency (EPA) regulate coatings containing toxic metals and the residue generated from the removal process as a hazardous waste. The Contractor shall comply with all Federal, State and municipal laws, regulations and ordinances that require the Contractor to provide for a safe and healthful work area for work to be performed by the Contractor under this Contract.

The Massachusetts Department of Labor and Workforce Development, Division of Occupational Safety, and the Federal Occupational Safety and Health Administration (OSHA) regulate the exposure to paint and debris containing toxic metals by workers involved in the removal of bridge coatings. Coatings removed from highway structures that contain toxic metals, has been shown to have serious health effects on workers if regulations and caution are not observed.

The existing structure(s) and components may be coated with a lead-based paint. Therefore, the Contractor shall be required to sample the existing coatings to determine the percent of lead and if other toxic metals are present. Within 30 days of the notice to proceed the Contractor shall submit a sampling protocol to the Engineer for approval. Upon approval of the protocol the Contractor shall sample and have analyzed in accordance with 310 CMR 30.155B (EPA SW846 Method 1311) the existing coatings.

The results of the testing shall be utilized in the development of the "Compliance Program" to protect workers from lead and toxic metals as required by Federal and State regulations. The remaining portion of this specification focuses on lead but requires the Contractor and the Certified Industrial Hygienist (CIH) to address other toxic metals.

The Contractor shall provide the Massachusetts Department of Labor and Workforce Development's, Division of Occupational Safety, a written notification of the project. The notification shall be received at least ten days prior to the beginning of any contract operations and include: its location, start date and anticipated completion date. The contractor shall also comply with all registration, license, and permit requirements.

Equipment noise in excess of 90 decibels or other local ordinances as measured at the closest residential, commercial or recreational area, shall be lowered by the contractor to a maximum of 90 decibels or other local ordinances. The use of sound barriers, mufflers or other equipment and materials used to lower noise levels shall be approved by the Engineer prior to installation and provided and installed at no additional cost to MassDOT.

A. Compliance Program.

The Contractor shall develop a written program under the direction and approval of a Certified Industrial Hygienist (CIH) to establish and implement practices and procedures for protecting the health of those employees exposed to lead. The Compliance Program shall establish methods for complying with any Federal, State or local regulations.

B. Services for MassDOT Representatives

The Contractor shall provide to not more than three representatives of the MassDOT, all the work place and worker protection requirements that the Contractor is required by law and regulations to provide to his own employees in order to maintain a safe and healthful work place.

Without limiting the Contractor's responsibilities under the prior paragraph, the Contractor shall provide to not less than three representatives of the MassDOT Department the following services:

1. Training: an initial and annual refresher training as required by the appropriate OSHA standards; Hazard Communication training (29 CFR 1926.59), including proper handling and disposal of hazardous waste.
2. Blood Tests: initial and periodic blood and zinc protoporphyrin (ZPP) sampling and analysis, and medical surveillance as required by OSHA health and safety standards for lead; verify that laboratories that conduct blood analysis meet the qualification requirements established by OSHA; conduct blood sampling and analysis within one month prior to the start of work and at a minimum of once every two months for the first six months of exposure, and a six months intervals thereafter; conduct blood tests within five days of separation and upon completion of the person's project activities that involve exposure to lead, even if this occurs prior to the completion of the Contractor's work on the project; supply the Massachusetts Blood Lead Registry (MBLR) and Engineer with the results of all blood tests prior to commencement of work; subsequent blood lead test results shall be supplied to MBLR and the Engineer within ten days of receipt; only certified laboratory copies of test results from OSHA-CDC approved laboratories may be submitted to MassDOT and the Department of Labor and Industries, Division of Occupational Hygiene, with more frequent testing to be done as required, in accordance with this specification and 29 CFR 1926.62; evaluate effectiveness of protection practices whenever a 10 ug/dl blood lead level increases between two results, or a single result in excess of 20ug/dl.
3. Physical Exams: provide all physical examinations as required by the appropriate OSHA standard for lead.

4. Respirators and Protective Clothes: provide respirators to those who enter areas where airborne exposures exceed or are expected to exceed the Permissible Exposure Limit (PEL) or Threshold Limit Value (TVL); provide protective clothing and equipment to those whose exposure exceed the PEL or TLV.
5. Lavatory and Hand Washing Facility: provide clean lavatory and hand washing facilities in accordance with OSHA sanitation standard 29 CFR 1926.51 and provide showers when the exposure limit exceed the PEL or TLV.

C. Signs and Daily Logbook.

Signs warning that lead paint removal operations are being conducted shall be posted at all approaches to the work areas and in areas where workers will be exposed to concentrations above the PEL. At a minimum, such signs shall include the words:

WARNING
LEAD WORK AREA
POISON
NO EATING OR SMOKING
AUTHORIZED PERSONNEL ONLY,
RESPIRATORS REQUIRED IN THIS AREA

The lettering shall be black block, no smaller than two inches tall, and on a white, yellow, or orange background. Caution ribbons shall also be used where appropriate.

A daily sign in/out log which identifies persons by name, address, and affiliation, or work classification for all employees with the project, and the times of arrival and departure must be maintained at the work site, and submitted to the Engineer on a weekly basis when lead paint removal operations are being performed.

961.66 Environmental Protection and Monitoring.

The Contractor shall comply with all Federal, State and municipal laws, regulations and ordinances that require protection of the environment, including laws and regulations whose purpose is to prevent contamination and pollution of the air, water and soil in and surrounding the work site, where lead paint being removed from a bridge under this contract is subject to abatement, containment, transportation and disposal.

A. Air Quality.

Baseline Monitoring

Pre-project monitoring shall be performed for a minimum of two days while no paint removal work is underway in order to establish baseline levels. Emissions from the project site will not be penalized by existing baseline levels. If the baseline levels are highly variable, the Engineer may require that periodic or full time upwind monitoring be conducted. Include provisions for such monitoring in Subsection 961.69 B "Environmental Protection and Monitoring Program" submittal.

High Volume Ambient Air Monitoring

High volume ambient air monitoring shall be conducted in strict accordance with the requirements of 40 CFR 50, 310 CMR 7.00, and the equipment manufacturer's instructions.

The Contractor shall submit methods and procedures for locating the monitors, calibrating and conducting baseline and project monitoring, and completion of chain of custody forms. Include the name and qualifications of the State-certified laboratory proposed for use, and the test methods that will be utilized for the analysis of the filters.

Conduct the following monitoring activities under the observation of the Engineer: locating and calibration of the monitors, daily removal and replacement of the filters, and completion of the chain of custody forms.

TSP Lead Monitoring

The monitoring shall be in accordance with 40 CFR 50 for 5 out of the first 10 days at the beginning of each project location while paint removal, containment movement, and cleanup activities are underway. Monitoring during paint application is not required, and if performed, will not be counted as one of the 5 days of project monitoring.

The monitors shall be placed at the point of maximum environmental impact (usually downwind of the cleaning operation) and other locations of potential public or environmental exposure. Monitors shall be moved to maintain this condition due to shifting wind patterns.

For TSP-lead monitoring, emissions in excess of the value attained by the following formula or exceeding 150% of background levels shall be cause to shut down the project until the work activities and/or containment are modified to provide better control of emissions. DA = (90 ÷ PD) x 1.5 $\mu g/m^3$, where DA is the daily allowance in $\mu g/m^3$ and PD is the number of preparation or paint disturbance days anticipated in a 90 day period.

The above calculation provides an allowance criteria for a 24-hour period. In order to convert this value to an allowance corresponding to the hours worked, do the following:

ADA=DA (24÷H)

where ADA = Adjusted Daily Allowance ($\mu g/m^3$) DA = Daily Allowance ($\mu g/m^3$)

and H = Hours worked in 24 hours

If the emissions are unacceptable at the end of the 5 days of monitoring, or a trend of exceedances is apparent from the 5 days of monitoring, the monitoring shall continue at the contractor's expense until 5 days of acceptable monitoring limits have been obtained.

After the initial 5 days of monitoring, if visible emissions are in excess of the stated duration for 2 days, additional monitoring shall be required for a period of 2 consecutive days of TSP monitoring. If the emissions are unacceptable after the 2 days of monitoring, the monitoring shall continue at the contractor's expense until 2 days of acceptable monitoring limits have been obtained.

The Contractor shall conduct additional ambient air monitoring after periods of prolonged shutdown or following any significant changes in work practices.

Laboratory Analysis and Report

The Contractor shall have all filters analyzed for lead using a State-certified laboratory. The analysis shall be conducted in accordance with 40 CFR 50. The Contractor shall provide the Engineer with verbal results of the laboratory analysis within 72 hours after the monitoring was performed, with a written summary report within seven days.

Visible Emissions

The Contractor shall conduct visible emissions assessments in accordance with 40 CFR 60, Appendix A, Method 22. This assessment is based on total visible emissions regardless of the opacity of the emission.

Visible emissions are permitted at the following duration provided they do not extend beyond the established regulated areas. Random airborne emissions of a cumulative duration of no more than 1 percent of the workday are permitted. This amounts to a duration of 5 minutes in an 8-hour workday. Visible emissions in excess of this criterion are cause for immediate project shut down until the cause of the emissions is corrected.

The visible emissions assessment will account for all locations where emissions of lead dust might be generated, including but not limited to, the containment or work area, dust collection and waste recovery equipment as applicable and waste containerizing areas. Observations and corrections of visible emissions and releases of dust debris are an ongoing daily requirement.

B. Soil Quality.

The Contractor shall not contaminate the soil. An approved impervious covering must be placed on the ground under the work and decontamination areas and under waste containers. In the event that it is not practical to place tarpaulins directly on the ground, shielding devices must be supported by suitable frame works to prevent falling contaminants from escaping.

Prior to the start of any work, the Contractor and the Engineer shall make a site inspection to determine the cleanliness of the area. Clean-up procedures that are required as a result of soil contamination caused by the Contractor shall be the responsibility of the Contractor. The Contractor shall pay all associated costs of the clean up including, Licensed Site Professional services and documentation.

The Contractor shall perform a pre-job and post-job soil analysis for lead. The Engineer will select locations for sampling within the likely dispersion zone of airborne dust or spills of debris.

The number of sites will be sufficient to properly characterize project conditions. Particular attention will be paid to wind direction, height of the structure, and the dust-producing nature of the operation when selecting the sites. Samples around equipment, in debris containerizing areas, inside and around regulated areas, beneath and around the structure being prepared and other locations of potential public or environmental exposure will be included.

The Contractor shall collect samples prior to the commencement of activities in a given area (e.g., collect samples in equipment staging areas prior to mobilization in those areas, and collect samples around the structure prior to the erection of the containment). A plot plan showing actual locations of sample sites shall be given to the Engineer. Samples shall be collected in the identical locations upon completion of all project activities.

Sample Removal Criteria

The Contractor shall comply with the following minimum requirements for the collection of each sample:

a.) Tools and resealable containers for the collection and storage of the samples shall be comprised of a material that will not contaminate the samples.
b.) Place a 930cm² (1 sq ft) template at each sample site. Remove plugs of ground (soil) measuring 19mm (3/4 in) diameter and 12.7mm (1/2 in) in depth from the four corners of the template and from the center. Place the five plugs into a single sample container. This represents a single sample from the test site.
c) Clean the sampling tool with deionized water and move the template 76.2mm (3 in.) in any direction and collect a duplicate sample (5 plugs). Package the sample in a separate container.
d) Accurately measure and document the specific location of each sample site in order for the precise locations to be resampled upon project completion.
e) Identify each sample container with the following minimum information: date of collection, contract number, specific location of the sample, and name and signature of the person removing the sample. Complete a chain of custody record.

Repeat the procedure at each sampling location, cleaning the sampling tool prior to each use.

Acceptance Criteria for Ground (Soil) Analysis

The soil samples shall be analyzed for lead in accordance with EPA Method 3050 or approved equivalent method by a State-certified laboratory.

The ground (soil) is considered to have been impacted by project activities based on increases over the geometric mean pre-job lead concentration. If the geometric mean pre-job total lead concentration is less than 200 ppm, an impact is considered to have occurred if the post-job geometric mean lead concentration is an increase of 100 ppm or more. If the pre-job concentration is greater than 200 ppm, an impact is considered to have occurred if the post-job geometric mean lead concentration exceeds the pre-job geometric mean plus 2 standard deviations, or an increase of 100 ppm occurs, whichever is greater.

The Contractor shall provide the Engineer with verbal results of the laboratory analysis within 7 calendar days, and a written summary report within 14 calendar days after the sampling was performed.

C. Water Quality.

The Contractor shall take all necessary precautions to prevent debris due to paint related activities from entering the water. Any notification and clean-up procedures required to abate lead contamination in sediments or water shall be the responsibility of the contractor. The Contractor shall protect all drains to prevent debris from entering the storm sewer system.

For bridges over water, the Contractor shall provide water booms, a method for anchoring the water booms and a procedure for removing the debris that inadvertently enters the water.

961.67 Containment.

The Contractor shall design, install, and maintain a containment to retain water, debris, and paint used during cleaning, surface preparation, and coating operations. The containment shall be designed to reduce worker exposure to lead, protect vehicular traffic, pedestrians, and the surrounding environment.

The following table outlines the minimum requirements for containment design for various activities, such as: cleaning, surface preparation, and paint application. Containment classifications and descriptions are based on SSPC – Guide 6, Guide for Containing Debris Generated During Paint Removal Operations.

Table	Dry Abrasive Blasting, Class 1A	Power Washing or Wet Abrasive Blasting, Class 1W	Power Tool Cleaning (both vacuum-assisted and not), Class 2P	Coating Application, Class 3A
CONTAINMENT MATERIALS	A1 Rigid or A2 Flexible			
PENETRABILITY	B1 Air Impenetrable	B1 Air Impenetrable and B3 Water Impenetrable	B1 Air Impenetrable	B1 Air Impenetrable
SUPPORT STRUCTURE	C1 Rigid or C2 Flexible			
JOINTS	D1 Fully Sealed	D1 Fully Sealed	D2 Partially Sealed	D2 Partially Sealed
ENTRYWAY	E2 Re-sealable Door	E2 Re-sealable Door	E3 Overlapping Door	E3 Overlapping Door
AIR MAKE-UP	F1 Controlled Air	F2 Open Air Supply	F2 Open Air Supply	F2 Open Air Supply
INPUT AIR FLOW	G2 Natural Input Air			
AIR PRESSURE	H1 Instrument and H2 Visual Verification	H3 Not Required	H3 Not Required	H3 Not Required
AIR MOVEMENT	I1 Minimum Specified	I2 Not Specified	I2 Not Specified	I2 Not Specified
EXHAUST DUST FILTRATION	J1 Air Infiltration	J2 Not Required	J2 Not Required	J1 Air Infiltration

A. Engineering.

The Contractor shall provide plans and calculations detailing the proposed method of containment and ventilation. The plans shall include an elevation view of the containment enclosure clearly showing any encroachments on the surroundings. The vertical clearance shall be maintained above any active travel lanes.

The plans shall contain details of the method of sealing joints, the entrance/exit openings, air intake points (including filters, louvers, and baffles), type/placement of lighting systems, and connections to the bridge. Methods of attachment that require welding, drilling, bolting, or any methods requiring alteration of the structure or part of it, are not allowed.

The Contractor shall analyze the bridge to determine its ability to safely support the proposed containment system, vehicular traffic, and the Contractor's vehicles and equipment. The following calculations are required: the maximum dead and live load imposed on the bridge by the containment system, and the maximum allowable load for the floor/platform. The calculations shall include an analysis of the stresses in all affected members and applicable load rating capacities for Type H, Type 3, and Type 3S2 AASHTO truckloads. The stress limits for all loads shall not exceed 120% of the inventory level allowable stress.

If the containment system is suspended from the bridge, each connection to the bridge shall have a tension load cell attached. A multi-channel digital load indicator shall be connected to all load cells and located in an accessible area. The Contractor shall report load readings to the Engineer at scheduled intervals (or at times) directed by the Engineer. The load indicator shall be capable of storing peak load readings.

All containment systems shall be analyzed to determine the amount of stress applied to the bridge as a result of wind loads on the containment. The Contractor shall calculate an "allowable wind speed" which will be used, in the field, to determine the threshold for dismantling the containment system.

B. Material Requirements.

All tarps, drapes and plastic sheeting materials used for containment or ground cover shall be fire-retardant and impermeable to air and water. All materials shall be in good condition.

C. Lighting.

Light at the steel surface within the enclosure shall be maintained by the Contractor at a minimum of 30 foot-candles as measured by a light meter. Such lighting shall be maintained throughout the surface preparation, painting, and inspection activities. The use of explosion-proof lighting is mandatory.

The Contractor shall maintain, as fully operational and functional, all existing lighting systems including navigation lights, aerial lighting, and roadway or parking lot lighting.

If existing lighting will be concealed, the Contractor shall install temporary lighting. A temporary lighting plan shall be included in the Contractor's submittal and forwarded to the Coast Guard or FAA, if appropriate, for approval in advance of the work.

D. Field Operations.

All debris and abrasive, which have accumulated, as the result of surface preparation shall be vacuum cleaned at a frequency specified in the Contractor's containment submittal, or more frequently if directed by the Engineer. Prior to removal or relocation to another point along the structure, all debris must be removed from the containment materials and equipment. The level of cleanliness shall be such that wind or physical contact during handling and transportation does not dislodge debris or dust.

E. Ventilation.

When negative pressure is required within a containment system, the designed system shall maintain a minimum negative pressure as measured by 0.76 mm (.03 in) of water column relative to external ambient air. Air velocity within the enclosure shall meet the minimum requirements of 30 meters/min (100 ft/min) crossdraft and 18 meters/min (60 ft/min) downdraft. Submittals shall include a description of the dust collection and filtration equipment, including the equipment data sheets and airflow capacity.

961.68 Handling of Hazardous Waste and Reporting Release Programs.

The Contractor shall submit a plan to the Engineer detailing all aspects of waste management including an Emergency Response Contingency Plan in accordance with 310 CMR 30.00 and 310 CMR 40.00. The plan shall detail the methods for the collection, handling, sampling, testing, site storage, and disposal of wastewater, lead paint and related debris. The Contractor and the Department are the co-generators of the waste. The Department will provide the EPA identification number and the Contractor is responsible for all other waste management.

A. Waste Sampling, Testing and Classification.

All waste streams generated as part of the work shall be tested by TCLP for all eight metals to determine proper disposal. The Engineer shall be the final authority on what shall be tested for possible contamination. Four samples representative of each waste stream shall be collected and tested in accordance with 310 CMR 30.155B (EPA SW846 Method 1311)

The Engineer must be notified of the date and time of sample collection prior to sampling activities. The Contractor, in the presence of the Engineer, shall perform sampling for testing and a State certified laboratory shall perform testing. Chain of custody must be adhered to for sample removal. TCLP test results certified by the testing laboratory shall be provided to the Engineer. The following information must be contained in the laboratory report as a minimum:

Contract number
Bridge Identification Number (BIN)
Identification of the waste stream analyzed
Number of samples collected and tested
Dates of sampling and testing
Defined laboratory test procedures
The names and signatures of sampling technicians and laboratory technicians
Summary of test results

The Contractor shall provide the Engineer with an original signed copy of the report no later than 10 days after the samples have been collected.

Non-hazardous waste shall not be mixed with hazardous waste. The DEP requires that a mixture of non-hazardous waste with hazardous waste must be treated as hazardous.

All debris cleaned and collected from abutments, pier caps, girder flanges and other areas of collection shall be disposed of properly. Debris which include, but not limited to, sand, gravel, bituminous materials and bird excrement shall be packaged and stored separately from waste generated as a result of surface preparation. A representative sample of the debris shall be analyzed to determine its classification prior to disposal.

All wastes generated through the use of steel abrasives shall be treated as hazardous and identified as such to the treatment facility.

B. Waste Handling, Packaging, and Storage.

Lead paint and related debris must be collected daily and placed in DOT approved containers of good integrity (i.e. no dents, holes, missing lids or locking mechanisms, etc.). The Contractor shall inspect drums weekly and the results recorded in an on-site logbook accessible to the Engineer. Containers shall be closed and clearly labeled to identify the contents. Hazardous wastes must be labeled with the words "HAZARDOUS WASTE", the name of the waste, the hazards associated with the waste, and the date when accumulation began in the container. The hazardous waste label shall also include the generators' name, address, and EPA identification number.

Containers shall be stored in a safe and suitable location at the job site. Storage shall be in a manner that protects the public and the environment (i.e. on a level impervious base, away from waterways, etc. Storage area(s) shall be approved by the Engineer prior to generating wastes.

Storage areas shall be labeled with the words "HAZARDOUS WASTE". Appropriate security (i.e. fencing, locked gated, etc.) must be maintained at the site to avoid injury, theft or vandalism with regards to hazardous waste. Once a container in the work area is full, it shall be moved to the secure storage area within 3 days. If a suitable location for hazardous waste storage does not exist on-site, the Contractor shall find an alternate storage site. The alternate storage shall only be allowed with documented permission by the Engineer and the DEP. Evidence of improper storage and handling shall be cause for immediate shutdown until corrective action is taken.

Storage of hazardous waste on site is limited to 90 days with the start date of initial accumulation in each container. The Engineer is to be informed one week in advance of the planned date(s) when hazardous waste is to be removed from the job site.

C. Waste Transportation and Disposal.

Hazardous waste shall only be removed from the site by DEP licensed haulers in the presence of the Engineer. Only EPA licensed Treatment Storage Disposal Facilities (TSDF) shall accept the hazardous waste. The Contractor shall submit the name, address, phone number, name of contact person and the EPA identification number of the TSDF. Before the start of work, the Contractor shall provide the Engineer with a letter of intent from the TSDF stating that they agree to accept and treat said waste in accordance with all state and federal regulations. All hazardous waste manifests must be signed by the Engineer upon removal of the waste. The Contractor shall provide the Engineer with a Certificate of Disposal upon receipt from the TSDF. The Engineer must receive a signed manifest copy directly from the TSDF.

D. Reportable Releases to the Environment.

The Contractor's on-site emergency response contingency plan shall outline steps to take in the event of a hazardous waste spill or release including procedures for notification to DEP in accordance with 310 CMR 30.00 and 310 CMR 40.00.

The Contractor is advised that a discharge of one or more pounds of lead with a particle size of 0.1 mm (4 mils) or less to the atmosphere, water or soil, within a 24 hour period, is considered to be a reportable release in accordance with 310 CMR 40.00 (40 CFR 300 and 40 CFR 302).

961.69 Submittals.

The Contractor shall submit the following written programs and plans to the Engineer within thirty (30) days of the Notice to Proceed. No work shall commence until the Engineer has approved all submittals with the exception of the Worker Health & Safety Program, which will only be received by the Engineer. Reception of the Worker Health & Safety Submittal does not constitute approval by the MassDOT.

A. Worker Health & Safety Program.

The Contractor shall provide a site specific compliance program prepared under the direction and approval of a Certified Industrial Hygienist (CIH), in accordance with 29 CFR 1926.62 and 29 CFR 1910.134.

The program shall describe all engineering, administrative, housekeeping and protective equipment that will be used to reduce the exposure of the employees to a level less than the PEL.

The program shall provide the name, address, accreditation, and qualifications for the Certified Industrial Hygienist and the firm(s) that will be utilized for monitoring, testing and analysis. The name and qualifications of the project's competent person shall be included along with an emergency contact person. The Program shall include the following elements:

- Employee Training Program
- Hazard Communication Training Program
- Medical Surveillance and Medical Removal Program
- Procedures for Exposure Monitoring / Initial Assessment
- Respiratory Protection Program
- Recordkeeping
- Protective Clothing and Equipment
- Personal Hygiene Facilities and Equipment
- Housekeeping

B. Environmental Protection and Monitoring Program.

The written program shall ensure the protection of the environment from project activity in accordance with this specification and 40 CFR 50 and 310 CMR 7.00.

The program shall detail programs for monitoring activities and provisions for complying with the results of any monitoring and analysis that is conducted. Included shall be a statement that corrective action will be implemented immediately in the event of unacceptable monitoring results. The program shall include the following elements:

- Procedures for High Volume Air Sampling
- Methods for monitoring and Establishing Baseline Levels
- Methods for Establishing Regulated Areas
- Assessment of Visible Emissions and Releases
- Methods for Sampling and Analysis for soil, waste water and debris

C. Containment.

The Contractor shall provide a written plan and drawings for the method employed for surface preparation, containment and ventilation. The submittal shall be approved and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts. The submittal shall include the following:

- Methods and equipment to be used for precleaning (washing) and surface preparation
- Location of equipment and impact on traffic
- Engineering Calculations: Load-bearing capacity, Wind load and Ventilation
- Connection Details
- Lighting plan
- Drawings and Plans for installing, moving, and removing the containment.
- Provisions for Emergency breakdown of containment.
- Provisions for moving the containment out of navigation lanes when working over active waterways.
- Provisions for the containment of debris that might escape when working over land, streams, rivers, lakes, or other bodies of water.
- Descriptions and product data or cut sheets for all containment system materials and all equipment to be used
- Confirmation that appropriate notification and coordination with other organizations or agencies such as the Coast Guard and Railroad have been accomplished with regard to right of ways, containment clearances, and other project restrictions.

D. Hazardous Waste, Handling & Reporting of Release Programs.

The written program shall establish the procedures that will be followed for the proper handling, packaging and disposal of all waste generated during contract activities. The program shall be in accordance with applicable EPA regulations, the requirements of this specification and 310 CMR 30.00 & 310 CMR 40.00. The program shall include the following elements:

- Methods for Sampling, Testing and Classification
- Methods for Handling, Packaging and Storage
- Identification of Transporter and Treatment Storage and Disposal Facility
- Methods for Reporting Releases into the Environment
- Emergency Response Contingency Plan

COMPENSATION

961.80 Method of Measurement.

The above work will be measured as a complete unit. For purpose of estimating partial payments, the work will be separated into distinct phases as listed below and the value of each will be assigned a percentage of the lump sum:

Containment.....30%
Clean, Collect and Prime 35%
Intermediate Coat 10%
Finish Coat.....10%
Final Inspection 15%

Partial payment for each phase will be based on the length of work completed, divided by the total length of the structure to be painted, or as determined by the Engineer.

Final inspection will be paid after the completion of punch list items, cleaning of the site(s), the removal of all equipment, materials and the removal of contaminated and hazardous waste generated during the cleaning operations.

961.81 Basis of Payment.

The work will be paid at the contract price per Lump Sum which shall include full compensation for all labor, equipment, worker protection, environmental compliance, materials, tools, rigging, and all incidentals necessary to complete the work as specified.

Incidental to this work is the removal and replacement of, anti-missile fencing, protective screening, signs and sign supports. The Contractor shall determine if anti-missile fencing, protective screening, signs and sign supports are to be removed to facilitate complete cleaning and painting of the structure as specified. Removal shall be accomplished prior to cleaning activities and will be subject to the approval of the Engineer.

961.82 Payment Items.

961.1*	Clean and Paint (Overcoat) Bridge No. _____	Lump Sum
961.2*	Clean (Full Removal) and Paint Bridge No. _____	Lump Sum

* - number assigned to the bridge being painted

SECTION 965
MEMBRANE WATERPROOFING AND PROTECTIVE COURSE FOR BRIDGE DECKS

SUBSECTION 965.20 General.
(page 312 English) Replace system 3 with the following:

†3. Preformed sheet systems -- either reinforced rubberized asphalt or reinforced tar and resin.

(page 313English) Add the following sentence to the end of this Subsection:

†System 3 is the only system acceptable for butted deck beam and box beam superstructures.

SUBSECTION 965.62 Hot Mix Asphalt Protective Course.
(page 314 English, II.285 Metric) Replace this Subsection with the following;

The first course of the hot mix asphalt overlayment shall serve as the protective course. It shall be placed within 24 hours after the membrane has been installed.

The hot mix asphalt 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 450, Hot Mix Asphalt 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 Hot Mix Asphalt Pavement in Section 450, 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 hot mix asphalt 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 450. Edges of the hot mix asphalt 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.

SUBSECTION 965.80 Method of Measurement.
(page 315 English, II.286 Metric) delete the last paragraph of this Subsection.

SUBSECTION 965.81 Basis of Payment.
(page 315 English, II.286 Metric) delete the last paragraph of this Subsection.

SUBSECTION 965.82 Payment Items.
(page 315 English, II.286 Metric) delete pay item 462.

SECTION 970
BITUMINOUS DAMP-PROOFING

SUBSECTION 970.60 General.
(page II.289 Metric) In the second paragraph from the top change "per 10 square meters of area." to "per square meter."

SECTION 971
ASPHALTIC BRIDGE JOINT SYSTEM

SECTION 971 ASPHALTIC BRIDGE JOINT SYSTEM
(page 317 English, page II.289 Metric) Add the following new Section:

DESCRIPTION

971.20 General.

The work shall include the furnishing and installation of a polymeric binder and aggregate system composed of specially blended, polymer modified asphalt and selected aggregate, placed into a prepared joint blockout as shown on the plans. The system shall provide a flexible waterproof bridge joint capable of accommodating a total movement of up to 2 inches (50 mm) from maximum expansion to maximum contraction, and maintain a continuous load bearing surface. Incidental to this system shall be the placement of the non-sag joint sealer and backing rod through the safety curb and sidewalk deck joint as shown on the plans.

MATERIALS

971.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Polyurethane Joint Sealer, Non-Sag M9.14.4
Asphaltic Binder for Asphaltic Bridge Joint System.....M9.17.0
Aggregate for Asphaltic Bridge Joint System.....M9.17.1
Backer Rod.....M9.17.2
Bridge Plate for Asphaltic Bridge Joint System.....M9.17.3

CONSTRUCTION METHODS

971.60 General.

A qualified employee of the manufacturer or an installer certified by the manufacturer and approved by the Department shall be at the job site prior to the beginning of the joint construction process to instruct the work crews in proper joint construction procedures and shall remain on the job site for the duration of the joint installation.

The minimum ambient air temperature during installation shall be 40ºF and rising.

The Contractor shall produce uniform and parallel surfaces in the forming and placement of the blockout area within the reinforced concrete deck slabs as detailed on the plans. The formed blockout area shall be protected by the Contractor to prevent any edge damage by any site equipment throughout the on-going construction process.

The Contractor shall produce the required gap width within the full depth of the joint as dimensioned on the plans. If the existing curb stones bridge the existing sidewalk and safety curb joint gaps, they shall be modified by saw cutting a smooth face which shall be aligned and placed to maintain the uniform joint gap.

Immediately prior to placing any binder, the blocked out section and the joint gap shall be inspected full depth and any debris shall be removed. Immediately thereafter the blockout, sidewalk and safety curb gap, and road surface 6 inches either side of the blockout shall be thoroughly cleaned and dried using a hot compressed air (H.C.A.) lance capable of producing flame-retarded air stream at a temperature of at least 2,000°F. The lance's blast orifice shall be capable of producing 150 psi of pressure (1MPa).

The backer rod shall be installed in the sidewalk and safety curb gap to the proper depth to ensure a correct width/depth ratio as specified by the manufacturer. The backer rod shall be set in accordance with the plans. There will be no splicing of the backer rod at the curb lines.

The binder shall be melted and heated to the application temperature in a double jacketed, hot oil, heat transfer kettle, or as recommended by the manufacturer. The kettle shall be equipped with a continuous agitation system and temperature controls that can accurately maintain the material temperatures.

The binder shall be poured into the joint gap. The binder shall overfill the roadway joint gap to allow the binder to be spread onto the adjacent concrete deck in order to form a bond breaker between the deck and the bridge plate.

For sidewalk, curb, and median joint gaps a non-sag polyurethane joint sealer compatible with the asphaltic binder shall be used.

The bridge plate shall be centered and placed over the entire length of the roadway joint gap. The plate shall be secured by placing locating pins through the pre-drilled holes into the joint gap backer rod. The bridge plate sections shall not overlap.

The horizontal and vertical surfaces of the joint blockout joint shall be coated immediately with hot binder before pouring hot binder over the floor area of the joint. The coating shall be continuous and adhere to the surfaces.

The aggregate shall be heated to a temperature of 300 to 390°F in a suitable rotating drum blending unit with a heat source attached or by a secure H.C.A. lance to remove moisture. Temperature of the aggregate shall be controlled by a hand held calibrated digital temperature sensor or other means as approved by the Engineer.

The heated aggregate and polymeric binder shall be combined in the blending unit with sufficient binder to thoroughly coat each aggregate individually while avoiding an excess of binder. In no instance shall the amount of the binder added to the blending unit be less than 15% by weight. The binder used for coating is not included in the above percentage.

The coated aggregate shall be placed in the blockout in layers and raked level as recommended by the joint material manufacturer.

The final layer shall be raked level and compacted flush with adjacent deck surface. This layer shall be compacted to the point of refusal with a 1½ to 2½ ton (1½ to 2½ Mg) roller to ensure the proper density and interlocking of the aggregate in the layer.

Immediately following the compaction, the surface of the joint and surrounding road shall be dried and cleaned using the H.C.A. lance.

Sufficient binder shall immediately be spread over the joint and adjacent road surface to fill surface voids and seal the surface stone. The finished joint shall then be dusted with a fine, dry aggregate to prevent tackiness.

QUALITY CONTROL

971.70 General.

The Contractor shall have sufficient mixers and personnel at the site to assure continuous and timely installation of the joint.

The Manufacturer shall document and submit the successful performance of their material in a similar Asphaltic Bridge Joint System.

The Installer shall have previously demonstrated the ability to have successfully produced a joint of similar nature and shall provide documentation of a working joint to the Department.

The Contractor shall furnish Certified Test reports, Materials Certificates and Certificates of Compliance for the asphaltic polymeric binder, the aggregate, and the joint sealer. The backer rod and locating pins require Certificates of Compliance.

COMPENSATION

971.80 Method of Measurement.

Item 971. Asphaltic Bridge Joint System will be paid for at the contract unit bid price per foot, as measured between curb lines complete in place.

Item 971.1 Asphaltic Bridge Joint System will be paid for at the contract unit bid price per cubic foot (m^3). The volume measurement shall consist of the product of (1) the distance between the curbs along the length of the joint times (2) the width of the asphaltic plug joint noted on the plans times (3) the average depth of the installation across the centerline of the joint.

The joint treatment at the safety curb, sidewalk and median shall be considered incidental to the work to be done under these items.

971.81 Basis of Payment.

Payment shall be considered full compensation for installation of the Asphaltic Bridge Joint System including all labor, material, equipment, manufacturer's representative and all items incidental to the satisfactory completion of the work.

Removal of existing joints and materials will be paid for under separate Item.

971.82 Payment Items.

971.	Asphaltic Bridge Joint System	Foot (m)
971.1	Asphaltic Bridge Joint System	Cubic Foot (m^3)

SECTION 972 STRIP SEAL BRIDGE JOINT SYSTEM

(page 318 English, page II.289 Metric) Add this Section.

SECTION 972
STRIP SEAL BRIDGE JOINT SYSTEM

DESCRIPTION

972.20 General.

The work shall consist of furnishing and installing strip seal bridge joint systems. This system shall consist of structural steel components, bolts, nuts, washers, lock washers, expansion anchors, preformed neoprene seal and lubricant-adhesive, and elastomeric concrete, all combined in the manner required by the Contract Documents so that a fully operational, waterproof system will seal the joint over which it is installed.

MATERIALS

972.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Epoxy-Resin Base Bonding System for Concrete M4.05.5
Elastomeric Concrete.....M4.07.0
Structural Steel M8.05.0
Steel Extrusions M8.05.7
Galvanized Coatings M7.10.0
Neoprene Seal.....M9.17.4

CONSTRUCTION METHODS

972.60 General.

The joint system shall be installed in strict accordance with the manufacturer's instructions and this Subsection. In the event of a conflict, the more stringent requirement shall rule. A representative of the strip seal joint manufacturer shall be present throughout the installation. The representative shall be fully conversant in all respects with the correct installation methods. The representative shall be responsible to advise both the Engineer and the Contractor, that the proper installation method is being followed.

972.61 Preparation of Surfaces, Handling, and Storage.

The preformed recess or blockout that is to receive the joint system shall be air blown or vacuum-cleaned such that all loose or foreign matter is removed prior to installation of the system. The blockout shall be constructed to the dimensions shown on the approved shop drawings. The concrete substrate must be clean (free of dirt, coatings, rust, grease, oil and other contaminants), sound, and durable. New concrete must have been cured for a minimum of 14 days and all laitance removed. Suitable preparation methods include sandblasting, chipping and scarification.

The joint system shall be stored, inspected and handled in accordance with the manufacturers requirements and approved by the Engineer. No material shall be dropped, thrown, or dragged upon the ground. Material shall be kept clean, properly drained and stored on proper supports above the ground. All material shall be adequately shored, braced, or clamped to resist lateral forces that might occur. Permanent distortion of the steel extrusions will be cause for rejection of material. Galvanizing shall be in accordance with M7.10.0 Galvanized Coatings and Subsection 960.64 Galvanizing and shall be done before other coatings are applied.

972.62 Pre-Installation Inspection.

Immediately prior to installation, the steel extrusions shall be inspected by the Engineer for proper alignment and anchor effectiveness. No bends or kinks in the steel extrusions shall be allowed, nor shall the straightening of such bends or kinks be allowed. Steel extrusion segments exhibiting bends or kinks shall be removed from the work site, and replaced with new steel extrusion segments at the Contractor's expense. Anchorage bars or studs and their welds shall be inspected visually. Any anchorage bars or studs that do not have complete attachment weld shall be replaced.

972.63 Field Preparation.

In order for the steel extrusion segments to be installed properly, they must be set at a width that is directly dependent upon the ambient temperature at the start of installation, as shown on the shop drawings. Before casting the elastomeric concrete, the setting dimension shall be adjusted under the direction of the Engineer to correspond to the proper ambient temperature setting as shown on the approved shop drawings. The width setting shall be accomplished through the use of mechanical devices supplied by the strip seal bridge joint system fabricator. After the steel extrusions have been set to their proper line and grade and securely attached to their supports, the mechanical devices shall be removed.

972.64 Field Splicing of Steel Extrusions.

If the system is to be installed in sections, the manufacturer will ship the joint with the appropriate ends beveled for field welding in accordance with the field splice detail shown on the approved shop drawings and the approved welding procedure specifications. Once the first joint section is installed and the elastomeric concrete has been cast, the adjacent length shall be field welded.

972.65 Placement and Finishing of Elastomeric Concrete.

Prior to the placement of elastomeric concrete in the prepared blockout, the inside bottom faces of the steel extrusions shall be aligned and spaced using the manufacturer’s support devices. The steel extrusions shall not be unsupported or cantilevered into the joint blockout.

Foam backer rod shall be placed inside the seal cavities of the steel extrusions prior to the placement of the elastomeric concrete. The backer rod will remain inside the steel extrusions until such time as the neoprene seal is about to be placed inside the extrusions.

The equipment used for the mixing and placement of the elastomeric concrete shall be supplied by the manufacturer or shall be approved by the manufacturer. The mixing and placement of elastomeric concrete shall be in accordance with the joint manufacturers written instructions. Proper consolidation of the elastomeric concrete shall be achieved around all embedded elements. A minimum clearance of ½" between the bottom of the steel extrusions and the concrete substrate shall be consistent throughout the length of the joint ensuring proper flow and consolidation of the elastomeric concrete. Bonding agent must be used as a primer on the properly prepared joint blockout prior to the installation of the elastomeric concrete. The aggregate component and the liquid component of the elastomeric concrete shall be thoroughly mixed until all aggregate is completely coated (approximately 1 minute). This mix shall then be poured into the properly prepared blockout.

972.66 Installation of Neoprene Seal.

The neoprene seals shall be field installed in continuous lengths spanning the entire roadway width. The neoprene seal shall be prefabricated in the shop to the final dimensions of the joint. Field splices or repairs of the neoprene seal shall not be permitted. To ensure proper fit of the seal and increase the ease of installation, dirt, spatter or standing water shall be removed from the steel extrusion using a brush, scraper or compressed air. Prior to installation, the neoprene strip seal lugs shall be thoroughly coated with a lubricant-adhesive that is approved and supplied by the strip seal joint manufacturer.

972.67 Watertight Integrity Test.

At least five workdays after the joint system has been fully installed, the Contractor shall test the entire (full length) joint system for watertight integrity to the satisfaction of the Engineer. The entire joint system shall be covered with water, either ponded or flowing, for a minimum duration of 15 minutes. The concrete surfaces under the joint shall be inspected, during this 15 minute period and also for a minimum of 45 minutes after the supply of water has stopped, for any evidence of dripping water or moisture. Water tightness shall be interpreted to be no dripping water on any surface on the underside of the joint.

Should the joint system exhibit any evidence of water leakage, the Contractor shall locate the place(s) of leakage and take all measures necessary to stop the leakage. All methods proposed by the Contractor to stop the leakage shall be approved by the Engineer. This work shall be done at the Contractor's expense. A subsequent water integrity test shall be performed subject to the same conditions and consequences as the original test.

COMPENSATION

972.80 Method of Measurement.

Item 972. Strip Seal Bridge Joint System will be paid for at the contract unit price per foot, as measured along the joint centerline between curb lines complete in place.

The additional plates, angles, and all related hardware required at the safety curb, sidewalk and median shall be considered incidental to the work to be done under this item.

972.81 Basis of Payment.

Payment shall be considered full compensation for installation and testing of the Strip Seal Bridge Joint System including all labor, material, equipment, manufacturer's representative and all items incidental to the satisfactory completion of the work.

Removal of existing joints and materials will be paid for under a separate Item.

972.82 Payment Items.

972.	Strip Seal Bridge Joint System	Foot (m)

SECTION 975 METAL BRIDGE RAILINGS
(page 318 English, page II.289 Metric) Replace this Section with the following:

SECTION 975
METAL BRIDGE RAILINGS AND PROTECTIVE SCREENS

DESCRIPTION

975.20 General.

Work under this item shall consist of furnishing and erecting metal bridge railing and protective screens in accordance with the plans and specifications.

MATERIALS

975.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Paint and Protective Coatings	M7
Anodized Coatings	M7.20.0
Powder Coatings	M7.25.0
Bridge Railing, Aluminum	M8.13.0
Aluminum Handrail and Protective Screen Type I and Type II	M8.13.3
Bridge Railing, Steel, Type S3-TL4	M8.13.1
Molded Fabric Bearing Pad	M9.16.2

The contractor will be required to submit specifications showing the chemical and physical analyses to the Department for approval.

CONSTRUCTION METHODS

975.60 Shop Drawings.

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 and protective screens shall be fabricated before the approval of the detail or shop drawings by the Engineer.

975.61 Fabrication.

Fabrication of the Metal members can only be performed by fabricators who are approved by the Department as specified in Subsection 960.61. All steel, except for the pickets and the anchor plates shall be blast cleaned prior to fabrication in accordance with Subsection 960.61C. The blast cleaning shall conform to Steel Structures Painting Council Surface Preparation Specification "Near White Blast Cleaning," SSPC-SP10. Aluminum components shall be cleaned of any foreign matter. In assembly and during welding, the component parts of built up members shall be held by sufficient clamps or by other adequate means to keep parts straight and in close contact.

Welding and fabrication of steel shall conform to the AASHTO Standard Specifications for Highway Bridges and the ANSI/AASHTO/AWS D1.5 Bridge Welding Code. If the members are tubular sections, the fabrication and welding shall conform to the ANSI/AWS D1.1 Structural Welding Code-Steel. Welding and fabrication of aluminum shall conform to AASHTO and the ANSI/AWS D1.2 Structural Welding Code-Aluminum.

After welding aluminum members, all exposed joints in the rail or cap plate elements shall be finished by grinding or filing to produce a neat appearance. All welding of aluminum members shall be completed prior to anodizing.

Prior to galvanizing, the fabricator shall ensure that all rail and rail components are smooth and without sharp protrusions that would present an injury hazard to pedestrians. Any drain holes necessary to ensure safe galvanizing shall be drilled by the fabricator.

975.62 Setting Railing and Protective Screens.

Anchor bolts for Type II Protective Screen and Aluminum Handrail shall be tightened 1/3 turn past snug-tight conditions. Anchor bolt nuts for the S3-TL4 steel bridge railing shall be tightened 1/8 turn past snug-tight conditions and shall have between 3/16 inch and 3/8 inch of exposed thread after tightening.

A. Aluminum.

The three-rail aluminum railing and Protective Screen Type II posts shall be set plumb except in those locations where roadway grade is less than 1.50% in which case they shall be set normal to the grade. Handrail posts shall be set to normal grade. Longitudinal members shall follow the grade of the coping. During the erection of the railing and protective screens, care shall be taken to insure proper grade and alignment in order to prevent springing or bending of the railing and protective screens during erection. Where required on curves, the rails shall be accurately formed to the required radius.

Protective Screen Type I and Type II components shall be carefully adjusted prior to fixing in place to insure proper matching or interlocking at abutting joints, and correct alignment and camber throughout their length. Holes for field connections to be drilled in the field shall be drilled with the screen railing in place in the structure at the proper grade and alignment. Field welding of aluminum components shall not be allowed.

Base plates shall be set on 1/8 inch (3 mm) thick molded fabric bearing pads. If additional shimming of the base plates is required, the shims shall be made from fully annealed aluminum alloy sheets or plates.

The anchor cages for Protective Screen Type II and Aluminum Handrails shall be accurately set as shown on the drawings. The ferrules shall have a plastic cap in the bottom to act as a seal and shall have a temporary bolt installed while the concrete is being placed. Caps shall be installed in the tops of the ferrules if the temporary bolts are removed prior to erecting the posts. Protective Screen Type I posts shall be attached with extruded aluminum clamps to the steel tabs on the back of the steel bridge railing posts.

B. Steel.

The post shall be set plumb except in those locations where the roadway grade is less than 1.50% in which case they shall be set normal to the grade. The rails shall follow the profile grade of the bridge at the vertical dimensions shown on the plans. When the bridge is on a vertical curve, the bridge rail shall be shop cambered to follow the profile grade of the bridge. The rails may follow chords for shallow curves if the deviation at the post from the theoretical curve is ±1/2 inch (±13 mm) or less. Care shall be taken for bridge railing layouts with both horizontal and vertical curves or angles. Field bending of the tube sections will not be allowed.

Base plates shall be set on 1/8 inch (3 mm) thick molded fabric bearing pads. If additional shimming of the base plates is required, the shims shall be of the same material as the base plates. The edges of the base plates shall be caulked to make a water tight joint.

975.63 Galvanizing.

The galvanizing bath for structural components, excluding hardware, shall contain nickel (0.05% to 0.09% by weight).

Galvanized members requiring shop assembly shall be welded and drilled prior to galvanizing. The fabricator shall ensure that all welds are cleaned thoroughly in accordance with the AASHTO/AWS Bridge Welding Code and AASHTO M 111 and shall have a suitable surface to accept the galvanizing.

All bolts, screws, nuts and washers shall be hot dipped galvanized in accordance with AASHTO M 232 or mechanically galvanized in accordance with AASHTO M 298. The screws may be electroplate galvanized.

The posts, base plates, rails, pickets, angles and splice tubes shall be galvanized after fabrication in accordance with AASHTO M 111.

975.64 Painting.

Aluminum bridge railing shall not be painted.

Galvanized hardware need not be shop painted; however any part of the bolts, screws, nuts and washers that are accessible after installation shall be painted in the field in accordance with Subsection 975.65 Touch-Up and Repair.

Prior to painting, the galvanizer shall ensure that all rails and rail components are smooth and have a suitable surface for accepting the paint. All runs shall be removed by grinding.

The galvanized surface shall be prepared for painting by one of the following methods.

Method 1: The two coat paint system shall be applied within twelve hours of galvanizing. The surface shall be blast cleaned immediately before painting (maximum of eight hours) in accordance with requirements of SSPC SP7 "Brush-Off Blast Cleaning" or other method producing equivalent results and uniform profile, to achieve a 1.0 to 1.5 mil anchor profile as indicated by Keane Tator Surface Profile Comparator or similar device. All detrimental material, i.e., dirt, grease, other foreign matter, shall be removed prior to blasting.

Method 2: The two coat paint system shall be applied within 15 days of galvanizing. In preparation for the two coat painting system, the surface shall be blast cleaned in accordance with the requirements of SSPC SP7 "Brush-Off Blast Cleaning", or other method producing equivalent results and uniform profile, to achieve a 1.0 to 1.5 mil anchor profile as indicated by a Keane Tator Profile Comparator or similar device. All detrimental material such as oil, grease, dirt, other foreign matter, shall be removed prior to blast cleaning. The blast cleaning shall be performed prior to the formation of "white rust" on the galvanized surface. If "white rust" is detected, the steel shall be stripped and re-galvanized in accordance with these specifications.

The preparation shall be followed by a pretreatment of zinc or iron phosphate. The phosphate shall be applied to the blast cleaned material within eight hours of blast cleaning. Phosphating shall be applied in accordance with the manufacturer's recommendations. The material shall be painted within twelve hours of phosphating. The applicator shall submit the procedure for phosphating to the Engineer for approval prior to performing the work.

The phosphating applicator shall maintain a record of in-process quality checks on the solutions.

The prime coat material shall be a polyamide epoxy applied to a minimum dry film thickness of 3.0 mils and force cured as given below for the finish coat.

The finish coat material shall be a two component, catalyzed aliphatic urethane applied by airless spray to a minimum dry film thickness of 3.0 mils.

The color and the corresponding Color Number as found in Federal Standard 595B, "Colors Used in Government Procurement", shall be stated on the Plans. The fabricator shall submit to the Engineer for approval, paint chips of the intended color prior to any work being done under this heading.

All finish coat material shall be applied under conditions within the following tolerances:

Air Temperature:	50 to 90ºF
Surface Temperature:	50 to 100ºF
Humidity:	65% max.

The finish coat shall be cured in a booth maintained at 150° F for two to four hours.

Should the coating system fail within one year after the project has been accepted, the damaged coating shall be repaired by the Contractor at no cost to the Department. The method of repair shall be acceptable to the Department.

975.65 Touch-up and Repairs.

Should any damage occur to the coating during shipping or handling at the job site, the contractor shall repair and touch-up any damaged areas to the satisfaction of the Engineer and the following:

Touch-up of the galvanizing before the finish coat is applied shall be accomplished by applying a galvanizing repair paint in accordance with Section M7.04.11. The dry film thickness of the applied repair paint shall not be less than 3.0 mils. Applications shall be in accordance with the Manufacturer’s instructions.

Field touch-up procedures shall conform to the recommendations of the company that performed the initial painting. Touch-up of the finish coat shall be by applying a coating of a two part urethane, as supplied by the company that performed the initial painting, to achieve a dry film thickness of at least 3.0 mils. Prior to the application of the paint, remove all damaged coatings down to a solidly adhered coating and apply galvanizing repair paint as a primer. Allow the primer to dry for at least four hours.

The Contractor shall also use the touch-up paint material to paint the galvanized hardware used in the field erection of the railing that has not been finish coated previously.

All paint used for touch-up and repair shall be the same manufacturer’s brand and lot number as was used in the shop.

The Contractor shall be careful to not damage the anodized aluminum surfaces. Protective Screen Type I and Type II fabric shall be wrapped to prevent damage during shipment and storage. Touch-up coating shall be applied by spray to the fabric after installation. Touch up of the anodized surface will be at the Contractor’s expense and shall be subject to the approval of the Engineer.

975.66 Inspection.

Inspection may be done at the mill and or fabricating plant by the Engineer or the Engineer's representative (Verification Inspector). The Contractor shall give 3 business days notice to the Engineer prior to starting the work so that the Department may arrange for inspection. The contractor shall give the same notice when material is being shipped between the fabricator, galvanizer and painter so that inspection may be arranged. No material shall be shipped to a project until the Verification Inspector affixes his/her stamp to the material. Material shipped without such stamp shall be rejected and immediately removed from the job site.

COMPENSATION

975.80 Method of Measurement.

Metal bridge railings and protective screens shall be measured by the foot from end to end of the top rail. Curved portions shall be measured along the centerline of the top rail.

975.81 Basis of Payment.

Metal bridge railing and protective screens shall be paid for at the contract unit price per foot under the item of railing or screen required, complete in place.

975.82 Payment Items.

975.1	Metal Bridge Railing (3 Rail), Steel (Type S3-TL4)	Foot (m)
975.2	Metal Bridge Railing (3 Rail), Aluminum (Type AL-3)	Foot (m)
975.3	Protective Screen Type I	Foot (m)
975.4	Protective Screen Type II	Foot (m)
975.5	Aluminum Handrail	Foot (m)

SECTION 995
BRIDGE STRUCTURE

SUBSECTION 995.81 Basis of Payment.

(page 323 English, page II.297 Metric) Replace the last sentence of the first paragraph under Basis for Partial Payments. with the following:

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

(page 324 English) Add "concrete penetrant sealer," after bridge railings in the fifth line of the first paragraph on the page.

(page 324 English, pages II.296/297 Metric) Replace the last sentence of the first paragraph of the page and the second through sixth paragraphs (English) / Replace the last sentence of the second paragraph of the subsection and the third through seventh paragraphs (Metric) with the following:

Walls, other than wingwalls or connecting walls between the structures, will not be included for payment under an item for Bridge Structure.

When the Engineer orders changes from the contract plans of a bridge structure, the cost of such changes will be negotiated based on the provisions of Subsections 4.03 and 9.03.

SUBSECTION 995.81 (continued)

(page 324 English, pages II.297 Metric) Under the heading ***Basis for Partial Payments****. replace the first sentence with the following:*

Within 10 days after Notice to Proceed, the Contractor shall submit, in duplicate, for approval by the Engineer, a schedule of quantities and unit prices for the major components of the respective items for Bridge Structure as listed in the Special Provisions.

SUBSECTION 995.82 Payment Item.

(page 324 English, page II.297 Metric) Delete payment items 999.995 and 999.996.

SECTION 996 NOISE BARRIER STRUCTURE

(page 324 English, page II.297 Metric) Add this Section:

SECTION 996
NOISE BARRIER STRUCTURE

DESCRIPTION

996.20 General.

Work included in this section shall consist of constructing noise barrier structures in accordance with the plans and these specifications to provide a satisfactory structure, complete in place.

MATERIAL

996.40 General.

All structural steel shall be new and in conformance with Section 960 Structural Steel.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Anchor bolts	M8.01.5.
Galvanizing	M7.10.0.
Paint and protective coatings	M7.
Reinforcement steel	M8.01.0.
Epoxy coating for reinforcing bars	M8.01.07.
4000psi-3/4”-565 Cement Concrete	M4.02.00
Elastomeric bearing pads	M9.14.5.
Joint sealer	M9.14.4.
Backer rod	M9.17.2.

CONSTRUCTION METHODS

996.0 General.

The method of construction shall be in accordance with the plans and these specifications.

The Contractor shall submit shop drawings in accordance Subsection 5.02. The shop drawings shall include all pertinent dimensions, reinforcing steel, pick points and precasting details.

The Contractor shall submit an erection procedure in accordance with Subsection 960.61, Erection.

All open excavations shall be suitably covered or filled in to the satisfaction of the Engineer at the end of the shift.

996.61 Weep Holes.

Weep holes, if required, shall be located as shown on the plans or as directed by the Engineer. They shall be located to avoid reinforcing steel. The Contractor shall propose a method for locating re-bar that is satisfactory to the Engineer.

The weep holes shall be cored in a manner which results in a smooth bore hole and which does not break or chip either panel surface at the edge of the hole.

996.80 Method of Measurement.

The Noise Barrier Structure shall be measured by the square foot (m^2), one face. The length of each wall section shall be measured centerline of post to centerline of post. The height of each wall panel shall be measured vertically from the bottom of the lowest panel to the top of the wall panel.

Noise Barrier Foundations shall be measured vertically by the foot (m), from the bottom of the shaft to the top of the concrete.

Weep Holes for Noise Barrier Structure shall be measured by each hole installed.

996.81 Basis of Payment.

The above work will be paid for at the contract unit price under the respective item of Noise Barrier Structure, Noise Barrier Foundation, and Weep Hole for Noise Barrier Structure.

Payment for Noise Barrier Structure shall include all panels including coloring, surfacing and anti-graffiti protection application, post assemblies including galvanizing and painting, signs, access doorways, hand holes, bearing pads, caulking, hardware, brick, plates, nuts, washers, temporary post supports, grout and mortar, and any and all incidental work necessary to construct the structure complete in place.

Payment for Noise Barrier Foundation, shall include all earth support, water control, grouting of pre-cast foundations concrete, reinforcing steel, anchor bolts, and any and all incidental work necessary to construct the foundations complete in place and ready to accept the posts.

Payment for Weep holes for Noise Barrier Structure will be made at the contract unit price each, complete in place.

Payment for excavation, test pits, crushed stone, geotextile fabric and clearing and grubbing shall be made under the respective items.

996.82 Payment Items.

English units:

945.101	Drilled Shaft Excavation 3.0 Foot Diameter	Foot
945.201	Rock Socket Excavation 3.0 Foot Diameter	Foot
945.301	Obstruction Excavation 3.0 Foot Diameter	Foot
996.1	Noise Barrier Structure	Square Foot
996.11	Noise Barrier Foundation	Foot
996.2	Weep Hole for Noise Barrier Structure	Each
101.	Clearing and Grubbing	Acre
156.	Crushed Stone	Ton
698.3	Geotextile Fabric for Separation	Square Yard
141.1.	Test Pit for Exploration	Cubic Yard
120.	Earth Excavation	Cubic Yard

Metric units:

945.101	Drilled Shaft Excavation 915 Millimeter Diameter	Meter
945.201	Rock Socket Excavation 915 Millimeter Diameter	Meter
945.301	Obstruction Excavation 915 Millimeter Diameter	Meter
996.1	Noise Barrier Structure	Square Meter
996.11	Noise Barrier Foundation	Meter
996.2	Weep Hole for Noise Barrier Structure	Each
101.	Clearing and Grubbing	Hectare
156.	Crushed Stone	Megagram
698.3	Geotextile Fabric for Separation	Square Meter
141.1.	Test Pit for Exploration	Cubic Meter
120.	Earth Excavation	Cubic Meter

DIVISION III
MATERIALS SPECIFICATIONS

SECTION M
MATERIALS

SUBSECTION M MATERIALS

(page 327 English, page III.3 Metric) Replace the paragraphs under ***Approval and Acceptance.*** *with the following:*

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. All questions relating to materials will be resolved by the Research and Materials Section of the Department or its duly authorized representative.

The Department maintains a Qualified Construction Materials List (QCML) of commonly used materials that meet these specifications. The Qualified Construction Materials List is available at www.massdot.state.ma.us/highway.

SECTION M1
SOILS AND BORROW MATERIALS

SUBSECTION M1.01.0 Ordinary Borrow.

(page 327 English) Add the following paragraph to the end of this Subsection:

The use of processed glass aggregate meeting the requirements of M2.01.8 may be homogeneously blended with the borrow material up to an addition rate of 10 % by mass in areas that will not be exposed, providing the AASHTO M 145 physical characteristics are maintained.

SUBSECTION M1.02.0 Special Borrow.

(page 327 English) Under a) replace the first sentence with the following:

a) A native in-situ soil that is classified under AASHTO-M145 as A-3, or that portion of A-1 and A-2 with less than 12% passing the No. 200 sieve as determined by AASHTO-T11 and T27.

(page 327 English) Add the following paragraph to the end of this Subsection:

The use of processed glass aggregate (PGA) meeting the requirements of M2.01.8 may be blended with either special borrow material outlined above. An addition rate of 10 % by mass in areas where the borrow will not be exposed will be allowed, providing the physical characteristics are maintained. The PGA will be blended so as to produce a homogeneous borrow material.

SUBSECTION M1.03.0 Gravel Borrow.
(page III.4 Metric) Change "course" to "coarse" in the first paragraph.

(page 328 English, page III.4 Metric) Add the following below M1.03 Type c:

M1.03 Type d	1 ½ inch (37.5 mm) largest dimension

(page 328 English, page III.4 Metric) Add the following paragraphs to the end of this Subsection:

The gradation for Gravel Borrow for Bridge Foundations shall have at least 70% passing the ¾ inch (19.0 millimeter) sieve.

The use of Processed Glass Aggregate (PGA) meeting the requirements of M2.01.8 may be homogeneously blended with the processed gravel up to an addition rate of 10 % by mass, providing the subbase material will not be exposed. The resulting blend will meet the physical requirements of gravel borrow types a, b, c and d specified above.

SUBSECTION M1.03.1 Processed Gravel for Subbase.
(page 328 English) Change the third sieve designation from ¼ in. to ¾ in..

(page 328 English) Add the following paragraph to the end of this Subsection:

The use of Processed Glass Aggregate (PGA) meeting the requirements of M2.01.8 may be homogeneously blended with the processed gravel up to an addition rate of 10 % by mass, providing the subbase material will not be exposed. The resulting blend will meet the physical requirements of processed gravel specified above.

SUBSECTION M1.04.0 Sand Borrow.
(page 328 English) Add the following paragraph to the end of this Subsection:

The use of processed glass aggregate meeting the requirements of M2.01.8 will be allowed at an addition rate of 10 % mass to type b sand borrow. This addition is allowed providing the material will not be exposed, that the blended material is homogeneous and that the physical requirements specified for Sand Borrow above are maintained.

SUBSECTION M1.05.0 Loam Borrow.
(page 329 English, page III.6 Metric) Replace this Subsection with the following

Loam Borrow shall be fertile, friable soil obtained from naturally well-drained areas or shall be the product of a commercial sand and gravel processing facility. It shall be uncontaminated by salt water, foreign matter, or substances harmful to plant growth. Loam Borrow shall be free of debris rocks, clods, and any other extraneous matter greater than 2 inches (50 mm) in diameter.

Loam Borrow shall have the following mechanical analysis:

Sieve Size	Percent Passing
No. 10 (2 mm)	85-100
No. 40 (425 μm)	35-85
No. 200 (75 μm)	10-35
<20μm	<5

Testing shall be on material that has passed the No. 10 sieve. Loam Borrow shall contain 4-10 percent organic matter as determined by the loss on ignition of oven-dried samples. Lawn areas shall have an organic content of at least 4 percent. Organic content for lawn areas shall be at least 4 percent; for woody plantings, organic content shall be 7-10 percent. Salinity (electrical conductivity) shall be less than 0.1 S/m as determined by a 1:2 (by volume) soil-to-water mix. Salt test samples shall not be oven-dried. The acidity range of the Loam Borrow shall be pH 5.5 to 7.0.

SUBSECTION M1.05.0 (continued)

The Contractor shall provide testing submittals as follows:

- One 25 pound (10 kg) representative sample per source of loam
- For sources providing >1000 cubic yards (1000 m^3), one additional 25 pound representative sample for each 1000 cubic yards unit of soil

In addition, five random representative 25 pounds (10 kg) samples of on-site stockpiles of delivered loam shall be collected and packaged in the presence of the Engineer.

The Contractor shall deliver samples to testing laboratories and shall have the testing report sent directly to the Engineer.

Testing and analysis will be at the Contractor's expense. Soil samples shall be dry. Tests for particle gradation, organic content, and pH shall be performed by an Agricultural Experiment Station testing laboratory or other testing laboratory approved by the Engineer. Soil analysis tests shall show recommendations for soil additives to correct soils deficiencies, and for additives necessary to accomplish particular planting objectives noted. University of Massachusetts Agricultural Extension Service methods for soil and soil additive analysis shall be used.

No Loam Borrow shall be delivered to the site until the review and approval of loam test results by the Engineer.

SUBSECTION M1.06.0 Peat Borrow.

(page 329 English, page III.6 Metric) Replace this Subsection with the following

M1.06.0 Organic Soil Additives.

The Contractor shall submit for approval a written list of all vendors of manufactured compost that will be used on the project, including locations of compost facilities and feedstock materials. All vendors shall submit certified results of regular periodic testing by an approved testing facility. Certification shall be per Massachusetts Highway Department approved compost certification programs.

In addition, the Contractor shall provide representative 1 gallon (3 L) samples from each proposed source for testing and analysis. The Contractor shall deliver samples to testing laboratories and shall have the testing report sent directly to the Engineer. Tests for levels of toxic elements and compounds shall be performed by a private testing laboratory approved by the Engineer. Tests for soil chemistry and pH may be performed by an Agricultural Experiment Station testing laboratory or other testing laboratory approved by the Engineer.

Compost shall be a well-decomposed humus material derived from the aerobic decomposition of biodegradable matter, free of viable weed seeds and other plant propagules (except airborne weed species), foreign debris such as glass, plastic, etcetera and substances toxic to plants. Compost shall be suitable for use as a soil amendment and shall support the growth of ornamental nursery stock and turf establishment. Compost shall be in a shredded or granular form and free from hard lumps. Food and agriculture residues, animal manure, or other biosolids that meet the above requirements and are approved by the Massachusetts Department of Environmental Protection are acceptable as source materials.

The level of toxic elements and compounds in organic matter shall be below the Massachusetts Department of Environmental Protection Type I standards for sludge and the United States Environmental Protection Agency standards for Class A "Exceptional Quality Sludge", whichever is more stringent. Levels of pathogens shall be below both federal and state thresholds.

Composted material with an unpleasant odor, such as that of ammonia or fecal material shall be rejected by the Engineer.

Compost shall have the following properties:

- maximum particle size of 1 inch (25 mm)
- stability =<10 mg CO2 - C/g BVS day, or
  =<10° C above ambient temperature (deWar self-heating test), or
  => 6 using Solvita test kit.

The Solvita test kit shall be procured by the Contractor, and the compost samples shall be tested on site in the presence of the Engineer for the following:

- moisture content between 35-55 %
- pH range between 5.5 and 7.5
- minimum organic matter content of 40% (minimum dry weight)
- maximum electrical conductivity of 0.4 S/m
- maximum of 1 percent foreign matter
- C:N ratio range of 11-25:1

An extended list of commercial sources of compost material is available from the Division of Consumer Programs, Bureau of Waste Products, Massachusetts Department of Environmental Protection.

SUBSECTION M1.06.1 Processed Planting Material.
(page 329 English) Delete this Subsection.

SUBSECTION M1.07.0 Topsoil and Plantable Soil Borrow.
(page 330 English, page III.7 Metric) Replace this Subsection with the following

M1.07.0 Topsoil.

Topsoil shall consist of fertile, friable, natural topsoil, reasonably free of stumps, roots, stiff clay, stones larger than 1 inch (25 mm) in diameter, noxious weeds, sticks, brush or other litter.

Prior to stripping the topsoil from the construction project, it shall have demonstrated by the occurrence 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.

SUBSECTION M1.09.0 Reclaimed Pavement Borrow Material.
(page 330 English, page III.7 Metric) Add this Subsection:

Reclaimed Pavement Borrow material shall consist of crushed asphalt pavement and/or crushed cement concrete, and gravel borrow meeting M1.03.0. The material shall be free of loam, clay, and deleterious materials such as brick, reinforcing steel, wood, paper, plaster, lathing, and building rubble, etcetera.

The coarse aggregate shall have a percentage of wear not greater than 50 as measured by the Los Angeles Abrasion Test.

Gradation requirements shall be determined by AASHTO T 11 and T 27 except the material shall not be oven dried. It shall be air dried, fan dried at low speed, or other low temperature heat so as not to liquefy the asphalt or cause the asphalt to adhere to the sieves. Water used for the #200 (75 μm) sieve analysis shall be cold tap water.

The gradation shall meet the following requirements:

Sieve Designation	Percent Passing
3 inch (75 mm)	100
1½ inch (37.5 mm)	70 - 100
¾ inch (19.0 mm)	50 - 85
No. 4 (4.75 mm)	30 - 60
No. 50 (300 μm)	8 - 24
No. 200 (75 μm)	0 - 10

The portion of materials passing the No. 40 (425 μm) sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6. The reclaimed pavement borrow shall be compacted to a minimum of 95% of AASHTO T 180 proctor density. Liquid limits shall be determined by AASHTO T 90.

Reclaimed pavement borrow material shall be processed by mechanical means and blended to form a homogeneous material. The equipment for producing crushed material shall be of adequate size and have sufficient adjustments to produce the desired materials. Blended materials that are stockpiled for more than 3 months shall be reworked to a uniform material and retested prior to use however, the Engineer may require additional testing any time the materials appear excessively hard, wet and/or segregated. The processed materials shall be stockpiled in such a manner as to minimize segregation of particle sizes. All reclaimed pavement borrow material shall come from approved sources and stockpiles.

The amount of combined crushed asphalt pavement and crushed cement concrete shall not exceed 50% by volume as determined by visual inspection, and/or by laboratory tests required by the Engineer.

SUBSECTION M1.10.0 Pavement Milling Mulch.
(page 330 English, III.7 Metric) Add this Subsection:

Pavement milling mulch shall consist of recently milled asphalt concrete pavement. The milled material shall meet the following gradation requirements as determined by AASHTO T11 and T27:

Square Opening Sieve	Percent Passing by Weight
1 ½ inch (37.5 mm)	100
1 inch (25.0 mm)	85 - 100
½ inch (12.5 mm)	10 - 98
No. 4 (4.75 mm)	0 - 70
No. 200 (75 µm)	0 - 12

SUBSECTION M1.11.0 Reclaimed Pavement Borrow Material for Base Course.
(page III.7 Metric) Delete this Subsection:

SECTION M2
AGGREGATES AND RELATED MATERIALS

SUBSECTION M2.01.6 Crushed Stone 3/8 inch.
(page 331 English) Change stone size from ¼ inch. to 3/8 inch.

SUBSECTION M2.01.7 Dense-graded Crushed Stone for Sub-base.
(page 331 English) Replace the title and the first paragraph with the following:

M2.01.7 Dense Graded Crushed Stone for Sub-base.

This Specification covers the quality and gradation requirements for a sub-base material combining crusher-run coarse aggregates of crushed stone (trap only, meeting M2.01.0,1), and fine aggregates uniformly premixed with a predetermined quantity of water.

(page 331 English) Add the following paragraph to the end of this Subsection:

The use of Processed Glass Aggregate (PGA) meeting the requirements of M.2.01.8 will be allowed at a maximum addition rate of 10 % mass, providing the blended material is homogeneous and the physical requirements of dense graded crushed stone are maintained.

SUBSECTION M2.01.8 Processed Glass Aggregate (PGA).
(page 331 English) Add this new Subsection in numerical order:

M2.01.8 Processed Glass Aggregate (PGA).

Processed Glass Aggregate shall be manufactured from an approved supplier of crushed cullet. The material shall consist of recycled glass food or beverage containers free of debris such as paper, metals, fabrics, toxins, clay, loam, or other materials that would be associated with the glass recycling process. A maximum of 5 % mass of the material may be produced from china dishes, ceramics, plate glass or other glass products. The material will have a nominal aggregate size of 3/8 inch and meet the following gradation requirements.

Sieve Designation	Percent by Mass Passing
3/8 inch	100
No. 4	70-100
No. 8	35-88
No. 16	15-40
No. 50	4-12
No. 200	0-5

The percent wear as determined by the Los Angeles Abrasion Test, Class C or D will be a maximum of 40 %.

SECTION M3
BITUMINOUS MATERIALS

SECTION M3 BITUMINOUS MATERIALS
(page 333 English, page III.13 Metric) Replace this Section with the following:

SECTION M3
ASPHALTIC MATERIALS

M3.00.0 General.

Asphaltic materials (also referred to as bituminous materials) include liquid asphalts as well as Hot Mix Asphalt (HMA) mixtures and other related materials. All asphaltic materials shall conform to the requirements of the specifications as designated

The sampling of liquid asphalt materials shall be in accordance with AASHTO R 66. The following procedure shall be followed in obtaining liquid asphalt samples from pressure distributors or tankers used for the transport of liquid asphalt 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 1 gallon of material shall be drained off through the sampling valve and discarded before the sample is obtained.
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.

M3.01.0 Performance Graded Asphalt Binder.

Performance Graded Asphalt Binder (PGAB) delivered to a project or to an HMA plant must be accompanied by a Bill of Lading (BOL) signed by the asphalt binder Supplier's authorized representative in accordance with AASHTO R 26. Shipments of material not accompanied by a BOL will not be accepted for use in the work.

The PGAB Supplier and the Contractor shall perform random Quality Control (QC) sampling and testing of PGAB as specified in Subsection 450.65F(1). The Contractor shall furnish, to the Engineer, the PGAB Supplier's BOL for each truckload of asphalt binder shipped to the project or HMA plant. The Contractor shall also submit to the Engineer the Supplier's Certificate of Compliance (COC) along with copies of the Certificate of Analysis (COA) showing the certified AASHTO M 320 test results for each Supplier Lot of PGAB. The COA shall meet the requirements of AASHTO R 26. The Contractor shall maintain a copy of the COA for each Lot of PGAB used, with a copy attached to each sample obtained for testing.

The Contractor shall assist the Engineer in obtaining random Department Acceptance samples of PGAB from the HMA plant in accordance with AASHTO R 66 and as specified in Subsection 450.74C. Each sample shall be labeled with the PGAB grade, Supplier source and Lot number, sampling location, quantity represented, project name, plant, date, and the sampling inspector. When the PGAB is used for HMA production under Section 450 the sample shall be obtained from an in-line sample valve located between the asphalt tanks and mixing chamber at a sampling location downstream of all additive injection ports.

The Engineer will test the Department Acceptance samples for verification of the PGAB grade. The material shall conform to the specification requirements for the applicable performance grade as specified herein. Material not conforming to specification requirements shall be subject to corrective action, production suspension, rejection, or removal as determined by the Engineer.

The blending of binder of different grades or binder from different Suppliers at the HMA plants is strictly prohibited without the Engineer's approval. Contractors may switch to another approved source of binder, upon written notification to the Engineer, and by certifying that the tank to be utilized has been drained to an un-pumpable condition. The binder tanks at the HMA production facility shall be managed in a manner which prevents contamination.

Contractors who modify, blend PG binders, or add additives to the PGAB at the HMA production facility will be reclassified as a Supplier and shall be required to certify the binder in accordance with AASHTO R 26.

A copy of the COA for each Lot shall be provided in accordance with AASHTO R 26. The data reported shall meet the requirements of the specific binder specification:

For AASHTO M 320 – Table 1

For AASHTO M 332 – Table 1

For Crumb Rubber Modified Asphalt ASTM D6114-09 – Table 1

M3.01.1 Standard Asphalt Binder Grade.

The asphalt binder for HMA mixtures shall be a PGAB which meets the specification requirements of AASHTO Standard M 320. PGAB shall be provided by an Approved Supplier in accordance with AASHTO R 26. Approved Suppliers shall be listed on the MassDOT Qualified Construction Materials List (QCML).

The standard PGAB Grade of PG64-28 shall be used.

M3.01.2 Modified Asphalt Binder Grades.

When specified by the contract documents, the PGAB shall be modified in accordance with the following:

A. Polymer Modified Asphalt Binder

The polymer modified asphalt binder shall be a PGAB which meets the specification requirements of AASHTO M 332, however "E" grades will not be subject to the Jnrdiff difference requirement. PGAB shall be provided by an approved Supplier in accordance with the AASHTO R 26. The modified PGAB Grade of PG64E-28 shall be used.

B. Crumb Rubber Modified Asphalt Binder

The modified binder shall be in accordance with ASTM D6114-09, Type II. Virgin PGAB for the crumb rubber modified asphalt shall be a PG 58-28 or PG 64-28 provided by an approved Supplier in accordance with the AASHTO R 26. The grade selected shall be based on laboratory testing by the asphalt-rubber Manufacturer.

The granulated rubber shall be vulcanized rubber product from the ambient temperature processing of scrap, pneumatic tires. The granulated rubber shall meet the gradation found in Table M3.1.

Table M3.1 – Crumb Rubber Gradation

Sieve Size	Percent by Weight Passing
#10	100
#16	90 – 100
#30	25 – 75
#80	0 – 20

The use of crumb rubber of multiple types from multiple sources is acceptable provided that the overall blend of crumb rubber meets the gradation requirements. The length of the individual rubber particles shall not exceed 1/8". The rubber shall be certified by the crumb rubber Manufacturer.

The percent of crumb rubber shall be a minimum of 15% by weight of binder. The temperature of the asphalt shall be between 350°F and 400°F at the time of addition of the granulated crumb rubber. The asphalt and crumb rubber shall be combined and mixed together in a blender unit and reacted in the distributor for a period of time as required by design. The temperature of the asphalt-rubber mixture shall be above 325°F during the reaction for a period of one hour.

M3.01.3 Asphalt Binder Grade for Recycled Asphalt Materials.

For any HMA mixture containing recycled asphalt materials, a binder that is softer than the standard asphalt binder shall be utilized in the mixture to account for the amount and stiffness of the recycled binder in accordance with Table M3.2.

If greater than 25% Reclaimed Asphalt Pavement (RAP) or any quantity of Recycled Asphalt Shingles (RAS) are used in an asphalt mixture, the virgin PGAB grade when blended with the RAP binder shall meet the binder grade specified by the project. The resulting final PGAB grade shall be in accordance with Table M3.2. Only PGABs meeting the requirements of AASHTO M 320 or M 323 will be used.

The type and amount of virgin asphalt binder to be used in the HMA mixture shall be included as part of the Laboratory Trial Mix Formula (LTMF). The Contractor shall submit certified test results from an AASHTO accredited laboratory showing the testing of the individual binders and the blending.

Table M3.2 – PGAB Grades for HMA Containing RAP/RAS

Amount of RAP in Mixture	Virgin PGAB Grade	Resulting PGAB Grade
≤ 25% RAP by Weight of Mixture	Project Specified Grade	Project Specified Grade
> 25% to 40% RAP by Weight of Mixture	Follow AASHTO M 323 Appendix X1	
≤ 5% RAS by Weight of Mixture	Follow AASHTO PP 78	

M3.01.4 Warm Mix Asphalt Additive.

All HMA shall be modified using a warm mix asphalt (WMA) additive. The WMA additive shall be evaluated by AASHTO's National Transportation Product Evaluation Program (NTPEP) and be listed on the MassDOT QCML. No WMA foaming technology which requires the mechanical injection of steam or water into the liquid asphalt will be permitted.

For HMA placed on bridge decks, the WMA additive shall not be used to lower the mixing and compaction temperatures. The mixing and compaction temperatures specified for the binder prior to addition of the WMA additive shall be used.

The WMA additive must be compatible with polyphosphoric acid modified binders, polymer modified binders, and anti-stripping agents. The WMA additive shall be introduced in accordance with the Manufacturer's dosing rates and approved blending methods.

The HMA mixture design shall incorporate the requirements of AASHTO R35 Appendix X2: Special Mixture Design Considerations and Practices for Warm Mix Asphalt (WMA). Laboratory mixing and compaction temperatures shall be reduced per the WMA Manufacturer's recommendations, however, the optimum laboratory compaction temperature for unmodified asphalt binders shall be less than 260°F. Target laboratory mixing and compaction temperatures shall be submitted to the Research & Materials Section (RMS) for review prior to performing a mix design.

When the asphalt binder is modified with the WMA additive at the HMA plant, all WMA additive equipment shall be fully automated and integrated into the plant controls and shall record actual dosage rates on the plant printouts. The Contractor's Quality System Manual shall provide mixture production and placement alterations due to the WMA additive and shall incorporate the modification of asphalt binders when the WMA additive is blended with the asphalt binder at the plant. This plan shall specifically address WMA metering requirements, tolerances and other Quality Control measures.

M3.01.5 Asphalt Anti-Stripping Additive.

An anti-stripping additive may be required in a HMA mixture to increase the resistance of the asphalt binder coating to stripping in the presence of water. An anti-stripping additive may be a liquid anti-strip or hydrated lime.

The Engineer may verify the effectiveness of the anti-strip used in a HMA mixture. When added at the dosage rate recommended by the Manufacturer to a HMA mixture showing moisture susceptibility, the anti-strip shall cause an improvement to the mixture's moisture susceptibility. This shall be determined by testing specimens with and without the liquid anti-strip additive in accordance with AASHTO T 324. If the antistrip does not show an improvement in the moisture susceptibility the additive will not be permitted for use.

The Manufacturer shall certify that the material is in accordance with this specification. The Manufacturer shall submit a COC for each Lot in accordance with Division 1 Section 6.0. The COC shall also include the:

Brand name and designation

Composition or description of the anti-strip additive

Manner in which the material will be identified on the containers

A. Hydrated Lime

The hydrated lime for HMA shall conform to the requirements of AASHTO M 303.

B. Liquid Anti-Strip

The anti-strip Manufacture shall submit product documentation, including the recommended dosage rate, to RMS for approval. Approved anti-strip additives shall be listed on the MassDOT QCML.

Anti-stripping additives shall be an organic chemical compound free from inorganic mineral salts or inorganic mineral soaps. The anti-strip additive shall be chemically inert to asphalt binder and shall not appreciably alter the specified characteristics of the asphalt binder. When blended with asphalt binder, it shall be stable and withstand storage at a temperature of 400°F for extended periods without loss of effectiveness.

M3.01.6 Asphalt Release Agents.

Approved asphalt release agents will be listed on the MassDOT QCML. The asphalt release agent shall not be detrimental to the HMA and shall not dissolve asphalt binder when applied to the truck bed. Dilution by diesel or other petroleum products will not be permitted.

Asphalt release agents shall be evaluated by AASHTO's National Transportation Product Evaluation Program (NTPEP). Release agents shall meet the following minimum requirements:

1. 7-Day Stripping Test - No stripping or discoloration when used in full strength and diluted forms
2. Mixture Slide Test - 10.0 grams retained, maximum
3. Asphalt Performance Test - Able to pull the cooled binder from the metal plate without adherence, a minimum of three pours
4. Flash Point, ASTM D93 - Have a flash point greater than 400°F on the undiluted product and contain no flammable materials, solvents, or petroleum elements

The Manufacturer shall submit a Certificate of Compliance (COC) for each Lot of asphalt release agent in accordance with Division 1 Section 6.0. The COC shall also include the:

1. Brand name and designation
2. Composition or description of the release agent
3. Manner in which the material will be identified on the containers

The Manufacturer shall certify that the material is in accordance with this specification. In addition, the Manufacturer shall furnish information for any dilution requirements, including the minimum dilution rate and special application requirements.

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 M 81 for the rapid curing type and AASHTO M 82 for the medium curing type.

M3.03.0 Asphalt Emulsions.

M3.03.1 Anionic Emulsified Asphalt.

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 M 140. Anionic emulsion used for tack coat shall be grade **RS-1h**.

M3.03.2 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 M 208. Cationic asphalt emulsion used for tack coat shall be grade CRS-1h.

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 meeting the requirements of ASTM D5727. 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.

M3.05.0 Hot Poured Joint Sealer.

This sealer shall meet the requirements of ASTM D6690 Type II. Products shall be evaluated by the National Transportation Product Evaluation Program (NTPEP) as an HMA Crack Sealer (CS) and be listed on the MassDOT QCML.

M3.05.1 Asphalt-Fiber Joint and Crack Sealer.

This material shall consist of a blend of asphalt cement (PG64-28) and polyester fibers. The asphalt-fiber blend shall consist of 6% fiber by weight of asphalt binder.

M3.05.2 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 M 213.

M3.05.3 Hot Applied Bituminous Concrete Crack Sealer.

This specification covers a hot applied crack sealer suitable for use in cement concrete and hot mix asphalt pavement. This sealer shall meet the requirements of ASTM D6690 Type II. Products shall be evaluated by the National Transportation Product Evaluation Program (NTPEP) as an HMA Crack Sealer (CS) and be listed on the MassDOT QCML.

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

The selvage shall have a width of between 1/8 inch and ½ inch inclusive.

	Minimum	Maximum
Width of Roll	36 in ± 2 in	48 in ± 2 in
Gross weight per roll	5 lb	16 lb
Average net mass per square yard	1.5 oz	
Coating on fabricated material per square yard	0.2 oz	

Uncoated Glass Fabric

	Minimum	Maximum
Average dry weight per square yard	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 D146, D5034, and D5035)*

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.

The material shall conform to the requirements of AASHTO M 190.

M3.11.0 Hot Mix Asphalt.

M3.11.1 General.

All Hot Mix Asphalt (HMA) mixtures shall meet the requirements of the Superpave volumetric mix design system as well as the following. Asphalt mixtures shall be composed of the following:

Mineral aggregate
Mineral filler (if required)
Performance Graded Asphalt Binder (PGAB)

The use of recycled materials shall be at the Contractor's option in accordance with these specifications. And as permitted, recycled materials shall be limited to:

Recycled Asphalt Pavement (RAP)
Recycled Asphalt Shingles (RAS)
Processed Glass Aggregate (PGA)

Each HMA pavement course placed shall be compromised of one of the mixture types listed in Table M3.3.

Table M3.3 – HMA Pavement Courses & Mixture Types

Pavement Course	Mixture Type	Mixture Designation
Friction Course	• Open-Graded Friction Course - 9.5 - Polymer • Open-Graded Friction Course - 9.5 - Asphalt Rubber	OGFC-P OGFC-AR
Surface Course	• SUPERPAVE Surface Course - 4.75 • SUPERPAVE Surface Course - 4.75 - Polymer • SUPERPAVE Surface Course - 9.5 • SUPERPAVE Surface Course - 9.5 - Polymer • SUPERPAVE Surface Course - 12.5 • SUPERPAVE Surface Course - 12.5 - Polymer • SUPERPAVE Surface Course - 19.0 • SUPERPAVE Surface Course - 19.0 - Polymer • Asphalt Rubber Gap Graded - 12.5	SSC - 4.75 SSC - 4.75 - P SSC - 9.5 SSC - 9.5 - P SSC - 12.5 SSC - 12.5 - P SSC - 19.0 SSC - 19.0 - P ARGG - 12.5
Intermediate Course	• SUPERPAVE Intermediate Course - 12.5 • SUPERPAVE Intermediate Course - 12.5 - Polymer • SUPERPAVE Intermediate Course - 19.0 • SUPERPAVE Intermediate Course - 19.0 - Polymer	SIC - 12.5 SIC - 12.5 - P SIC - 19.0 SIC - 19.0 - P
Base Course	• SUPERPAVE Base Course - 25.0 • SUPERPAVE Base Course - 37.5	SBC - 25.0 SBC - 37.5
Leveling Course	• SUPERPAVE Leveling Course - 4.75 • SUPERPAVE Leveling Course - 9.5 • SUPERPAVE Leveling Course -12.5	SLC - 4.75 SLC - 9.5 SLC - 12.5
Bridge Surface Course	• SUPERPAVE Bridge Surface Course - 9.5 • SUPERPAVE Bridge Surface Course - 9.5 - Polymer • SUPERPAVE Bridge Surface Course - 12.5 • SUPERPAVE Bridge Surface Course - 12.5 - Polymer	SSC-B - 9.5 SSC-B - 9.5 - P SSC-B - 12.5 SSC-B - 12.5 - P
Bridge Protective Course	• SUPERPAVE Bridge Protective Course - 9.5 • SUPERPAVE Bridge Protective Course - 9.5 - Polymer • SUPERPAVE Bridge Protective Course - 12.5 • SUPERPAVE Bridge Protective Course - 12.5 - Polymer	SPC-B - 9.5 SPC-B - 9.5 - P SPC-B - 12.5 SPC-B - 12.5 - P

M3.11.2 Aggregate for Hot Mix Asphalt.

A. Coarse Aggregate

The coarse mineral aggregate shall be clean, hard, durable, crushed rock consisting of the angular fragments obtained by breaking and crushing shattered natural rock, reasonably free from thin and/or elongated pieces, free from dirt or other objectionable materials. It shall be surface dry and shall have a moisture content of not more than ½ percent after drying. Aggregates from multiple sources of supply shall not be mixed or stored in the same stockpile.

B. Fine Aggregate

The fine aggregate shall consist of one of the following:

1. 100% Natural Sand.
2. 100% Stone Sand.
3. A blend of sand and stone screenings, the proportions of which shall be approved by the Engineer.
4. 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.

Stone sand shall be a processed material prepared from stone screenings to produce a consistently graded material conforming to specification requirements.

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.

C. Consensus Properties

Aggregates utilized in HMA mixtures, including RAP if used in the mixture, shall be tested for conformance with the Consensus Property requirements outlined in AASHTO M 323 Sections 6.2 to 6.6 and Table M3.5 below.

D. Source Properties

The coarse aggregate utilized in asphalt mixtures shall be clean, crushed rock consisting of the angular fragments obtained by breaking and crushing shattered natural rock. It shall be free from dirt or other objectionable materials. The coarse aggregate, including RAP if used in the mixture, shall be tested for conformance with the requirements indicated in Table M3.6. The specific gravity of each aggregate component shall be determined as specified in Table M3.7 below.

To determine the bulk specific gravity of RAP aggregate the method outlined in FHWA Publication Number FHWA-HRT-11-021 "Reclaimed Asphalt Pavement in Asphalt Mixtures: State of the Practice" shall be used. The following excerpt is the method to be followed:

If the source of RAP is known and original construction records are available, the bulk specific gravity (BSG) value of the virgin aggregate from the construction records may be used as the BSG value of the RAP aggregate. However, if original construction records are not available, the recommended procedure for estimating BSG of the RAP aggregate is a simple three-step process as follows:

Determine the maximum theoretical specific gravity of the RAP mixture, G_{mm}^{RAP}, according to AASHTO T 209.

Calculate the effective specific gravity of the RAP aggregate, G_{se}^{RAP}, using G_{mm}^{RAP}, the asphalt content of the RAP mixture (P_b) and an assumed asphalt specific gravity (G_b) as follows:

$$G_{se}^{RAP} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where $G_b = 1.030$.

The asphalt absorption, P_{ba}, shall be assumed to be 0.5%. Use this value to estimate the BSG of the RAP aggregate, G_{sb}^{RAP}, from the calculated G_{se}^{RAP}.

$$G_{sb}^{RAP} = G_{se}^{RAP} / \left(\frac{P_{ba} \times G_{se}^{RAP}}{100\, G_b} + 1 \right)$$

E. Recycled Asphalt Pavement

Reclaimed Asphalt Pavement (RAP) shall meet the requirements of Subsection M3.11.2C and D as well as the following. RAP shall consist of the material obtained from state highways or streets by crushing or milling existing HMA pavements. This material shall be transported to the HMA production facility yard and processed through an appropriate crusher so that the resulting material will contain no particles larger than the maximum aggregate size of the HMA mixture in which it will be used.

The RAP shall be stockpiled on a free draining base and kept separate from the other aggregates. RAP stockpiles shall be covered in a manner that prevents the intrusion of water but also allows the flow of air. The RAP stockpiles shall have a reasonably uniform gradation from fine to coarse and shall not be contaminated by foreign materials. The RAP used in the HMA mix production shall have a moisture content such that the final HMA contains no more than 0.5% moisture.

The use of RAP will be permitted at the option of the Contractor and provided that the end product is in conformance with the approved Job Mix Formula (JMF). The proportion of RAP to virgin aggregate shall be in accordance with Table M3.4 and Subsection M3.01.3.

Table M3.4 – Maximum Allowed RAP Content by Mix Type

Mix Type	Maximum Amount of RAP Allowed (%)
Friction Course (OGFC)	0
Friction Course (ARGG)	10
Surface Course	15
Leveling Course	
Bridge Surface Course	
Bridge Protective Course	
Intermediate Course	40
Base Course	

F. Recycled Asphalt Shingles

Recycled Asphalt Shingles (RAS) shall consist of only the by-product materials obtained from the roofing shingle manufacturing process. Post-consumer shingle waste and re-roofing shingle scrap will not be allowed. The Contractor or the plant shall provide certification from the roofing shingle manufacturer that RAS material provided is a by-product of the shingle manufacturing process. This material shall be transported to the HMA production facility yard and processed through an appropriate crusher so that the resulting material will contain no particles larger than ½ inch. The material shall be stockpiled on a free draining base and kept separate from the other aggregates. The material contained in the processed stockpile shall not be contaminated by foreign materials. RAS stockpiles shall be covered in a manner that prevents the intrusion of water but also allows the flow of air.

RAS may be used in HMA leveling courses, HMA intermediate courses, and HMA base courses at a maximum rate of 5% by weight. When RAS is used in HMA mixtures containing RAP or other recycled materials, the RAS will be considered as part of the overall allowable weight of recycled materials in the mixture.

G. Processed Glass Aggregate

The use of Processed Glass Aggregate (PGA) meeting the requirements of Subsection M2.01.8 may be added at a maximum addition rate of 10% by weight. This addition will only be allowed in base and intermediate mixtures. PGA in mixes containing RAP will be considered as part of the overall allowable mass of RAP in the mix. If PGA is used in the mix, a separate aggregate bin shall be used and the use of lime as an anti-stripping agent shall be required.

Table M3.5 – Aggregate Consensus Property Requirements

Traffic Level	Design ESALs (Millions)[1]	Fractured Faces, Coarse Aggregate, [2] % Minimum		Uncompacted Void Content of Fine Aggregate, % Minimum		Sand Equivalent, % Minimum	Flat and Elongated,[2] % Maximum
		All Courses (except Base Course)	Base Course	All Courses (except Base Course)	Base Course		
1	< 0.3	55/--	--/--	--[4]	--	40	--
2	0.3 to < 10	85/80[3]	60/--	45	40	45	10
3	≥ 10	95/90	80/75	45	40	45	10

(1) The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.
(2) This criterion does not apply to 4.75 mm nominal maximum size mixtures.
(3) 85/80 denotes that 85 percent of the coarse aggregate has one fractured face and 80 percent has two or more fractured faces.
(4) For 4.75 mm nominal maximum size mixtures designed for traffic levels below 0.3 million ESALs, the minimum Uncompacted Void Content is 40.

Table M3.6 – Aggregate Source Property Requirements

Source Property Test	Test Method	Limit
Toughness	AASHTO T 96	Maximum Loss < 30 %
Soundness	AASHTO T 104	Maximum Loss < 10 %
Deleterious Materials	AASHTO T 112	Maximum Permissible < 0.5 %

Table M3.7 – Aggregate Specific Gravity Test Method

Aggregate Type	Test Method
Coarse	AASHTO T 85
Fine	AASHTO T 84 or ASTM D7370
Mineral Filler	AASHTO T 100
RAP	From FHWA-HRT-11-021

M3.11.3 Performance Graded Asphalt Binder.

The PGAB utilized in the HMA mixture shall be specified by the Contract and shall comply with the requirements of Subsection M3.01.0.

M3.11.4 Hot Mix Asphalt Mixture Design.

The Contractor shall be responsible for development of all HMA mixture designs. All HMA surface courses, intermediate courses, base courses, leveling courses, bridge surface courses, and bridge protective courses shall be supported by volumetric mixture designs using the Superpave mixture design system. All Superpave HMA designs shall be developed in accordance with the following AASHTO standards, as modified herein:

1. AASHTO M 323
2. AASHTO R 35
3. AASHTO T 312

Open Graded Friction Course (OGFC) and Asphalt Rubber Gap Graded (ARGG) mixtures shall be designed in accordance with Subsections M3.11.4G and M3.11.4H, respectively.

A. Development of Laboratory Trial Mix Formula

The Contractor shall develop and submit a Laboratory Trial Mix Formula (LTMF) for each HMA mixture type, which is to be proposed as a Job Mix Formula (JMF), a minimum of sixty (60) days prior to HMA production. Each LTMF shall be submitted with supporting documentation and adequate amount of blended aggregate material and PGAB in order to verify the LTMF.

Once verified by the Department, the LTMF may become the Job Mix Formula (JMF) for a project. Two or more JMFs per HMA type may be approved for a particular plant, however, only mixture conforming to one JMF is permitted to be produced and placed on any given day.

B. Estimated Design Traffic

The estimated traffic level to be used for HMA mix designs shall be specified by the contract. The traffic level shall be expressed in Equivalent Single Axle Loads (ESALs) for the design travel lane over a 20-year period in million 18-kip ESALs.

C. Specific Gravity Requirements

The individual aggregate specific gravities shall be included with the LTMF. The Contractor shall provide samples of each aggregate material a minimum of sixty (60) days prior to production for each LTMF to the Department for verification specific gravity of each stockpile.

D. Superpave Aggregate Gradation Requirements

The combined aggregate blend for each Superpave HMA mixture shall conform to the Gradation Control Point requirements specified in Table M3.8. The results of the selected optimum design aggregate structure shall be plotted on a 0.45 power chart and included with the LTMF.

The combined aggregate gradation shall be classified as coarse-graded when it passes below the Primary Control Sieve (PCS) control point as defined in Table M3.9. All other gradations shall be classified as fine graded.

When a Superpave Surface Course - 19.0 (SSC - 19.0) is specified in the contract, the LTMF aggregate gradation shall provide a fine-graded HMA mixture as defined in Table M3.9.

E. Gyratory Compaction Criteria

Each asphalt mixture shall be designed and controlled during production using an approved gyratory compactor which meets the requirements of AASHTO T 312. Compaction shall be in accordance with the requirements of AASHTO T 312. The density of each HMA mixture shall be evaluated at the initial number of gyrations ($N_{initial}$), the design number of gyrations (N_{design}), and the maximum number of gyrations (N_{max}). The gyratory-compacted specimens for each LTMF shall meet the density requirements specified in Table M3.10 below.

F. Superpave Volumetric Design Requirements.

Each Superpave HMA mixture shall be designed in accordance with the volumetric mixture design specifications contained in AASHTO M 323 and procedures contained in AASHTO R 35, as modified herein. Each HMA mixture LTMF shall be tested for conformance with the following volumetric properties:

1. Air Voids at N_{design} (V_a)
2. Voids in the Mineral Aggregate at N_{design} (VMA)
3. Voids Filled with Asphalt at N_{design} (VFA)
4. Fines to Effective Asphalt Ratio ($P_{0.075}$ / P_{be})

The volumetric property test results shall be submitted with the LTMF for each Superpave HMA mixture. The required minimum or maximum criteria for each of the volumetric property tests are specified in Tables M3.10, M3.11, and M3.12.

Table M3.8 – Superpave Aggregate Gradation Control Points

Sieve	Nominal Maximum Aggregate Size – Control Points (% Passing)											
	#4 (4.75 mm)		3/8" (9.5 mm)		1/2" (12.5 mm)		3/4" (19.0 mm)		1" (25.0 mm)		1 1/2" (37.5 mm)	
Inches	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
2											100	
1 1/2									100		90	100
1							100		90	100		90
3/4					100		90	100		90		
1/2	100		100		90	100		90				
3/8	95	100	90	100		90						
#4	90	100		90								
#8			32	67	28	58	23	49	19	45	15	41
#16	30	55										
#30												
#50												
#100												
#200	6	13	2	10	2	10	2	8	1	7	0	6

Table M3.9 – Gradation Classification

PCS Control Point for Mixture Nominal Maximum Aggregate Size (% Passing)					
Nominal maximum aggregate size	3/8" (9.5 mm)	1/2" (12.5 mm)	3/4" (19.0 mm)	1" (25.0 mm)	1 ½" (37.5 mm)
Primary control sieve	#8 (2.36 mm)	#8 (2.36 mm)	#4 (4.75 mm)	#4 (4.75 mm)	3/8" (9.5 mm)
PCS control point, % passing	47	39	47	40	47

Table M3.10 – Superpave Asphalt Mixture Design Laboratory Compaction Requirements

Traffic Level	Design ESALs	Number of Gyrations			Percent Density of G_{mm} from Asphalt Mixture Gyratory Specimen		
	(millions)	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}
1	< 0.3	6	50	75	≤ 91.5	96.0	≤ 98.0
2	0.3 to < 10	7	75	115	≤ 90.5	96.0	≤ 98.0
3	≥ 10	8	100	160	≤ 89.0	96.0	≤ 98.0

Table M3.11 – Superpave Volumetric Requirements

	Nominal Maximum Aggregate Size					
	#4 (4.75 mm)	3/8" (9.5 mm)	1/2" (12.5 mm)	3/4" (19.0 mm)	1" (25.0 mm)	1 ½" (37.5 mm)
P_b	LTMF Value					
G_{mb}						
G_{mm}						
V_a	4.0					
VMA	≥ 17.0	≥ 16.0	≥ 15.0	≥ 14.0	≥ 13.0	≥ 12.0
VFA	Table M3.12					
Dust/P_{be} (1)	0.9 - 2.0	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2	0.6 - 1.2
Mixture Temp	Unmodified PGAB ≤ 325°F Modified PGAB ≤ 350°F					

(1) If the aggregate gradation passes beneath the PCS Control Point specified in M 323 Table 5, the dust-to-binder ratio range may be increased from 0.6-1.2 to 0.8-1.6 at the Engineer's discretion.

(2) Laboratory mixing and compaction temperatures shall be based on the PGAB Certificate of Analysis. When additives such as WMA, polymers, and rubber are introduced the mixing and compaction temperatures may be modified from the PGAB COA. Temperature modifications shall recommended by the binder Supplier and approved at the Engineer's discretion.

Table M3.12 – Superpave Asphalt Mixture VFA Requirements

Traffic Level	Design ESALs (Millions)	Voids Filled with Asphalt (VFA) Based on Nominal Maximum Aggregate Size					
		#4 (4.75 mm)	3/8" (9.5 mm)	1/2" (12.5 mm)	3/4" (19.0 mm)	1" (25.0 mm)	1 ½" (37.5 mm)
1	< 0.3	70 - 80	70 - 80	70 - 80	70 - 80	67 - 80	64 - 80
2	0.3 to < 10	65 - 78	65 - 78	65 - 78	65 - 78	65 - 78	64 - 78
3	≥ 10	75 - 78	73 - 76	65 - 75	65 - 75	65 - 75	64 - 75

G. Open Graded Friction Course Design Requirements

Each OGFC asphalt mixture shall be designed in accordance AASHTO PP 77, as modified herein. The combined aggregate gradation shall conform to Table M3.13 and the mixture shall conform to Table M3.14.

1. OGFC-P will utilize asphalt binder meeting the requirements of Subsection M3.01.2A.
2. OGFC-AR will utilize asphalt binder meeting the requirements of Subsection M3.01.2B.

Table M3.13 – OGFC Aggregate Gradation Control Points

Sieve	Nominal Maximum Aggregate Size Control Points (% Passing)	
	3/8" (9.5 mm)	
Inches	Min	Max
1	-	-
3/4	-	-
1/2	100	-
3/8	85	100
#4	20	30
#8	5	15
#200	0	4

Table M3.14 – OGFC Mixture Requirements

Property	Requirement
N_{des}, gyrations	50
P_b, % (Polymer)	≥ 6.5
P_b, % (Asphalt Rubber)	≥ 7.5
V_a, %	18 – 22
VCA_{mix}, %	< VCA_{DRC}
Draindown at Production Temperature, %	≤ 0.3
Abrasion Loss, %	≤ 15
TSR, %	≥ 70
Permeability, in/sec(1)	≥ 0.0178
(1) Permeability shall be performed in accordance with the procedure outlined by RMS.	

H. ARGG Design Requirements

Each Asphalt Rubber Gap Graded (ARGG) asphalt mixture shall be designed in accordance with the AASHTO M 323 and procedures contained in AASHTO R 35, as modified herein. The combined aggregate gradation shall conform to Table M3.15 and the mixture shall conform to Table M3.16.

ARGG will utilize asphalt binder meeting the requirements of Subsection M3.01.2B.

Table M3.15 – ARGG Aggregate Gradation Control Points

Sieve	Nominal Maximum Aggregate Size Control Points (% Passing)	
	½" (12.5 mm)	
Inches	Min	Max
1	-	-
¾	100	-
½	90	100
3/8	83	87
#4	28	42
#8	14	22
#200	0	6

Table M3.16 – ARGG Mixture Requirements

Property	Requirement
N_{des}, gyrations	100
P_b, %	≥ 7.6
V_a, %	3 – 6
VMA, %	18 – 23
Draindown at Production Temperature, %	≤ 0.3

M3.11.5 Verification of Laboratory Trial Mix Formula.

The Contractor shall submit an LTMF in accordance with Subsection M3.11.4. The Engineer will perform laboratory verification of each LTMF.

If the Engineer is unable to verify the Contractor's LTMF in accordance with the applicable LTMF Verification Limits in Table M3.17, Table M3.18, or Table M3.19, then the Engineer will work with the Contractor to resolve the verification issue(s). The Contractor shall not proceed with production and placement of a Control Strip under Section 450 until the LTMF is verified by the Engineer.

Table M3.17 – Superpave LTMF Verification Limits

Properties	LTMF Verification Limit
Asphalt Binder Content (P_b)	Target ± 0.3%
Gradation Passing #4 (4.75 mm) and Larger Sieves	Target ± 6.0%
Gradation Passing #8 (2.36 mm) Sieve	Target ± 5.0%
Gradation Passing #16 (1.18 mm) to #50 (0.30 mm) Sieve	Target ± 3.0%
Gradation Passing #100 (0.15 mm) Sieve	Target ± 2.0%
Gradation Passing #200 (75 µm) Sieve	Target ± 1.0%
Bulk Specific Gravity (G_{mb})	Target ± 0.022
Max. Theo. Specific Gravity (G_{mm})	Target ± 0.020
Air Voids (V_a)	Target ± 1.0%
Voids in Mineral Aggregate (VMA)	Target ± 1.0%
Voids Filled With Asphalt (VFA)	Target ± 5.0%
Rutting and Moisture Susceptibility	Table M3.20

Table M3.18 – OGFC LTMF Verification Limits

Properties	LTMF Verification Limit
Asphalt Binder Content (P_b)	Target ± 0.3%
Gradation Passing #4 (4.75 mm) and Larger Sieves	Target ± 6.0%
Gradation Passing #8 (2.36 mm) Sieve	Target ± 4.0%
Gradation Passing #16 (1.18 mm) to #50 (0.30 mm) Sieve	Target ± 4.0%
Gradation Passing #100 (0.15 mm) Sieve	Target ± 2.0%
Gradation Passing #200 (75 µm) Sieve	Target ± 1.0%
Bulk Specific Gravity (G_{mb})	Target ± 0.022
Max. Theo. Specific Gravity (G_{mm})	Target ± 0.020
Air Voids (V_a)	Target ± 2.0%
Voids in Mineral Aggregate (VMA)	Target ± 2.0%
Voids Filled With Asphalt (VFA)	Target ± 5.0%
Draindown	≤ 0.3%
Abrasion Loss	≤ 15%
Tensile Strength Ratio	≥ 70%

Table M3.19 – ARGG LTMF Verification Limits

Properties	LTMF Verification Limit
Asphalt Binder Content (P_b)	Target ± 0.3%
Gradation Passing ¾" (19.0 mm) Sieve	Target ± 0.0%
Gradation Passing #4 (4.75 mm) to ½" Sieve	Target ± 6.0%
Gradation Passing #8 (2.36 mm) Sieve	Target ± 5.0%
Gradation Passing #16 (1.18 mm) to #50 (0.30 mm) Sieve	Target ± 3.0%
Gradation Passing #100 (0.15 mm) Sieve	Target ± 2.0%
Gradation Passing #200 (75 µm) Sieve	Target ± 1.0%
Bulk Specific Gravity (G_{mb})	Target ± 0.022
Max. Theo. Specific Gravity (G_{mm})	Target ± 0.020
Air Voids (V_a)	Target ± 1.0%
Voids in Mineral Aggregate (VMA)	Target ± 1.0%
Draindown	≤ 0.3%
Rutting and Moisture Susceptibility	Table M3.20

A. Evaluation of Rutting and Moisture Sensitivity

Each HMA mixture, with the exception of Base Courses and OGFC, shall be tested by RMS for rutting and moisture sensitivity in accordance with the requirements of AASHTO T 324 using the Hamburg Wheel-Tracking Device (HWTD).

The Engineer may also require that mixtures meet the requirements of AASHTO T 283 with a minimum tensile strength ratio of 80%.

Table M3.20 – Hamburg Wheel Tracking Device Requirements

Traffic Level	Maximum Rut Depth Inches (mm)	Minimum number of passes before Stripping Inflection Point is observed
1	½ (12.5)	10,000
2		15,000
3		15,000

M3.11.6 HMA for Driveways, Sidewalks, Berm, and Curb.

HMA mixtures for driveways, sidewalks, berm, and curb shall conform to the master ranges in Table M3.21. The PGAB shall conform to Subsection M3.01.1. The Contractor shall submit a Job Mix Formula (JMF) prior to production which shows the target aggregate gradation and PG asphalt binder content for each HMA mixture for driveways, sidewalks, berm, and curb.

With the approval of the Engineer, the Contractor may substitute a MassDOT approved 9.5 mm or 12.5 mm Superpave Surface Course mixture (Traffic Level 1 or 2) for Driveways and Sidewalks.

The Contractor shall perform QC testing at the start of plant production and in conjunction with the calibration of the plant in order to verify that the JMF can be produced within the Engineering Limits specified in Table M3.22.

The composition limits in Table M3.21 are HMA mix design master ranges for aggregate gradation and asphalt binder content. The JMF for each HMA mixture type shall establish a single percentage of aggregate passing each required sieve size, and a single percentage of asphalt binder material to be added to the aggregate.

The JMF shall be submitted in writing by the Contractor to the Engineer at least 30 days prior to the start of paving operations and shall include the following as a minimum:

1. Source of materials
2. Percent of each aggregate stockpile
3. Percent passing each sieve size
4. Combined aggregate specific gravity
5. Percent of asphalt binder
6. Performance grading test results and Certificate of Compliance certifying the PG grade
7. Mixing temperature
8. Compaction temperature
9. Temperature of mix when discharged from the mixer
10. Maximum theoretical specific gravity of the mixture

AASHTO T 195 (Ross Count) with a coating factor of 98% will be used when necessary to evaluate proper mixing time.

The use of recycled materials will be permitted at the option of the Contractor and provided that the end product is in conformance with the designated JMF. The proportion of reclaimed materials (including RAP, PGA, and RAS) in the total mix shall be limited to a maximum of 15%.

All HMA JMFs for sidewalks, wheelchair ramps, driveways, and berm will be submitted to the Engineer for approval. The JMF 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 the Engineering Limits found in Table M3.22.

For each project, at least one QC sample shall be randomly obtained by the Contractor for every 2,000 tons produced, but not less than one QC sample per day. The Engineer shall also obtain a minimum of one random Acceptance sample for every 2,000 tons produced. The sample will be tested for conformance with the submitted JMF and Engineering Limits. When testing shows the mixture is not in conformance the Engineer will determine the disposition in accordance with Section 6.04 of Division I.

The JMF for each mixture shall be in effect until modified in writing by the Contractor and approved by the Engineer. Should a change in sources of materials be made, a new JMF must be approved by the Engineer before the new material is used.

Table M3.21 – Master Ranges for HMA for Driveways, Sidewalks, Berm, and Curb

	Nominal Maximum Aggregate Size Control Points (% Passing)			
Mixture Type	Driveways, Sidewalks, and Berm		Berm and Curb Only	
Sieve (Inches)	Min	Max	Min	Max
1	-	-	-	-
3/4	100	-	-	-
1/2	95	100	100	-
3/8	87	93	87	93
#4	57	69	62	73
#8	41	45	52	55
#16	30	36	40	45
#30	21	25	28	34
#50	14	17	18	23
#100	9	12	10	14
#200	4	5	6	6
P_b, %	6.0	6.6	7.4	7.6

Table M3.22 – Engineering Limits for Aggregate Gradation and Asphalt Binder Content

Sieve Designation / Binder Content	Engineering Limits
Passing No. 4 and larger sieve sizes	JMF Target ± 6%
Passing No. 8 sieve	JMF Target ± 5%
Passing No. 16 to No. 50 sieves (inclusive)	JMF Target ± 3%
Passing No. 100 sieve	JMF Target ± 2%
Passing No. 200 sieve	JMF Target ± 1%
Asphalt Binder Content	JMF Target ± 0.4%

M3.11.7 Hot Mix Asphalt Production Facility.

All facilities producing HMA must be approved on an annual basis by the Department. All sources of materials used for the production of HMA must be approved by the Department prior to their use. Such materials shall include:

1. Coarse aggregate
2. Fine aggregate
3. Mineral filler
4. Performance graded asphalt binder
5. Modifiers and/or additives

HMA production operations shall follow industry accepted best management practices including:

1. Aggregate handling and stockpile management
2. Recycled asphalt pavement handling and stockpile management
3. PGAB storage
4. Plant process controls
5. Silo loading
6. Truck loading

The plant shall meet the requirements of AASHTO M 156 as well as the following provisions. HMA plants meeting these requirements and which have been approved by RMS shall be listed on the MassDOT QCML.

An adequate quantity of each size aggregate, mineral filler and asphalt binder shall be maintained at the HMA plant site at all times while the plant is in operation to ensure that the plant can continuously produce mixtures that meet these specifications. The quantity of such materials shall never be less than one day's production capacity.

A. Scales

Plant and truck scales shall be certified:

1. At the start of each construction season, prior to use for MassDOT projects.
2. At intervals of not more than 90 calendar days.
3. Whenever the plant changes location.
4. At any time as requested by the Engineer.

B. Calibration of Plant Equipment

The plant's systems shall be calibrated:

1. At the start of each construction season, prior to use for MassDOT projects.
2. Whenever there is a significant change to the material.
3. Whenever a plant component supply system affecting the ingredient proportions has been repaired, replaced, or adjusted.
4. At any time as requested by the Engineer.

C. Automatic Recordation

Recordation equipment shall be provided. Each recorder shall include an automatic printer system. The printer shall be so positioned that the digital display and the printer can be readily observed within the plant's control room by the Engineer and the plant operator, simultaneously. The delivery ticket shall be printed with an original and at least one copy. The original shall be furnished to the Engineer at the paving site and the copy to the Engineer at the plant. The delivery ticket format shall be approved by RMS and will include the following information:

1. Company / plant location.
2. MassDOT contract number and/or distinct project name.
3. MassDOT mix ID number and/or distinct mix description.
4. Percentage of RAP in the mixture.
5. Percentage of asphalt binder in the mixture.
6. Date and time of loading.
7. Sequential load number for the contract for a 24 hour period.
8. Total weight of mix in truck (pay weight).

The following mixture production information shall also be provided:

For Batch Plants

1. Date mixed.
2. Time of batching.
3. Tare weight of aggregate weigh box.
4. Tare weight of PGAB weigh bucket.
5. Moisture content of recycled materials.
6. Target and actual cumulative or net weights as batched for each bin with a batch total for all net ingredients.
7. Target and actual weight of PGAB.
8. Total weight of mix in truck (pay weight).

Note: This information shall be included on the delivery ticket when the mix is batched directly into a truck. When the mix is batched and stored in a silo the information may be separate from the delivery ticket however it must be provided to the Engineer at the plant.

For Drum Plants

1. Percent of mixture as well as the target and actual production rate for each individual mix component including:
    a. Aggregate
    b. Mineral Filler
    c. PGAB
    d. Recycled materials
    e. Additives
2. Moisture content of aggregates and recycled materials.
3. PGAB temperature.
4. Target and actual mix temperature.
5. Target and actual mix production rate.

Note: This information is not required to be included on the delivery ticket however it must be provided to the Engineer at the plant.

D. Surge and Storage Silo Holding Time

The mixtures shall not be stored in surge and storage bins longer than the following:

1. Unheated and not insulated ..... 2 hours
2. Unheated and insulated with heated gate..... 15 hours
3. Insulated and heated..... 24 hours

Note: In order to prevent excessive draindown, OGFC shall not be stored in a surge or storage bin for longer than two (2) hours. ARGG shall not be stored for more than six (6) hours.

E. Air Quality

The plant shall be designed and operated to meet all current Federal and State air quality requirements.

F. Equipment Failure

If at any time the automatic proportioning or recording system becomes inoperative, the plant will cease all HMA production. Work will only be allowed to restart once all automatic controls and recording systems are functional.

M3.11.8 HMA Plant Facility Inspection.

The Engineer or his/her 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 mixture.
5. Inspection of incidental related procedures.

M3.12.0 Hot Mix Asphalt Materials Testing Laboratory and Equipment.

M3.12.1 Contractor Quality Control Laboratory.

All Contractor QC testing shall be performed in laboratories that are approved by RMS and qualified through the NETTCP Laboratory Qualification Program (LQP) or accredited through the AASHTO Accreditation Program (AAP). All laboratories shall maintain a Quality System Manual (QSM) in accordance with the outline maintained by the Research & Materials Section.

1. Laboratories that perform HMA mix designs or QC testing under Section 450 shall at a minimum be qualified as a NETTCP LQP Category 2 laboratory.
2. Laboratories performing only QC testing shall be qualified as a NETTCP LQP Category 3 laboratory.

Contractors who do not produce mixtures under Section 450 will not be required to have their own laboratory at the production facility but will be required to either test at their central laboratory or hire a consultant testing company to perform the QC testing required in the specification. The Contractor will still be required to maintain a QSM.

The Contractor's QC laboratory shall be qualified to perform all testing required by Table M3.23 as well as contract specifications.

Laboratories meeting these requirements and which have been approved by the RMS shall be listed on the MassDOT QCML.

The Contractor's QC Manager shall have overall responsibility for ensuring that all laboratories utilized for Quality Control are in compliance with the requirements of the NETTCP LQP. This includes providing required AASHTO, ASTM, and NETTCP reference documents and ensuring that all required equipment and tools are properly functioning and calibrated.

The Engineer shall be permitted unrestricted access to inspect and review the Contractor's laboratory facility.

M3.12.2 Department Acceptance Laboratory at HMA Production Facility

The Engineer shall be provided laboratory working space meeting the requirements of Subsection M3.12.1 as well as the following. A desk must be located in close proximity to the laboratory but be separated from the ovens, sieve shakers, and anything else that can cause poor air and sound quality. The Engineer's desk and laboratory space will not be shared with any other entity.

If the Engineer is unable to perform their duties either due to lack of working space, poor working conditions, or access to equipment it will be considered a laboratory facility deficiency. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. Deficiencies shall be grounds for the Engineer to order an immediate stoppage of work until the deficiencies are corrected.

Along with the required testing capabilities the laboratory facilities shall meet the following:

1. Be kept clean and all equipment shall be maintained in proper working condition.
2. Provide adequate environmental control to the satisfaction of the Engineer and must be able to maintain an inside temperature of 68 to 86°F during working hours.
3. Adequate ventilation to remove dust and fumes from the laboratory.
4. Hot and cold potable water.
5. First aid kit and emergency eye wash station.
6. Multi-class ABC fire extinguisher.
7. A restroom shall also be made available within 500 ft of the laboratory during all work shifts. The restroom facilities shall be enclosed in a separate room with proper ventilation and comply with applicable sanitary codes as well as:
    a. A flush toilet.
    b. A sink with hot and cold running water.
    c. A sewer or septic tank with connections.
    d. Adequate rest room supplies.
    e. Maintained environmental control and cleanliness.

The plant, silos, and sample rack shall be in view of laboratory when performing testing under Section 450. The Engineer shall be provided with the following:

A. Computer

The Engineer shall be furnished with a computer with high speed internet access which conforms to the requirements determined by RMS. The minimum requirements shall include:

1. The Engineer is required to have one (1) computer at the laboratory.
2. Computers shall be required to have the latest MS Office Professional with all security updates, Antivirus software with all current security updates maintained, and any other software required by RMS.
3. A laser printer with the capability to also scan and copy. The printer shall be compatible and connected to the laboratory's computer.

B. Testing Equipment

The Contractor shall supply the Engineer with the following equipment. This equipment shall only be utilized by the Engineer and shall be labeled as such. It shall be the Contractor's responsibility to maintain and replace equipment as needed.

1. For T 27 and T 30:
   a. 12 inch sieve stack (2 inch to #200) with cover and pan.
   b. Mechanical sieve shaker (only for Section 450 Category A Lots).
   c. Electronic balance (only for Section 450 Category A Lots).
2. For T 166 and T 209: Complete setup (only for Section 450).
3. For T 312: Gyratory mold.
4. For T 308:
   a. Ignition oven sample basket.
   b. Ignition oven and two (2) sample baskets (only for Section 450 Category A Lots).
5. Miscellaneous equipment such as sample buckets, scoops, pans, brushes, thermometers, etc.
6. Oven which meets AASHTO R 30 and is capable of storing the sample buckets for 3 samples (only for Section 450 Category A Lots).
7. Supply of sample boxes.
8. Sample rack which is a suitable sampling platform from which the Engineer is able to stand and sample the material in the truck bed adequately and safely. The rack shall:
   a. Be of sturdy construction.
   b. Be able to safely accommodate at least two people at a time (min. standing area of 4 ft x 4 ft).
   c. Have a safe stairway that is attached to the sampling platform.
   d. Be at a height which allows the Technician the ability to reach the HMA in the bed of any size truck safely and efficiently.
   e. Have a mounted spot light to allow for sampling at night.
   f. Be within 100 ft of the laboratory and visible from the laboratory.
   g. Meet applicable OSHA standards.

Table M3.23 – Required Test Methods by Laboratory

Test Method	Description	Mix Design Laboratory	QC Laboratory	Department Acceptance Laboratory
AASHTO M 323	Superpave Volumetric Mix Design	X		
AASHTO R 30[(1)]	Mixture Conditioning of HMA	X		
AASHTO R 35	Superpave Volumetric Design for Asphalt Mixtures	X		
AASHTO R 47	Reducing Samples of HMA to Testing Size	X	X	X
AASHTO R 66	Sampling of Asphalt Materials		X	
AASHTO R 76	Reducing Samples of Aggregate to Testing Size	X	X	
AASHTO R 79 [(2)]	Vacuum Drying Compacted HMA Specimens		X	
AASHTO T 2	Sampling of Aggregates		X	
AASHTO T 11	Material Finer Than #200 Sieve by Washing	X	X	X
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates	X	X	X
AASHTO T 30	Sieve Analysis of Extracted Aggregate	X	X	X
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate	X		
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregates	X		
AASHTO T 96	Coarse Aggregate L.A. Abrasion	X		
AASHTO T 104	Soundness of Aggregates	X		
AASHTO T 166	Bulk Specific gravity of HMA	X	X	X
AASHTO T 168	Sampling Bituminous Paving Mixtures		X	X
AASHTO T 176	Sand Equivalence	X		
AASHTO T 209	Theoretical Maximum Specific Gravity of HMA	X	X	X
AASHTO T 255	Moisture Contents of Aggregates		X	
AASHTO T 283[(4)]	Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage	X		
AASHTO T 304	Un-compacted Void Content of Fine Aggregate	X		
AASHTO T 305 [(3)]	Draindown in Uncompacted Asphalt Mixtures	X		
AASHTO T 308	Asphalt Binder Content by Ignition Oven		X	X
AASHTO T 312	Density of HMA by Superpave Gyratory	X	X	X
AASHTO T 329	Moisture Control of HMA		X	X
AASHTO T 331[(4)]	Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing	X	X	X
AASHTO T 335	Determining the Percentage of Fracture in Coarse Aggregate	X		
AASHTO T 354 [(2)]	Specific Gravity and Absorption of Aggregate by Volumetric Immersion	X		
ASTM D3549	Thickness of Compacted HMA Specimens		X	
ASTM D4791	Flat & Elongated Particles in Coarse Aggregate	X		

(1) Two ovens shall be required; one to heat binder, aggregate, and mixing tools to mixing temperature and one to condition the loose mixture at the compaction or conditioning temperature.
(2) Optional test.
(3) Required for Open Graded Friction Course and Asphalt Rubber Gap Graded.
(4) Required for Open Graded Friction Course.

SUBSECTION M4.02.00 Cement Concrete.

*(page 347 English) Delete the ** after "Minimum Cement Content" on the first line. Delete the second line after the table which reads "**Fly ash may be substituted for cement up to a maximum of 15% by weight.".*

*(page III.28 Metric) Delete the * after "Minimum Cement Content" on the first line. Delete the second line after the table which reads "*Fly ash may be substituted for cement up to a maximum of 15% by weight.".*

(page 347 English, page III.28 Metric) Change "% Entrained Air (±1.0%)" to "% Entrained Air (±1.5%)" in the table titled Classification of Concrete Mixes. and replace the second paragraph from the bottom of the Subsection with the following:

Concrete which will be subjected to conditions of severe exposure will be 4000 PSI (30 MPa) with air-entrained content of 7.0 % ± 1.5% when so specified. Concrete that is used to construct drilled shafts shall have an entrained air content of 4.0% ± 1.5%.

(page 348 English, page III.29 Metric) Add the following to the end of this Subsection:

Alkali Silica Reactivity - Resistant Portland Cement Concrete

All cement concrete and precast/prestressed concrete products shall be alkali silica reactivity-resistant. Proportion Portland cement concrete mixes to include materials that meet either the aggregate requirement or Alkali-Silica Reactivity (ASR) mitigation criteria listed below. Provide cement mill test reports from certified laboratories that show the materials' source, composition and the cement alkali content expressed as sodium oxide equivalent[(a)] not to exceed 1.4%. Certified test reports according to test procedures as specified in Table A will be required to be submitted with the trial batch submission to the Research and Materials Division for approval every year or whenever the source of material is changed.

Select non-reactive aggregates that meet all the criteria of Table A. Mitigate the mix as described below when non-reactive aggregates are unavailable. If non-reactive aggregates are used for portland cement concrete mix, 15% by weight of the cementitious content shall be fly ash meeting AASHTO M 295, Type F.

Select a material or a combination of materials that meet the criteria shown in Table B to mitigate ASR when concrete mixes must be proportioned with reactive aggregates. Perform verification test according to AASHTO T 303 and ASTM C295 to determine the effectiveness of the resulting mix design against ASR. Use the same proportion of cement and pozzolan for each test mixture as that proposed for the actual mix design. Provide the Department with certified documentation of the mixtures' effectiveness to control ASR.

Table A
Tests and Criteria for Proposed Aggregates

Procedure	Description	Limits
AASHTO T 303 Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction	Mean mortar bar expansion at 14 days	0.08% maximum metamorphic aggregate 0.10% maximum all other aggregates
	Perform a polynomial fit[(b)] of 4, 7, 11, and 14 days to determine reliability of results	Repeat the AASHTO T 303 if r^2 is less than 0.95
ASTM C295 Petrographic Examination of Aggregates for Concrete	Optically strained, microfractured, or microcrystalline quartz	5.0% maximum[(c)]
	Chert or chalcedony	3.0% maximum[(c)]
	Tridymite or cristobolite	1.0% maximum[(c)]
	Opal	0.5% maximum[(c)]
	Natural volcanic glass	3.0% maximum[(c)]

Table B
Mitigation Methods for ASR in Portland Cement Concrete

Material	Specification	Cementitious Material Percentage[(d)]
Low alkali cement[(e)]	AASHTO M 85	100%
Fly ash - Class F	AASHTO M 295	15% minimum to 30%[(f)] maximum
Silica Fume[(g)]	AASHTO M 307	6% ± 1%[(h)]
Slag Grade 100 and 120	AASHTO M 302	25% minimum to 50% maximum

Note:
(a) Na_2O equivalent = $\%Na_2O + 0.658\ (\%K_2O)$
(b) Use a second order polynomial of $\%Exp = A^o + A^1SQRT(t) + A^2t$. See publication SD92-04-F.
(c) Based on the total aggregate sample.
(d) Measure this minimum content of cementitious material as percent by weight of cement plus pozzolan.
(e) This single criterion is not effective in all cases in remediating ASR. Low alkali cement (0.60% maximum[(a)]) must be used in combination with other pozzolanic materials in Table B.
(f) Fly ash, Type F, shall replace 15% by weight of the design cement content, and any additional fly ash will be considered as fine aggregate.
(g) Silica fume shall only be used in silica fume cement concrete.
(h) The total amount of Type F fly ash and silica fume shall constitute 20% by weight of the design cement content, and any additional fly ash shall be considered as fine aggregate.

SUBSECTION M4.02.01 Cement.
(page 347 English, page III.29 Metric) Add the following sentences to the end of the sixth paragraph:

Cement furnished without a current Mill Analysis Report shall not be used in the work until the Engineer has had sufficient time to make appropriate tests and has approved the cement for use. A current Certificate of Compliance for concrete admixtures, fly ash, silica fume, and slag based on test results shall be available for the inspector prior to production.

SUBSECTION M4.02.02 Aggregates.
*(page 348 English) Under the heading **A. Fine Aggregates** replace the third line and table with the following:*

The sieve analysis of the sand shall show it to be well graded and conforming to the following:

		Fine Aggregate
Sieve Designation	Minimum	Maximum
3/8 inch	100	
No. 4	95	100
No. 16	45	80
No. 50	10	30
No. 100	2	10
No. 200	0	3

*(page 349 English) Under the heading **C. Sieve Analysis** replace the table entitled Percent by Weight Passing (AASHTO T 27) with the following:*

Percent by Weight Passing (AASHTO T 27)						
Designation and Nominal Sieve Size	1½ inch		¾ inch		⅜ inch	
	Min.	Max.	Min.	Max.	Min.	Max.
1½ inch	90	100				
¾ inch	35	60	90	100		
½ inch					100	
3/8 inch	10	25	20	50	85	100
No. 4	0	5	0	10	10	30
No. 8			0	5	0	10
No. 16					0	5

SUBSECTION M4.02.06 Proportioning.
(page 350 English, page III.32 Metric) Under paragraph B., 1. Minimum Cement Content and Minimum Strength, replace the second sentence of the first paragraph with the following:

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 the test specimens fail to meet the requirements of M4.02.13.

SUBSECTION M4.02.06 (continued)

(page 350 English, page III.33 Metric) Under B., 2. Consistency. replace the general requirements in regard to consistency with the following:

English:

Mass Concrete	2 ± 1/2 inch slump
Exposed Bridge Deck Concrete	21/2 ± 1/2 inch slump
Reinforced Concrete	3 ± 1 inch slump
Very Constricted Placement Conditions	4 ± 1 inch slump
Pump Concrete	4 ± 1 inch slump
Tremie Concrete	6 ± 1 inch slump
Drilled Shaft Concrete (Permanent Casing or Dry Uncased Placement)	5 ± 1 inch slump
Drilled Shaft Concrete (Dry Temporary Casing Placement)	7 ± 1 inch slump
Drilled Shaft Concrete (Tremie or Slurry Placement)	8 ± 1 inch slump

Metric:

Mass Concrete	50 ± 13 mm slump
Exposed Bridge Deck Concrete	63 ± 13 mm slump
Reinforced Concrete	75 ± 25 mm slump
Very Constricted Placement Conditions	100 ± 25 mm slump
Pump Concrete	100 ± 25 mm slump
Tremie Concrete	150 ± 25 mm slump
Drilled Shaft Concrete (Permanent Casing or Dry Uncased Placement)	125 ± 25 mm slump
Drilled Shaft Concrete (Dry Temporary Casing Placement)	175 ± 25 mm slump
Drilled Shaft Concrete (Tremie or Slurry Placement)	200 ± 25 mm slump

(page 350 English, page III.32 Metric) Replace paragraph B., 4. Air Content, with the following:

The air content of the concrete by volume shall be as shown in the table above when tested in accordance with AASHTO T 152. A tolerance of ± 1.5% in the above percentages will be allowed.

SUBSECTION M4.02.07 Measuring Materials.
(page 351 English, page III.34 Metric) Replace this Subsection with the following:

Materials shall be measured in accordance with AASHTO M 157, Section 8, with the following exceptions:

All wash water shall be removed from truck mixers and truck agitators prior to charging with a fresh load.

Water may be held back at the plant by up to 5.0 gallons per cubic yard (24.75 L/m^3) of concrete mixed. The use of this water on the project is at the direction of the Engineer and must be verified through sight glass increments or in-line meter readings and then the amount will be written on the ticket. Absolutely no additional water may be utilized on site for slump adjustment purposes. If after placing all the allowable hold-back water and mixing the proper time, the concrete mixture still does not attain the proper slump, the Engineer will reject the truckload.

SUBSECTION M4.02.08 Plant and Equipment.
*(page 352 English) Replace the third sentence of the first paragraph under the heading **B. Testing Facilities** with the following:*

The building or room shall have a least dimension of 7 feet and a minimum of 220 square feet.

SUBSECTION M4.02.10 Mixing and Delivery.
(page 354 English, page III.37 Metric) Delete the fourth paragraph under section F. and add the following paragraph to the end of this Subsection:

H. Concrete may be tempered only once before the initial set with the permission of the Engineer and only with an approved superplasticizer to bring the slump back to within the specification. The concrete shall be mixed thoroughly according to the manufacturer's recommendation. Concrete shall not be re-tempered by adding water. Any batch of concrete that does not conform to the specification with respect to delivery time, temperature, slump or entrained air content shall be rejected.

SUBSECTION M4.02.12 Cold Weather Concrete.
(page 355 English, page III.38 Metric) Delete this Subsection.

SUBSECTION M4.02.13 Test Specimens.
(page 355 English, page III.38 Metric) Add the following sentence to the end of paragraph A:

Slump, air content and temperature shall be measured and recorded when concrete cylinders are fabricated.

(page 355 English, page lll.38 Metric) Replace paragraph B with the following:

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/she deems necessary.

The Contractor shall furnish concrete and such assistance as the Engineer may require.

After the fabrication of concrete cylinders by the Engineer, the concrete cylinders shall be protected and cured on the project by the Contractor in accordance with AASHTO T 23 and as directed by the Engineer without additional compensation. The Contractor shall furnish and maintain, without extra compensation, a protected environment to provide initial curing of all concrete cylinders at the project. The protective environment shall be available at each site where concrete is placed and then maintained by the Contractor until such time that all concrete cylinders have been transported to the laboratory for testing. The Engineer shall approve each protective environment prior to the beginning of any project concrete placement.

The protective environment shall be shielded from direct sunlight and radiant heating devices. The protective environment shall be capable of maintaining the temperature for the stored concrete cylinders in the range between 60 and 80°F and loss of moisture from the cylinders shall be prevented.

When moving the concrete cylinders into the protective environment, precautions shall be taken to avoid any damage to the freshly made concrete cylinders. If the top surface is marred during movement to the protective environment, refinish immediately.

SUBSECTION M4.02.13 (continued)

The protective environment for the concrete cylinders shall consist of tightly constructed, firmly braced wooden boxes, damp sandpits, temporary building at construction sites, wet burlap covered in plastic in favorable weather, or heavyweight closed plastic bags. Other suitable methods may be used, upon approval by the Engineer, provided that the foregoing requirements limiting concrete cylinder temperature and moisture loss are met.

Storage temperature shall be regulated by means of ventilation, or thermostatically controlled cooling devices, or by using heating devices such as stoves, light bulbs, or thermostatically controlled heating elements. A temperature record of the concrete cylinders shall be established by means of maximum-minimum thermometers.

After finishing the concrete cylinders, they shall be covered and placed immediately into the protective environment where they will remain undisturbed for the initial curing period.

Concrete cylinders that are to be transported to the laboratory for standard curing before 48 hours shall remain in the molds in a moist environment until they are received in the laboratory, demolded and placed in standard curing. Concrete cylinders that will be transported to the laboratory for standard curing after 48 hours age may be cured in the protective environment provided that the loss of moisture is prevented until the time of transportation and testing. Concrete cylinders shall be demolded no later than 48 hours.

28-day and 56-day concrete cylinders shall be transported to the laboratory for standard curing and testing by the Department personnel within six days of the time of cylinder fabrication. 7-day cylinders shall be transported to the laboratory as soon as possible but not until at least 8 hours after final set (Setting Time may be measured by AASHTO T197).

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 T 23 by the Contractor, without additional compensation, under the direction of the Engineer

(page 355 English, page III.39 Metric) Add the following to the end of this Subsection:

E. Strength tests will be performed to determine concrete strength compliance for the project. The concrete cylinders must be fabricated in accordance with the sampling schedule as specified in the Materials Manual; the number of concrete cylinders fabricated will depend on the number of ages at which they are to be tested. Test cylinders shall be cured under controlled conditions as described in Article 9.3 of AASHTO T 23 and tested at the age of 28 days and/or other ages as specified. A test is defined as the average strength of two concrete cylinders of the same age, fabricated from a sample taken from a single batch of concrete.

F. Individual strength tests shall not fall below the specified strength (fć) by more than 500psi (3.5 MPa). If the 28-day cylinder breaks fail to meet the specified strength, 56-day cylinder breaks shall be accepted as proof of reasonably close conformity with the specification. If the 56-day cylinder breaks fail to meet the specified strength, the Contractor may request permission to core the concrete to verify its strength. Coring may only be done with the permission of the Department, at locations chosen by the Department and within 2 weeks of being notified that the 56-day cylinder breaks have failed. The Department shall specify a minimum of 3 core locations. Core results shall be evaluated in accordance with ACI procedures whereby the average of all core breaks must exceed 85% of the specified design strength and no single core break may be less than 75% of the specified design strength. The Contractor may request permission to core the concrete immediately after the failure of 28-day cylinder breaks, rather than waiting for 56-day cylinder tests, if waiting for later tests will compromise the project's schedule. All concrete represented by the compression test that indicates a compressive strength of more than 500 psi below the specified 28-day strength will be rejected and shall be removed and replaced with acceptable concrete. However, the Contractor may, at his own expense, obtain and submit evidence as outlined below, acceptable to the Engineer, that the strength and quality of the concrete placed in the work is acceptable, then the concrete will be permitted to remain in place and the contractor will be paid at a reduced price as outlined below.

G. If three consecutive standard concrete cylinders tests (AASHTO T 22) taken on the jobs from the same plant for the same mix design of concrete fail to meet the strength requirement, the plant shall submit remedial actions for all future production until the source of the problem can be identified and corrected, or new trial batches can be performed. When the average of three consecutive tests, falls to less than 150 psi (1.0 MPa) above the specified strength or any single test falls more than 200 psi (1.2 MPa) below the specified strength, the plant shall make corrective changes in the materials, mix proportions or in the concrete manufacturing procedures before placing additional concrete of the same mix design. Such changes shall be subjected to the approval of the Engineer prior to use.

SUBSECTION M4.02.13 (continued)

H. Evaluation and Acceptance of Concrete.

The strength of the concrete will be considered satisfactory provided that the average of all sets of three consecutive test results of the same concrete mix equal to or exceed the required specified strength fć, and no individual test result falls below the specified strength fć by more than 500 psi (3.5 MPa).

Non-destructive testing will not be permitted in lieu of compressive strength tests of concrete cylinders, air content tests by the pressure method, slump or other test for evaluation and acceptance on concrete placed on the projects. Coring is the only acceptance method to determine the in-situ characteristics of concrete. The size of the core shall be 4-inch (100 mm) finished diameter for concrete with ¾ inch (20 mm) or less aggregate and 6-inch (150 mm) finished diameter for concrete with aggregate greater than ¾ inch. The length of the concrete core, when capped, shall be as nearly as practicable twice its diameter and a strength correction factor in accordance with AASHTO T 24 must be determined based on the ratio of Length to Diameter (L/D). Cores with L/D ratio less than 1 shall not be tested. Wipe off the surface of the drilled cores and allow the remaining surface moisture to evaporate. When the surfaces appear dry but not more than an hour after drilling, place cores in separate plastic bags or non-absorbent containers and seal to prevent moisture loss. Allow the cores to remain in the sealed plastic bags or non-absorbent containers for at least 5 days after last being wetted before making the compression test.

A request for strength analysis by coring shall be approved by the Engineer prior to beginning the work. Coring will not be permitted if the Department determines it would be harmful to the integrity of the structure, Cores shall be obtained by the Contractor and witnessed by the Engineer in accordance with AASHTO T 24 and delivered to Research and Materials for testing in accordance with AASHTO T 22. The test results will be considered proof of in-situ concrete strength and will supersede all other strength data for the concrete represented by that placement. Cores shall be obtained no later than two weeks after the 56 day cylinder breaks have failed. All reinforcing steel shall be located with a pachometer around the proposed coring locations prior to the coring operation. The Department shall approve the location to be cored. And all cost associated with the coring operation including the repair of cored area shall be the responsibility of the contractor. The Contractor shall patch the core holes with low slump mortar, similar to that used in the concrete, immediately after coring, to the satisfaction of the Engineer. Acceptance by core method requires that the average compressive strength of three cores from the same concrete placement exceeds 85 percent of the specified design strength with no single core less than 75 percent of the specified design strength.

These cores may be subjected to petrographic analysis, if deemed necessary by the Engineer and at the expense of the Contractor, to determine if there is microscopy evidence that identifies the constituents of concrete, possible reasons for the strength deficiency of the in-situ concrete, if any, and to provide a basis for assessing the quality and long term durability of the in-situ concrete. The results of the petrographic analysis will be considered in conjunction with the results of concrete cylinders to determine if the concrete can remain in place or has to be removed.

Concrete that meets the strength requirements through the 28 day, the 56 day break or the core break shall be considered in reasonably close conformance with the specifications and no credit shall be taken.

Concrete with cylinder or core compressive strength (fc) which fails to meet acceptance level requirements shall be evaluated for structural adequacy at the Contractors' expense. The Department shall review all production records, the concrete test records, petrographic analysis report, field notes, and the placement records for the concrete in question. If the Engineer determines the material is found to be adequate to remain in place, payment shall be adjusted in accordance with the following formula:

Pay adjustment for substandard concrete, $P= 2(fc-fć)(UP)(Q)/(fć)$

Where fć = Specified minimum compressive strength at 28 days

fc = Substandard concrete cylinder compressive strength at 28 days or compressive strength of substandard concrete cores determined by AASHTO T22.

P = pay adjustment for substandard concrete.

Q = Quantity of concrete represented by the acceptance cylinders tested.

UP = Unit contract price or the lump sum breakdown price per cubic yard for the class of concrete involved complete in place.

SUBSECTION M4.02.14 Precast Units.

(page 356 English, page III.39 Metric) Replace the language under A. Plant Requirements with the following:

The precast manufacturing plant shall be approved by the Department prior to manufacturing, and be certified by either the National Precast Concrete Association (NPCA) Plant Certification Program, or the Precast/Prestressed Concrete Institute (PCI) Plant Certification Program for the category of product being produced. The cement concrete production and precast product fabrication shall be produced at a single plant site operated by a single company.

The units shall be manufactured in an approved enclosed building under the Engineer's control and inspection with a guaranteed provision to meet the requirements for curing and protecting the concrete as specified.

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 units shall be cast true to line and dimensions, free from checking, cracking, voids, surface honeycombing and without requiring additional rubbing or patching.

All steel reinforcement (bars or welded wire fabric) shall be epoxy coated (M8.01.7) or galvanized steel (M8.01.8), conforming to the respective materials specifications.

(page 356 English, page III.39 Metric) Under C. Vibration, change 901.65C to 901.63C.

(page III.40 Metric) Replace the language under D. Protection and Curing., 1. Steam Curing. with the following:

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 the cement. The steam shall be directly applied to the concrete. During the application of steam the ambient temperature shall increase at the rate not to exceed 20ºC per hour until a minimum temperature of 55ºC is reached.

When discontinuing the steam application, the ambient temperature shall be decreased at the rate of 20ºC per hour until a temperature of 10ºC 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.

(page 357 English, page III.40 Metric) Delete the last paragraph of D. Protection and Curing., 3. Protective Coating.

(page 357 English, page III.40 Metric) Replace the language under H. Quality Control, 1. Personnel: with the following:

There shall be sufficient personnel trained and certified to perform the tests listed under M4.02.13, Part D. The certification required shall be the American Concrete Institute (ACI) Field Technician Level I certification, or Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level I or higher.

(page 357 English, page III.41 Metric) Add (English) / Replace (Metric) the following sentence to the first paragraph under the heading H. Quality Control, 3. Laboratory:

An additional desk and file cabinet shall be provided for the exclusive use of the Engineer.

SUBSECTION M4.02.15 Cement Mortar.

(page 357 English) Change M4.02.02B to M4.02.02A.

SUBSECTION M4.02.16 Precast Drainage Structures.

(page 357 English, page III.41 Metric) Add this new Section.

Precast manholes and catch basins shall conform to the requirements of AASHTO M 199. Special manholes shall meet the requirements of M4.02.14, Precast Units. After curing a minimum of 14 days, the outside surface of the tapered or cone section of precast cement concrete drainage structures shall be dried, cleaned and coated with a coal tar emulsion meeting the requirements of M3.03.3 Protective Seal Coat Emulsion.

SUBSECTION M4.02.17 Self-Consolidating Concrete for Precast Concrete Products.

(page 357 English, page III.41 Metric) Add this new Section.

Self-Consolidating Concrete (SCC) may be used at the Fabricator's discretion. SCC is a non-segregating concrete that is sufficiently flowable to fill formwork, spread into place, and encapsulate reinforcing steel, requiring minimal or no mechanical vibration to avoid segregation of the plastic concrete mixture. The following provision shall apply in addition to the other requirements specified in Section M4.

A. Fine Aggregates.

The fine aggregate portion of a given mix shall not exceed 50 percent by weight of the total aggregate in the mix.

B. Chemical Admixtures.

Chemical admixtures shall be selected from the MassDOT Qualified Construction Materials List (QCML), shall be used in accordance with manufacturer's recommendations, and shall be compatible with all mix components. Any type of chemical admixture that is not included in the QCML (such as shrinkage reducing admixtures) shall be used in accordance with the manufacturer's recommendations, shall be compatible with all mix components and shall conform to AASHTO M 194 and the following:

1. Air entraining admixtures shall comply with AASHTO M 154.
2. VMA shall comply with the ASTM C 494 Type S.
3. High-range water-reducing admixtures (HRWRA) shall comply with the requirements of ASTM C 494 Type F (water-reducing, high range) or G (water-reducing, high range, and retarding) or ASTM C 1017. Such HRWRA can be used in combination with regular water-reducing admixtures or mid-range water-reducing admixtures. High-Range Water-Reducing Admixture (HRWR).
4. All corrosion inhibitors shall comply with AASHTO M 194.

C. SCC Mix Design.

Prior to concrete production, the Contractor shall submit a copy of the SCC mix design to the MassDOT Research & Materials Section for review and approval.

SCC Compressive strength specimens shall be fabricated in accordance to ASTM C1758. Multiple samples from the same batch shall be made simultaneously. Prior to testing for compressive strength, the de-molded cylinders shall be visually examined for evidence of segregation. The results of the observations shall be reported as part of the strength results.

In addition to the testing provided in M4.02, the following tests shall be performed by qualified staff, in the presence of the Engineer and submitted to the MassDOT Research and Materials Section for the prequalification of the SCC mix design;

Table 1: Additional Material Acceptance Criteria for SCC Trial Batch Testing

Property	Test Method	Target Value
Filling Ability	Slump Flow (AASHTO T 347)	22 – 29 in.
Passing Ability	Slump Flow (AASHTO T 347) J-Ring Flow (AASHTO T 345)	The measured difference between the Slump Flow and the J-Ring Flow shall be < 2 in.
Static Stability	Column Segregation (ASTM C 1610)	Percent static segregation (S) ≤ 15%
	Visual Stability Index (AASHTO T 351)	0 or 1

Note: Slump flow values outside of the above range will be considered, provided mock-ups performed during the trial batch process demonstrate full consolidation of concrete without segregation as approved by the Engineer.

D. Production Sampling and Testing.

In addition to production sampling and testing defined in M4.02, the following testing shall be performed during production. These tests shall apply whether performed by MassDOT for acceptance or by the Contractor for Quality Control. Sampling and testing requirements shall be performed in accordance with the specifications for the precast concrete unit.

Table 2: Additional Material Criteria for SCC Production Testing

Property	Test Method	Target Value	Testing Frequency
Filling Ability	Slump Flow (AASHTO T 347)	+/- 2 in. of Trial Batch Slump Flow Target Value and within Range of 22 – 29 in.	1 per Sublot
Static Stability	Visual Stability Index (AASHTO T 351)	0 or 1	1 per Sublot

SUBSECTION M4.03.00 Prestressed Concrete Beams.
(page 357 English, page III.41 Metric) Replace the title and the first 3 paragraphs with the following:

M4.03.00 Prestressed Concrete Beams and Piles.

This work consists of fabricating pre-tensioned bonded prestressed concrete beams in accordance with the plans and these specifications.

The precast/prestressed concrete manufacturing plant shall be approved by the Department prior to manufacturing product and be certified by the Precast/Prestressed Concrete Institute (PCI) Plant Certification Program. The approved plant shall be certified to manufacture at the Category B3 level or higher. The cement concrete production, and precast product fabrication shall be produced at a single plant site operated by a single company.

The work under this Section shall conform to the relevant requirements of the current AASHTO Standard Specifications for Highway Bridges, and shall be supplemented by the relevant provisions of "The Manual For Quality Control For Plants and Production of Precast And Prestressed Concrete Products", Prestressed Concrete Institute Publication Number MNL-116-85, except as noted herein.

Prestressed concrete piles shall be designed and manufactured in accordance with the latest joint AASHTO / PCI committee recommendations. Piles shall support design loads and moments shown on the plans. No piles shall be delivered to the site until at least 3 days after casting and until concrete strength is at least 5,000 psi as determined by compression tests on standard concrete cylinders.

The Contractor shall order all materials and services for this work immediately after execution of the contract.

SUBSECTION M4.03.01 Drawings.
(page 358 English, page III.42 Metric) Add (English) / Replace (Metric) the following paragraph at the end of this Subsection:

After the shop drawings have been approved, the Contractor shall give the Department a minimum two weeks notice prior to the commencement of fabrication.

SUBSECTION M4.03.02 Responsibility.
(page 358 English) Replace the existing Subsection, including the title, with the following:

M4.03.02 Quality Control.

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. The Quality Control staff shall have sufficient personnel trained and certified as Technician/Inspector Level II, by the Precast/Prestressed Concrete Institute (PCI).

The quality of all materials, the process of manufacture, and the finished sections shall be subject to inspection and approval by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places. Sections rejected after delivery shall be marked for identification and shall be removed from the site at once. The Department shall be notified three days prior to the shipment from the fabrication shop so that a representative may be present during the loading operations.

SUBSECTION M4.03.02 (continued)

All sections which have been damaged after delivery will be rejected or, if already installed, shall be repaired or removed and replaced entirely at the Contractor's expense as may be directed by the Engineer.

All sections shall be inspected for general appearance, dimensions, and soundness. The surface shall be dense, close textured, and free of blisters, cracks, roughness, and exposure of reinforcement.

Minor imperfections may be repaired, subject to the approval of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi at the end of 7 days and 6,000 psi at the end of 28 days when tested in 2-inch cubes stored in the standard manner. Epoxy mortar may be utilized for repairs, subject to the approval of the Engineer.

The contractor shall provide quality control in the form of personnel, equipment, and laboratory and office space in accordance with section M4.02.14H.

(page III.42 Metric) Add the following sentence to the second paragraph:

The Quality Control staff shall have sufficient personnel trained and certified as Technician/Inspector Level II, by the Precast/Prestressed Concrete Institute (PCI).

SUBSECTION M4.03.05 Steel.

(page 358 English) Replace the existing Section with the following:

Reinforcing Steel shall conform to the requirements of M8.01.0 and shall be epoxy coated in accordance with M8.01.7.

Structural steel for prestressed concrete beams, including anchor plates, shall conform to AASHTO M 270 Grade 36 and the relevant provisions of Section M8. Other steel not actually attached to the beams, such as bed plates, pipe supports, bolts, nuts and washers, is not included under "Prestressed Concrete Beams".

SUBSECTION M4.03.06 Pretensioning Strands.

(page 358 English, page III.43 Metric) Replace the existing Section with the following:

Pretensioning Strands shall be uncoated, seven-wire, low-relaxation Grade 270 strands conforming to the requirements of AASHTO-M203.

Strand diameter shall be ½ inch (13 mm).

The approval of the Engineer is required if the Contractor desires to use strands of larger diameter.

Where required, strands shall be debonded for the length specified by a wrapped plastic sheath taped to the strand. Other methods of debonding strands such as greasing, chemical retarders and taping alone will not be allowed.

SUBSECTION M4.03.08 Placing Tension Strands.

(page 359 English) Replace the second paragraph with the following:

Each strand shall be tensioned to the percentage of the Manufacturer's rated ultimate strength specified in the AASHTO Standard Specifications for Highway Bridges for the type of strand used and the tension held until the concrete has attained the minimum required strength for prestressing.

SUBSECTION M4.03.15 Quality Control.

(page 361 English) Delete this Subsection.

SUBSECTION M4.05.2 Clay Brick.

(page 363 English, page III.48 Metric) Change AASHTO M91 to ASTM C32.

SUBSECTION M4.05.5 Epoxy–Resin Base Bonding System for Concrete.
(*page 363 English, page III.48 Metric) Replace the entire Subsection with the following:*

This specification covers two-component, epoxy-resin bonding systems for application to Portland cement concrete. The materials shall meet AASHTO M 235 Type III, IV, or V. The Type, Grade and Class shall be specified for each individual application.

SUBSECTION M4.06.1 High Performance Cement Concrete.
(page 363 English, page III.48 Metric) Add this new Subsection:

M4.06.1 High Performance Cement Concrete.

High Performance (HP) Cement Concrete shall meet the requirements of M4.02.00 in the classifications listed below and shall be modified by the addition of silica fume, calcium nitrite, and an admixture of either fly ash or ground granulated blast-furnace slag or a combination of fly ash and ground granulated blast-furnace (GGBF) slag. The Contractor may elect to use fly ash, GGBF slag, or a combination thereof provided that the permeability and strength provisions contained herein are satisfied and the Research and Materials Division has approved the trial batches and mix design. Changing the mix design shall not be accepted and approved by the Research and Materials Division without the preparing, testing, and approval of trial batches for the revised mix design.

28 Day Compressive Strength	Maximum Coarse Aggregate Size	Total Cementitious Content
4000 psi	¾ inches	585 lb/cy
5000 psi	¾ inches	685 lb/cy
5000 psi	3/8 inches	710 lb/cy
30 MPa	20 mm	335 kg/m^3
35 MPa	20 mm	405 kg/m^3
35 MPa	10 mm	425 kg/m^3

The concrete placed shall be air entrained (6.5±1.5%) High Performance Cement Concrete with a target slump of 4 inches (100 mm). The permitted slump range shall be 2 to 6 inches (50 to 150 mm), except for concrete to be pumped, which shall have a permitted slump range of 3 to 6 inches (75 to 150 mm). Silica fume shall constitute of 6±1% (dry weight) of the cementitious content. Fly ash, if used instead of GGBF slag, shall constitute 15% (dry weight) of the cementitious content. GGBF slag, if used instead of fly ash, shall constitute 25% (minimum dry weight) to 40% (maximum dry rate) of the cementitious content. Combinations of fly ash and GGBF slag may be used provided that the permeability and strength provisions contained herein are satisfied and the Research and Materials Division has approved the mix design and approved the trial batches. The trial batches must have used GGBF slag and/or fly ash addition rates that are consistent with the mix design's addition rates. The water-cementitious ratio shall be 0.40 maximum. The cementitious content shall be the sum of the Portland cement, silica fume, fly ash, ground granulated blast-furnace slag, and all other approved pozzolanic admixtures. The water content of all additives shall be included in the water-cementitious ratio.

Calcium nitrite corrosion inhibitors shall conform to AASHTO M 194. MassDOT Research and Materials Division must approve the material. Acceptance will depend upon the material's conformance, as documented by certified test results, to all applicable sections of AASHTO M 194. The calcium nitrite solution shall contain 30±2 % calcium nitrite by weight. The calcium nitrite material shall have neutral set characteristics.

The calcium nitrite shall be added at a rate of 3 gallons per cubic yard (15 L/m^3) of concrete in order to increase the active corrosion threshold to 9.9 pounds of chloride per cubic yard (5.9 kg/m^3)of concrete at the reinforcing bar level.

Fly ash shall conform to AASHTO M 295, Type F.

Ground granulated blast-furnace slag shall be Grade 100 and/or Grade 120 and shall conform to AASHTO M 302.

SUBSECTION M4.06.1 (continued)

Silica fume shall conform to AASHTO M 307. Pre-blended silica fume cement meeting both AASHTO M 307 and AASHTO M 240 Blended Hydraulic Cement may be used for producing Silica Fume Modified Concrete provided that the overall amount of silica fume is 6±1 % (dry weight) of the cementitious content. If pre-blended silica fume cement is proposed for use, the Contractor shall provide certificates from the manufacturer which certify that the silica fume meets the requirements of AASHTO M 307. The Contractor shall obtain a written statement from the manufacturer of the silica fume that it is compatible with the other materials from the sources proposed by the Contractor along with mill analysis test certification demonstrating conformance to the referenced specifications.

The HP Cement Concrete shall be mixed for a minimum of 20 minutes at mixing speed for a minimum total of 120 revolutions to ensure proper dispersion of the admixtures. The mix shall contain superplasticizer conforming to AASHTO M 194 Type F or G, which shall be added in accordance with the concrete technician's recommendations. The amount of superplasticizer added to the cement concrete at the batching facility and at the job site shall be recorded on the delivery slip. The delivery slip shall be signed by the concrete technician. The concrete technician shall be supplied by the silica fume manufacturer and be either an ACI Certified Concrete Technician (minimum Grade I - Field) or a New England Transportation Technician Certification Program - Certified Concrete Technician.

Trial batch testing will be performed on samples of the same contents and proportions as the HP Cement Concrete to be used in the proposed structures. Trial batches shall be prepared using representative concrete at a 6 inch (150 mm) maximum slump. Coulomb tests shall be made on two 4 x 8 inch (100 x 200 mm) representative samples that do not contain calcium nitrite and have been moist cured for a maximum of 90 days. Coulomb tests on trial batches shall be performed as early as possible during the construction season in order that the approval process does not delay the anticipated date of HP Cement Concrete placement. An independent AASHTO accredited laboratory shall perform the Coulomb testing. If test results exceed a maximum of 1500 coulombs, the Contractor, at his expense, shall adjust the mix and resubmit trial batches until a trial batch passes the coulomb test.

Prior to concrete placement, the Contractor shall develop and forward a copy of the HP Cement Concrete design mix to the Department for review and approval. Approval of the design mix must be obtained prior to placement of concrete. The mix design sent to the Department must be accompanied with trial batch information. Trial batches shall be performed in accordance with procedures outlined by the Department. The Contractor shall have technical representatives from the silica fume supplier and the ready mix producer at the job site during placement of the concrete. The concrete technicians shall each meet the certification requirements as referenced previously in this section. The Contractor will assume these costs.

Appropriate retarders and high range water reducers shall be used as recommended by the ACI certified concrete representative to ensure that potential for the formation of temperature induced plastic shrinkage cracking is minimized.

SUBSECTION M4.07.0 Latex Modified Mortar and Concrete Overlayments.

(page 363 English, page III.48 Metric) Replace this Subsection with the following.

M4.07.0 Elastomeric Concrete.

Elastomeric concrete for use in strip seal bridge joint systems, shall consist of a two component polyurethane material that shall be mixed and placed at the job site. The cured elastomeric concrete shall have the following physical properties:

PROPERTY	TEST METHOD	REQUIREMENT
Compressive Stress @ 5% deflection	ASTM D695	800 psi minimum
Resilience @ 5% deflection	ASTM D695	70% minimum
Impact Resistance@ -20°, 32° and 158°F	ASTM D3209	No Cracks

SUBSECTION M4.08.0 Controlled Density Fill.
(page 367 English) Add this new Subsection after M4.07.0

M4.08.0 Controlled Density Fill.

Controlled Density Fill (CDF) material is a flowable, self consolidating, rigid setting, low density material that can substitute for compacted gravel in backfills, fills and structural fills. There are two main categories of CDF's, excavatable and non-excavatable with a sub category of flowable and very flowable. It shall be a mixture of portland cement, fly ash (if very flowable), sand, and water designed to provide strengths within the range specified.

The categories of CDF's are:
Type 1.....Very Flowable (Non Excavatable)
Type 1E .....Very Flowable (Excavatable)
Type 2.....Flowable (Non Excavatable)
Type 2E .....Flowable (Excavatable)

The Very Flowable mixes (Type 1 and 1E) shall contain a Minimum of 250 pounds of class F Fly Ash or high air (25% plus) and will be self leveling.

Excavatable mixes (Type 1E and 2E) shall be hand tool excavatable.

Type 1 mixes are intended for permanent installations such as structural fills under structures. It has very flowable characteristics needed for distances and small areas. This type of mix should be not be used as a bedding material. It is used to fill small hard-to-reach areas.

Type 1E mixes are excavatable material designed to have very flowable characteristics needed for filling small or far areas that later may need to be removed.

Type 2 mixes are used in areas where size and distance do not need the very flowable characteristic. It is intended for permanent installations such as thick fills under structures.

Type 2E mixes are excavatable mixes where size and distance of the installation do not require the flowable characteristics of a Type 1E mix.

CDF is to be batched at a ready mix plant and is to be used at a high or very high slump of approximately 10 to 12 inches (250 mm to 300 mm). It shall be flowable, require no vibration and after it has been placed can, for Types 1E and 2E, be excavatable by hand tools and/or small machines.

The ingredients shall comply with the following:

Portland Cement .....AASHTO M 85.
Fly Ash .....AASHTO M 295. Class F
Sand M4.02.02
Air entraining admixtures M4.02.05

Note 1. In lieu of the slump test, a 6 inch long, 3 inch diameter tube may be filled to the top and then slowly raised. The diameter of the resulting "pancake" may be measured and the range of the diameter shall be 9 to 14 inches.

Note 2. The maximum for structural flowable fills may be in the 1000's of psi and will depend on the Engineer's requirements.

Note 3. High air may be used instead of fly ash with an adjustment in sand content.

The following Type 1 and Type 1E mix designs are for information only, the actual mix designs submitted by the ready mix operator, in accordance with standard Department practice, must be confirmed by trial batches.

MATERIAL	TYPE 1 MIX DESIGN	TYPE 1E MIX DESIGN
Cement	100 pounds	50 pounds
Fly Ash	250 pounds	250 pounds
Sand	2,650 pounds	2,700 pounds
Water	60 gallons	60 gallons

Various types of controlled density fill must meet the requirements set forth in the table below:

CONTROLLED DENSITY FILL	TYPE 1 & 2	TYPE 1E & 2E
Compressive Strength @ 28 days	30 - 150 psi	30 - 80 psi*
Compressive Strength @ 90 days	200 psi maximum	100 psi maximum *
Slump	10 - 12 inches	10 - 12 inches

* May be changed by Design Engineer to fit particular job requirements.

SECTION M5
PIPE, CULVERT SECTIONS AND CONDUIT

SUBSECTION M5.01.0 Clay Pipe.
SUBSECTION M5.02.0 Cement Concrete Pipe.
(page 367 English, page III.55 Metric) Delete these Subsections.

SUBSECTION M5.03.0 Asphalt Coated Corrugated Metal Pipe.
(page 368 English, page III.55 Metric) Replace this Subsection with the following:

M5.03.0 Corrugated Metal Pipe.

This pipe shall consist of metallic coated (galvanized or aluminized) corrugated metal pipe and couplings. The coating shall completely cover the inside and outside of all pipe and couplings.

Galvanizing shall conform to M7.10.0.

Aluminizing shall conform to M7.15.0

Aluminized and galvanized pipe components shall not be used together in a pipe run.

The pipe shall conform to AASHTO M 36. Pipe 8 inches (200 mm) or less in diameter shall be constructed of sheets not less than 0.052 inches (1.32 mm) thick. End sections shall be 16 gage for all pipes 24 inch (600 mm) diameter and under, 14 gage for all 30 and 36 inch diameter pipes and 12 gage for all diameters greater than 36 inches (915 mm). The coating on end sections shall match the coating on the pipe connected to it.

SUBSECTION M5.03.1 Perforated Asphalt Coated Corrugated Metal Pipe.
(page 368 English, page III.56 Metric) Replace this Subsection with the following:

M5.03.1 Perforated Corrugated Metal Pipe.

This pipe shall meet the requirements of M5.03.0 and contain perforations conforming to AASHTO M 36, Type III. The pipe shall conform to AASHTO M 36 except that reinforcing the ends of the pipe will not be required.

SUBSECTION M5.03.2 Perforated Corrugated Metal Pipe.
SUBSECTION M5.03.3 Asphalt Coated Corrugated Aluminum Pipe.
SUBSECTION M5.03.4 Perforated Asphalt Coated Corrugated Aluminum Pipe.
SUBSECTION M5.03.5 Perforated Corrugated Aluminum Pipe.
(pages 368 and 369 English) Delete these Subsections.

SUBSECTION M5.03.3 Asphalt Coated Corrugated Aluminum Pipe.
SUBSECTION M5.03.4 Perforated Asphalt Coated Corrugated Aluminum Pipe.
(page III.56 Metric) Delete these Subsections.

SUBSECTION M5.03.10 Corrugated Plastic Pipe.
(page SUPPLEMENT C2015-227, page 369 English, page III.57 Metric) Replace this Subsection with the following:

Pipe shall consist of corrugated polyethylene or polypropylene tubing, flare ends, couplings and fittings. Materials, dimensions, physical properties and fabrication shall be in accordance with AASHTO M 294, Type S or D or AASHTO M330 Type S or D. Perforated pipe shall meet Type SP or DP.

SUBSECTIONS M5.03.11 Porous Concrete Pipe.
(page 369 English, page III.57 Metric) Add this new Subsection:

Porous Concrete Pipe shall meet the requirements of AASHTO M 176 for Extra-Strength Porous Concrete Pipe. Aggregates for the concrete may consist of inert carbon material.

SUBSECTION M5.04.1 Half Circle ACCM Pipe.
(page 370 English) Delete this entire Subsection.

SUBSECTION M5.05.1 Cast Iron for Water Systems.
(page 370 English, page III.58 Metric) Delete this Subsection.

SUBSECTION M5.05.3 Ductile Iron Pipes and Fittings.
(page 370 English, page III.58 Metric) Replace the first four paragraphs with the following:

Ductile iron pipe shall conform to the requirements of AWWA C150, C151, C111 and shall be double cement lined and asphalt seal coated in accordance with AWWA C104. The wall thickness shall be Class 52.

Ductile iron fittings for pipes 3 through 24 inches (75 through 610 mm) in diameter shall be of the compact type and conform to the requirements of AWWA C153 American National Standard for Ductile-Iron compact Fittings, 3 Inches through 24 Inches, for Water and Other Liquids.

Ductile iron fittings for pipes greater than 24 inches (600 mm) and up to 48 inches (1.220 m) in diameter shall conform to the requirements of AWWA C110 American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 Inches through 48 Inches, for Water and Other Liquids.

SUBSECTION M5.07.0 Electrical Conduit–Rigid, Nonmetalic (Type NM).
(page 371 English, page III.59 Metric) Replace this entire Subsection with the following:

M5.07.0 Electrical Conduit-Rigid Nonmetallic (Type NM).

Rigid Nonmetallic Electrical Conduit and associated fittings shall conform to Article 352 of the NEC, NEMA TC 2, UL 514B and UL 651.

Unless encased in concrete, all Type NM conduit installed underground shall be Schedule 80 (Electric Polyvinyl Chloride-80).

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 3 feet long and ¼ inch less in diameter than the nominal inner diameter of the conduit.

The bore of bends, elbows, and other fittings shall pass freely a ball of ¼ inch 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.

The minimum acceptable radii dimensions for elbows and bends shall conform to the requirements of the NEC. 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 feet will not be accepted. A tolerance of plus or minus 1 inch is permissible in the conduit lengths specified.

Each length of conduit and all associated fittings shall be clearly and durably marked at least every 10 feet with the manufacturer's name, trademark, or other descriptive marking by which the fabricator can be identified. The material type, trade size, and UL labelling shall also be included in the marking.

SUBSECTION M5.07.1 Conduit–Rigid Metalic (Type RM) (English)
SUBSECTION M5.07.1 Electrical Conduit-Rigid Metallic (Type RM) (Metric)
(page 371 English, page III.59 Metric) Replace this entire Subsection with the following:

M5.07.1 Electrical Conduit-Rigid Metallic (Type RM).

Rigid Metallic Electrical Conduit and associated fittings shall conform to Article 344 of the NEC and the following:

Class 1 – Type A –UL Standard 6 – Rigid Metal Electrical Conduit.

Class 2 – Type A – UL Standard 1242 – Intermediate Metal Conduit.

Class 1 and 2 – Types B, C, and D – UL Standard 514B – Fittings for Conduit and Outlet Boxes.

Each length of conduit and all associated fittings shall be clearly and durably marked at least every 10 feet with the manufacturer's name, trademark, or other descriptive marking by which the fabricator can be identified. The material type, trade size, and UL labelling shall also be included in the marking.

SUBSECTION M5.07.2 Conduit–Flexible Mettalic (Type FM). (English)
SUBSECTION M5.07.2 Electrical Conduit-Flexible Metallic (Type FM) (Metric)
(page 371 English, page III.59 Metric) Replace this entire Subsection with the following:

M5.07.2 Electrical Conduit-Flexible Metallic (Type FM).

Flexible Metallic Electrical Conduit and associated fittings shall be liquid-tight and conform to Article 350 of the NEC and UL-360.

Each length of conduit and all associated fittings shall be clearly and durably marked at least every 10 feet with the manufacturer's name, trademark, or other descriptive marking by which the fabricator can be identified. The material type, trade size, and UL labelling shall also be included in the marking. Type FM conduit suitable for direct burial shall also be so marked.

SUBSECTION M5.08.0 Pull and Junction Boxes.Metallic. (English)
SUBSECTION M5.08.0 Pull and Junction Boxes - Metallic. (Metric)
(page 372 English, page III.59 Metric) Replace this Subsection with the following:

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 UL 514A Metallic Outlet Boxes.

SECTION M6
ROADSIDE DEVELOPMENT MATERIALS

SUBSECTION M6 ROADSIDE DEVELOPMENT MATERIALS
(page 372 English, page III.60 Metric) Replace this Section with the following:

M6.00.0 General.

This section describes requirements for materials used for soil amendments, seed, plant material, mulches, and other materials required for the care and establishment of plants.

M6.01.0 Inorganic Amendments.

Limestone shall consist of pulverized limestone obtained by grinding either calcareous or dolomitic limestone such that 95% of the material will pass a 20 mesh sieve and at least 50% will pass a 100 mesh sieve. The limestone shall meet the applicable provisions of State and Federal laws which relate to commercial fertilizers.

Sulfur for adjustment of loam pH shall be elemental or flours of sulfur, unadulterated, and shall be delivered in containers with the name of the manufacturer, material, and net weight appearing on each container.

Gypsum for soil structure amendment and de-icing salt mitigation shall be agricultural grade, 80 percent calcium sulphate ($CaSO4 \times 2H2O$), in granular or slurry form, with 100 percent passing a 2 mm screen, and 90% passing through 150 μm screen. Gypsum may be derived from natural sources or from recycled wallboard.

Soil wetting agent shall be a synthetic, non-toxic acrylic polyacrylamide or natural soluble plant extract. Application rates shall be per manufacturer's recommendations. Submit supplier specifications and certification.

M6.02.0 Fertilizer.

Fertilizer shall meet the applicable provisions of State and Federal laws and be furnished in containers plainly marked with the chemical analysis of the product.

Fertilizer for general planting shall be slow release and shall be commercial grade 10-10-10, or sufficient to meet the recommendations for soil amendment. At least 40% of the nitrogen content shall be slow release, phosphorus shall be available phosphoric acid, and potassium shall be water-soluble potash.

M6.03.0 Long Term Seed Mixes for Lawns and Slopes

The seed mixture specified for slopes and shoulders consists of a tough hardy type for use on slopes graded at the rate of 1 vertical to 4 horizontal, and steeper slopes, and on shoulders adjacent to the roadway pavement or as otherwise directed. The mixture for lawn grass plots is of a finer type that will produce finer turf.

Grass seed shall be of the previous year's crop and in no case shall the weed seed content exceed 1% by mass. All Bluegrass, Fescue, and Ryegrass shall be within top 25% of either of two most recent National Turfgrass Evaluation Program reports. The grass seed shall conform to the requirements of the following tables:

Grass Type	Proportion	Germination Minimum	Purity Minimum
Lawn Grass Areas			
Creeping Red and/or Chewings Fescue	55%	85%	95%
Kentucky Blue	30%	85%	90%
Perennial Rye	5%	90%	98%
Redtop	5%	85%	92%
Dutch White Clover	5%	85%	96%
Slopes and Shoulders			
Creeping Red, Chewings, and/or Hard Fescue	50%	85%	95%
Tall Fescue	35%	85%	95%
Perennial Rye	5%	90%	98%
Red Top	5%	85%	92%
Dutch White Clover	5%	85%	96%

Warm Season Mix	Proportion (Pure Live Seed)
Canada Wild Rye	20%
Switchgrass	20%
Big Bluestem	15%
Indiangrass	15%
Little Bluestem	15%
Partridge Pea	15%

The seed shall be furnished and delivered premixed in the proportions specified above. All seed shall comply with State and Federal seed laws. Clover shall be pre-inoculated.

Contractor will supply a manufacturer's Certificate of Compliance to the specifications shall be submitted by the manufacturers with each shipment of each type of seed mix. Certificates will be attached to the seed bags for inspection. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net mass and date of shipment. No seed may be sown until the Contractor has submitted the certificates.

M6.03.1 Short Term Erosion Control 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 Type	% by Weight	Germination Minimum %
Winter Rye	80 minimum	85
Red Fescue (Creeping)	5 minimum	80
Perennial Rye Grass	5 minimum	90
Dutch White 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.

M6.04.0 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.

M6.04.2 Straw Mulch.

Straw Mulch shall be seed free, consisting exclusively 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 of trees, brush or shrubs with chippers or from the chipping of stumps, and shall be free of topsoil, stones, and other extraneous material. The chippers shall be approved for use by the Engineer. Wood chip mulch must be free from long stringy material over 4 inches in length and from live, rot-free wood and bark, except that 35% or less by volume of the wood chip mulch may consist of "slab wood", chipped to an acceptable size by chippers equipped with a ¼ inch knife set and thoroughly mixed with the live material. Wood Chip Mulch containing an excess of fine particles, such that mulch will blow or wash away, decay too quickly, or percolate too slowly, will not be acceptable. Wood Chip Mulch may be produced on the project from acceptable cuttings. Wood chip mulch containing remnants of invasive species such as Japanese Knotweed and Bittersweet shall not be used.

M6.04.4 Wood Fiber Mulch.

Wood Fiber Mulch shall consist of wood fiber 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. Recycled material may be evaluated for acceptance based on evaluation of submitted sample, specifications and certified test results from an approved laboratory, per the requirements of Section M1.06.0, Organic Soil Additives.

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.

Bark mulch shall be shredded pine bark aged a minimum of six months. The mulch shall be dark brown in color, free of chunks and pieces of wood thicker than 1/4 inch and shall not contain, in the judgment of the Engineer, an excess of fine particles. Do not use wood chips, recycled, dyed, wood product, or crumb rubber mulch.

Mulch must be free from long stringy material.

M6.05.0 Sod.

Sod shall be composed of the grass mixture recommended by the New England Sod Producer's Association and shall be specified as:

Sod Type / Species	Percent by turf area*
No. 1 - For full sun turf areas: (6 or more hours direct sunlight in growing season)	
Kentucky Bluegrass	50 - 80%
Fine Fescues	10 - 30%
Perennial Ryegrass	0-20%
No. 2 - For partial shade turf areas (4-6 hours minimum direct sunlight in growing season)**	
Fine Fescues	75 - 90%
Kentucky Bluegrass	10 - 25%
Perennial Ryegrass	0-10%
No. 3 - For multi-use turf areas (and minimum 4-6 hours minimum direct sunlight in growing season)**	
Tall Fescue	50 - 90%
Fine Fescues	20-50%
Kentucky Bluegrass	0 - 20%
Perennial Ryegrass	0 - 20%

*All species with >70% of the mix shall have at least 3 varieties; >40% shall have at least 2 varieties.

**Areas receiving less than 4 hours per day of direct sun during growing season should not receive sod.

Lawn sods shall have been nursery grown on cultivated agricultural land used specifically for sod purposes. Grasses shall be drought tolerant cultivars.

The sods shall be free of objectionable grassy and broadleaf weeds. Sods shall be considered free of such weeds if less than 5 such plants are found per 10 square yards of area.

The sod shall be machine cut at a uniform minimum thickness of ¾ inch 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.

Sod that has dried out, or that has been unplanted over 3 days (including weekends) since harvest, will be rejected.

M6.06.0 General Planting.

The Contractor shall furnish all plants as shown on the plans.

M6.06.1 Nursery Stock – General.

All scientific and common plant names of the items specified shall conform to 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 names. All plants will have durable, non-fading labels applied at the nursery that clearly bears the correct botanical name, including cultivar, as well as common name and size. Caliper or spread shall govern over height specifications. The Contractor must obtain written permission from the Engineer for any substitutions of types or sizes specified.

All plants shall be grown in a certified nursery. All plants shall be typical of their species or variety in growth habit. Plant sizes, habit, rootball dimensions, stem and cane count shall conform to the requirements of the American Standards for Nursery Stock (ASNS) standards as a minimum requirement for acceptance. Container sizes shall also be consistent with the guidance per plant size per the ASNS. Each plant shall have plenty of fibrous roots, healthy buds, and shall be free of disease and insect pests. No plant material from cold storage will be accepted. All plant parts shall show active green cambium when cut and shall be densely foliated when in leaf.

Deciduous shrubs shall have 4 to 6 canes coming from the roots and shall have a well-branched root system.

Vines and ground cover shall be minimum 2-year No. 1 stock. Herbaceous plants shall be minimum 1-year No. 1 stock, and clumps shall have not less than 6 buds, eyes, or crowns.

The trunk of each tree shall be free from sunscald, frost cracks, or wounds resulting from abrasions, animal pest, fire or other causes. Pruning wounds shall be no larger than 2 inches and shall show vigorous scar tissue. No trees with double-leaders or twin-heads will be acceptable without the written approval. The plants must be in a vigorous condition and free from dead wood, bruises and other root or branch injuries. Deficient plants may be rejected at any time.

Any species (including all cultivars) listed on the Massachusetts Department of Agricultural Resources Prohibited Plant List shall not be used including but not limited to the following:

Norway Maple (*Acer platanoides*)
Sycamore Maple (*Acer pseudoplatanus*)
Japanese Barberry (*Berberis thunbergii*)
Autumn Olive (*Eleagnus umbellata*)
Burning Bush or Winged Euonymus (*Euonymus alatus*)
Glossy or European Buckthorn (*Frangula alnus*)
Dames Rocket (*Hesperis matronalis*)
Yellow Iris (*Iris pseudoacoris*)
Border Privet (*Ligustrum obtusifolium*)
Honeysuckle -- Japanese, Amur, Morrow's, Tatarian, Bell's (*Lonicera japonica, L. maackia, L. morrowii, L. morrowii x tartarica*)
Plume grass (*Miscanthus sacchariflorus*)
Forget-me-not (*Myosotis scorpoides*)
Reed Canarygrass (*Phalaris arundinacea*)
Amur Cork Tree (*Phellodendron amurense*)
Common Buckthorn (*Rhamnus cathartica*)
Black Locust (*Robinia pseudoacacia*)
Wild Rose (*Rosa multiflora*)

M6.06.2 Nursery Stock – Balled and Burlapped.

All plants that are to be balled and burlapped previous to shipment are designated "B&B". B&B plants shall be dug so as to retain as many fibrous roots as possible. All B&B plants shall come from soil that will hold a firm root ball and the solidity of the ball shall be carefully preserved. B&B plants shall be wrapped with untreated 8-ounce burlap, firmly held in place by a stout cord or wire. Wire containers shall be of adequate size to allow root development for the plant size as per ASNS requirements. Plants prepared with plastic or other non-biodegradable wrappings will not be accepted. Rootballs shall remain intact during all operations. No plant will be accepted if the rootball has been cracked or broken prior to, or during, the process of planting. All plant materials shall be dug with reasonable care and skill immediately prior to shipment.

M6.06.3 Nursery Stock – Container Grown.

All container grown plants shall be healthy, vigorous and well rooted in the container in which they are sold. They shall have tops that are of good quality and are in healthy growing condition. No single-stemmed shrubs or sparsely leafed plants will be accepted. The side branches must be generous and well twigged, and the plant as a whole must be well-branched to the ground or typical of the species or cultivar. Container-grown stock shall have been grown in the container long enough for the root system to develop sufficiently to hold the soil together firmly. No plants shall be loose in the container. Container-grown plants shall not be pot bound with spiraling roots or roots growing densely against the sides of the container. The container shall be sufficiently rigid to protect the root mass during shipment and sizes shall be provided in accordance with the ASNS standards. The size of plant, as well as minimum number of stems or canes, will conform to the type of plant per ASNS standards.

The soil medium for container-grown plant material shall be a uniformly blended, stable medium free from weeds, weed seeds, disease organisms, insects, herbicide residue, and all other harmful organisms or materials. The soil shall fill the container to at least 85% of its height, serving as a stable base for the anchorage and support of the plant growing in it. It shall be well-aerated sandy loam or fine sandy loam, per USDA Soil Classification, and of sufficient structure to provide adequate moisture to plants.

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. Plants shall have been grown in the container for a minimum of 12 weeks. A random sample is required from each delivery for soil and root inspection upon request of the Engineer.

M6.06.4 Nursery Stock -- Bare-Root.

Bare-root material shall be dug during dormancy within 72 hours of shipping and shall be kept moist and stored in a cool, shaded location until planting. All bare-root material shall be accompanied by certification of digging date. The roots of bare-rooted material shall be dipped in soil wetting agent and carefully protected with wet straw, moss or other suitable material that will ensure the arrival of the plants at the site of the work in good condition. All bare-root material shall be installed within 48 hours of arrival on the construction site, and shall be kept moist and out of wind or direct sunlight until planting. Maximum time between digging for shipping and installation shall be one week.

M6.06.5 Nursery Stock – 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 year transplants, bare rooted.

Lining out stock seedlings shall be two year seedlings.

Root cuttings shall be established in peat pots 2.5 inches deep by 2 inches wide at the open end and tapered to 1 inch wide at the closed end (inside measure).

M6.06.6 Nursery Stock – Trees.

Per the requirements of the ASNS, the sizes of trees shall be as called for on the plans and measurements shall be determined by caliper at a point 6 inches above the ground for plants specified up to 4 inches in caliper. Larger minimum caliper shall be measured 12 inches from ground.

Trees for streetscape plantings (i.e. in or adjacent to walkways) shall have a single straight leader not cut back.

They shall have a symmetrical development of strong, healthy branches beginning at least 7 feet from the ground; and below this point, the trunk shall be clean for street trees. Coniferous Evergreens shall be dug before spring “candling” of new growth.

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.

M6.06.7 Nursery Stock -- Shrubs, Vines, Groundcover and Perennials.

Shrubs shall have the form required per ASNS. Specified spread shall govern over height requirements.

Vines and ground cover in this group shall be 2 year, No. 1 stock.

Herbaceous plants in this group shall be minimum 1 year, No. 1 year stock, and clumps shall have not less than 6 buds, eyes or crowns.

M6.07.0 Delivery and Protection.

All plants shall be packed so as to arrive at the delivery point in good growing condition and shall be kept moist for delivery and during transit. 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.

Shipment of plant material shall be scheduled to minimize the time between arrival and installation at the construction site. Plants may be stored at the construction site for up to 3 days on in an approved location that is out of direct sunlight and wind. Contractor shall store plants in wood chips and shall provide watering to maintain containers and root balls in moist condition at all times prior to installation.

M6.07.1 Wrapping for Transport.

Wrapping material shall be used for transport only. Wrapping material for root balls shall be 8-ounce jute burlap; plastic is not acceptable. Material for tree trunks shall be 4 to 6 inch wide strips of burlap, paper, cardboard, 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. Wrapping must be removed once tree has been installed.

M6.08.0 Materials for Guying and Staking.

The stakes shall be unpainted spruce or other suitable wood free from large knots, dimensioned 2x2 by 8 feet in length and sharpened at one end. Binding and guying shall be bio-degradable webbing. Stake fastenings shall be 10 penny galvanized nails. Trees shall not be wrapped.

M6.08.1 Temporary Fencing for Tree Protection.

Temporary Tree Protection Fence shall be brightly colored polypropylene barricade or wooden snow fencing for tree protection or safety fencing. Fencing shall be a minimum of 4 feet high and supported by steel or hardwood stakes spaced at a maximum of 8 feet on center or by other means acceptable to the Engineer.

M6.08.2 Trunk Cladding for Tree Protection.

Cladding for trunk protection shall be 2x4 or 2x3 nominal lumber, at least 6 feet in length, sufficiently tall to protect tree trunk from construction activities, and bound together with wire. Alternatively, trunks may be shielded with sections of corrugated plastic pipe of sufficient diameter and height to shield trunk from construction activities. Trunk protection shall include burlap, which shall be untreated 8-ounce burlap.

M6.08.3 Sheeting for Tree Root Protection.

Sheeting for tree root protection shall be minimum ¾" thickness plywood, cut and trimmed to required sizes and configurations.

M6.09.0 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. Water shall be free from impurities injurious to vegetation.

Submittal shall be required, including anticipated demand, irrigation method, watering schedule, sources of water, and any incidental work required to provide water for the plants.

SECTION M7 PAINTS AND PROTECTIVE COATINGS
(page 377 English, page III.66 Metric) Change title of this section to read as follows.

SECTION M7
PAINTS, PROTECTIVE COATINGS AND PAVEMENT MARKINGS

SUBSECTION M7.01 Pavement Markings.
(page 378 English, page III.67 Metric) Replace M7.01.7 Glass Bead with the followings.

M7.01.07 Glass Beads.

This specification covers the requirements for glass beads which are to be dropped or sprayed on pavement markings.

Glass bead suppliers and approved batch numbers are listed on the MassDOT Qualified Construction Materials List.

All glass beads shall meet the requirements of AASHTO M 247, AASHTO T 346 and the following:

1. A minimum of 80% of the glass beads shall be true spheres when tested in accordance with ASTM D1155, Procedure A.
2. The glass beads shall be manufactured from commercial grade soda lime glass cullet meeting EPA and DEP requirements for concentrations of lead and arsenic. The silica content shall be 60% minimum (ASTM C 169).
3. Moisture Resistance - The Type 1 and Type 4 glass beads shall be treated with a moisture proof coating and be moisture resistant as tested by AASHTO T 346, Referee Method.
4. Adherence - The Type 4 glass beads shall be coated with a silane-type adherence coating to enhance embedding in, and adherence to, the applied binder film. The coated beads shall emit a yellow-green fluorescence when tested by the Dansyl Chloride test procedure.
5. Intermix glass beads used in the manufacture of thermoplastic pavement markings shall meet the requirements of AASHTO M247, Type 1 glass beads. A moisture proof coating is optional.

A. Gradation

The glass beads shall be tested in accordance with ASTM D1214 (By use of U.S. Standard Sieves).

Standard gradation beads shall meet the requirements of AASHTO M 247, Type 1.

Large gradation beads shall meet the requirements of AASHTO M 247, Type 4.

B. Packaging.

The beads shall be packaged in 50 pound or greater polyethylene-lined burlap bags or equal container; such containers guaranteed to furnish dry and undamaged beads. The following information shall be indelibly labeled in a clear and legible manner on each container:

(a) The name of the manufacturer.
(b) The place of manufacture.
(c) The words: "Glass Beads-Traffic".
(d) Size/Type/Coating.
(e) Materials Specification Number.
(f) The date of shipment (month and year).
(g) The batch number.
(h) Net weight.

C. Approval Procedure.

Requests for approval shall be submitted to the MassDOT Research and Materials Section, accompanied by;

a. Certificate of Compliance stating that the material complies with AASHTO M 247, AASHTO T 346 and all applicable MassDOT requirements,

b. Independent lab test results,

c. Three bags of glass beads per batch in sample bags meeting the specifications above for verification testing.

SUBSECTION M7.01 Pavement Markings.
(page 378 English, page III.67 Metric) Delete M7.01.20 Thermoplastic Pavement Marking Compound, Alkyd.

SUBSECTION M7.01 Pavement Markings.
(page 378 English) Add the following to the end of the listing:

M7.01.23 Fast Drying White Water-borne Traffic Paint
M7.01.24 Fast Drying Yellow Water-borne Traffic Paint

SUBSECTION M7.02 Structural Paint
(page 379 English, page III.67 Metric) Replace this subsection with the following;

Coatings systems shall be non-lead (Pb), non-chromate, low VOC, (450 grams/liter, max.) systems. Coating systems shall be selected from the NEPCOAT Qualified Products List for Protective Coatings.

SUBSECTION M7.05 Epoxy Protective Coating.
(page 379 English) Add the following specifications:

M7.05.11 Epoxy - Polyamide Primer Paint (non lead)
M7.05.12 Brown Epoxy - Polyamide Top Coat (non lead)
M7.05.13 Green Epoxy - Polyamide Top Coat (non lead)
M7.05.15 One Coat Hi Build Mastic Coating
M7.05.21 Coal Tar Epoxy Polyamide Paint
M7.05.31 Self-Priming Epoxy Coating

SUBSECTION M7.10.0 Galvanized Coatings.
(page 379 English, page III.68) Replace this subsection with the following:

Galvanized coatings shall conform to the following requirements:

ASTM A143 – Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.

ASTM A384 – Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.

ASTM A385 – Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).

ASTM B6 – Standard Specification for Zinc. A range of 0.05% to 0.09% nickel (by weight) shall be added to the galvanizing bath.

ASTM B695 Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

AASHTO M 111 –Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

AASHTO M 232 – Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

SUBSECTION M7.15.0 Metallized Coatings.
(page 379 English, page III.68 Metric) Add this new Subsection.

The wire used for metallizing shall be zinc or 85/15 zinc/aluminum per ASTM B833, Standard Specification for Zinc Wire for Thermal Spraying (Metallizing). All thermal spray wire must be manufactured domestically.

SUBSECTION M7.20.0 Anodized Coatings.
(page 379 English, page III.68 Metric) Add the following new Subsection:

Aluminum extrusions to be anodized shall be finished in a dark bronze Architectural Integral-Color Anodized finish conforming to Aluminum Association designation AA-M10-C22-A44. The anodic coating shall be Aluminum Association Architectural Class 1 with a minimum thickness of 0.7 mils and a minimum weight of 35 mg/in^2 (54.25 g/m^2).

Prior to production, the finisher shall submit surface smoothness samples and color range samples to the MHD Research and Materials Division for the Engineer's approval, to establish inspection limits of allowable surface smoothness and allowable color shade range.

Samples of anodized extrusions from production lots, as selected by the Engineer, shall be tested in accordance with ASTM B137, ASTM B244 and ASTM B136.

SUBSECTION M7.25.0 Powder Coatings.
(page 379 English, page III.68 Metric) Add the following new Subsection:

Aluminum to be powder coated shall be finished in a dark bronze powder coat finish to match the color of the anodized extrusions. The coating shall be a polyester-TGLC (triglycidyl isocyanurate) resin system conforming to the following:

PHYSICAL AND MECHANICAL PROPERTIES		
QUALITY	TEST	LIMITS
Abrasion	ASTM D4060 Taber Abraser CS-10, 1000 gram load, 1000 cylcles	100 mg maximum weight loss
Adhesion	ASTM D3359 Initial - 1000 hours -	 5A 5A
Gloss	ASTM D523 60°F - 600 hours 60°F - 1000 hours	 82% Retention 90% Retention(washed)
Hardness	ASTM D3363	2H - No Gouge
Impact	ASTM D2794, Direct	Pass 80 in-lb
Salt Spray Resistance	ASTM B117, ASTM D1654 1000 Hrs. unscribed - 400 Hrs. Scribed -	 Table 2 - 10 Table 1 - 10
Weather	ASTM G23 1000 hours, 18 minutes Waterspray, 102 minutes Light	No film failure
Color	Dark Bronze, to match color of anodized aluminum framework	n/a
Identify	Infrared Fingerprint	Match
Flexibility	180° bend with ½ inch diameter mandrel within 10 seconds	No breaks, flaking or cracks Tested with a - Q- panel with 2 mills or less of coating
Humidity	ASTM D2247, 1000 Hrs	No blister or film failure
Thickness	N/a	4 ± 1 mills
Mar Resistance	N/a	Good

SECTION M7.25.0 (continued)

Aluminum to be powder coated shall be bare and free of oil or any mill coating. The aluminum shall be caustic cleaned to standard near white. A chromic conversion coating shall be applied after caustic cleaning. The finish coating shall be applied immediately after chromic coating as an electrostatically charged dry powder, sprayed onto the grounded aluminum using an electrostatic spray gun. The coated aluminum shall be heated in accordance with the powder manufacturer's recommend procedure to provide a fully cured finish. The coating thickness after cure shall be a minimum of 3 mils.

Prior to production, the coater shall submit a 3 foot by 1 foot coated sample and color range samples to the MHD Materials Testing Laboratory for the Engineer's approval to establish inspection limits of allowable coating coverage and color shade range.

All stainless steel fasteners shall be colored by a thermal conversion process to match the dark bronze color of the aluminum extrusions. The finish shall be such that it does not peel, chip or crack. Samples of all fasteners shall be submitted along with material certificates to the Engineer for approval.

SECTION M8
METALS AND RELATED MATERIALS

SUBSECTION M8.00.0 General.

(page 380 English, page III.69 Metric) Replace this Subsection with the following:

All structural steel and miscellaneous steel products shall be welded in accordance with the requirements of the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5). All aluminum material shall be welded in accordance with the AWS Structural Welding Code - Aluminum (ANSI/AWS D1.2). All stainless steel material shall be welded in accordance with the AWS Structural Welding Code – Stainless Steel (ANSI/AWS D1.6). All steel tubular material shall be welded in accordance with the AWS Structural Welding Code - Steel (ANSI/AWS D1.1). All steel reinforcing shall be welded in accordance with the AWS Structural Welding Code – Reinforcing (ANSI/AWS D1.4).

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. Testing will be done in accordance with latest standard procedures of ASTM and/or AASHTO.

SUBSECTION M8.01.0 Reinforcing Bars.

(page 380 English, page III.69 Metric) Replace this Subsection with the following:

Reinforcing bars shall consist of deformed bars rolled from new billet steel conforming to the requirements of AASHTO M 31, Grade 60. Spiral reinforcement for columns shall be plain steel meeting the requirements of AASHTO M 31, Grade 60.

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.

SUBSECTION M8.01.1 Cold Drawn Steel Wire.
thru
SUBSECTION M8.03.2 Steel Castings.

(page III.69 thru III.70 Metric) Change the following wording in all locations:

Grade 400 to Grade 420
Grade 500 to Grade 520
400 MPa to 420 MPa
500 MPa to 520 MPa
AASHTO M 31, to AASHTO M 31M
AASHTO M 32 to AASHTO M 32M
AASHTO M 54 to AASHTO M 54M
AASHTO M 55 to AASHTO M 55M
AASHTO M 103 to AASHTO M 103M
AASHTO M 164 to ASTM A325
AASHTO M 183 to AASHTO M 183M
AASHTO M 270 to AASHTO M 270M
AASHTO M 284 to AASHTO M 284M

SUBSECTIONS M8.01.5 Anchor Bolts, Nuts and Washers.
(page 380 English, page III.70 Metric) Replace this Subsection with the following:

Bolts, nuts and washers used for anchoring bridge railing base plates to concrete shall be fabricated from steel conforming to the requirements of ASTM A449.

Bolts, nuts and washers use for anchoring bridge bearings to concrete shall conform to the requirements of ASTM F1554 Grade 105 (Grade 724 MPa).

Bolts, nuts and washers used for anchoring signal lighting and sign structures shall conform to the requirements of one of the following:

AASHTO M 31 Grade 60 / AASHTO M 31M Grade 420
AASHTO M 31 Grade 75 / AASHTO M 31M Grade 520
AASHTO M 314 Grade 36 (Grade 379 MPa)
AASHTO M 314 Grade 105 (Grade 248 MPa)
AASHTO M 314 Grade 55 (Grade 724 MPa)
ASTM F1554 Grade 105 (Grade 724 MPa)
ASTM F1554 Grade 55 (Grade 380 MPa)

Nuts and washers for the above shall be suited to the approved bolts.

High strength 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, with the exception of those with weathering characteristics, shall be galvanized in accordance with AASHTO M 232 or M 232M.

SUBSECTION M8.01.6 Anchor Rods (Prestressed Beams).
(page 381 English, page III.70 Metric) Delete the entire Subsection.

SUBSECTION M8.01.8 Galvanized Reinforcing Bars.
(page 381 English) Add this new Subsection.

Galvanized Reinforcing Bars shall be bars conforming to M8.01.0 and shall be galvanized in accordance with ASTM A767.

SUBSECTION M8.01.9 Mechanical Reinforcing Bar Splicer.
(page 381 English, page III.70 Metric) Add this new Subsection.

Mechanical reinforcing bar splicers are devices to join two steel reinforcing bars subject to tension, compression, fatigue, and/or cyclic loading. All mechanical reinforcing bar splicers shall meet the following requirements:

DESCRIPTION	REQUIREMENT
Ultimate Tensile Strength of Mechanical Coupler System (California Test No. 670)	90% of ultimate tensile strength of reinforcement bars (80,000 psi minimum for AASHTO M 31 Grade 60, 560 MPa minimum for AASHTO M 31M Grade 420). During testing, the ultimate failure of the spliced reinforcing bar system shall occur either in the reinforcing bar being joined or in the splicing device at a minimum of 150% of the yield strength of the reinforcing bar.
Allowable Slip (California Test No. 670)	0.01 inch, maximum for #14 and smaller bars, 0.03 inch maximum for #18 bars (0.25 mm, maximum for #43 and smaller bars, 0.76 mm maximum for #57 bars)
Yield Strength of Mechanical Coupler System	125% of yield strength of reinforcement bars, minimum

Mechanical reinforcing bar splicers shall be epoxy coated or shall be galvanized and shall be tested with epoxy coated or galvanized reinforcing steel as applicable. The mechanical splicer must be either epoxy coated or galvanized consistent with the reinforcement to be spliced. The final assembly shall be in conformance with the specifications for epoxy coating or galvanizing.

Mechanical reinforcing bar splicers which have been successfully tested and met all of the above requirements shall be placed on the *Qualified Construction Materials List*. Only products on the *Qualified Construction Materials List* maintained by the MassDOT Highway Research and Materials Section are acceptable for use.

The contract time will not be extended to allow for the testing and approval process required for inclusion on the *Qualified Construction Materials List*.

SUBSECTION M8.02.0 Drilled Steel rods.
(page 381English, page III.70 Metric) Replace "ANSI – W1" with "AISI – W1".

SUBSECTION M8.03.0 Iron Castings.
(*page 381 English, page III.70 Metric) Replace this Subsection with the following:*

Gray Iron Castings shall conform to the requirements of AASHTO M 105, Class 35B. Test bars shall conform to the requirements of tension test specimen B with a minimum of 1 in thread on each end. The thread size shall be 1 1/8 in – 7 UNC. Ductile Iron Casting for double grates shall conform to the requirements of ASTM A536 Grade 80-55-06. Test bars shall conform to the requirements of standard round tension specimen (2 in gage length) with a minimum of 1 in thread on each end. The thread size shall be 7/8 in -9 UNC.

All iron castings shall conform to the requirements of AASHTO M306 and shall be manufactured true to pattern in form and dimensions, free from pouring faults, cracks, bl**o**w holes and other defects 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.

SUBSECTION M8.03.2 Steel Castings.
(page 381 English, page III.70 Metric) Replace this Subsection with the following:

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 M 103, Grade 65-35, full anneal.

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.

Castings shall be shot blasted prior to painting. Painting shall consist of a coating system approved by the Department's Research and Materials Section.

SUBSECTION M8.04.1 Stud Shear Connectors.
*(page 381English) Under **1. General Requirements.**, Replace Subsection A with the following:*

A. Shear connector studs shall be of a design suitable for end welding to steel beams and girders with automatically timed stud welding equipment. Ferrules shall be kept clean and dry and stored at a temperature of 60ºF.

*(page 381 English, page III.71 Metric) Replace **1. General Requirements.**, Subsection E. with the following:*

E. All studs shall be qualified by AASHTO/AWS D1.5 of the Bridge Welding Code.

*(page 382 English) Replace the heading **Material Requirements.** with **2. Material Requirements.**. and delete the alphabetical paragraph headers for this section. Under the first paragraph of **2. Material Requirements.**, change "ASTM A108" to "AASHTO M 169", and delete the last sentence. Delete former paragraph B.*

*(page III.71 Metric) Replace the heading **Material Requirements.** with **2. Material Requirements.**. and delete the alphabetical paragraph headers for this section. Under the first paragraph of **2. Material Requirements.**, change AASHTO M 169 to read AASHTO M 169M, change "wither semi-skilled" to "either semi-skilled" and delete the last sentence. Delete former paragraph B.*

*(page 382 English, page III.72 Metric) Delete entire section titled **3. Shear Connector Stud Weldability Qualification Procedure.***

SUBSECTION M8.04.2 Steel Pins.
(page 383 English) Replace this Subsection with the following:

Pins more than 9 inches in diameter shall be manufactured from carbon steel conforming to AASHTO M 102, Classes B, C and D. Pins 9 inches or less in diameter shall conform to AASHTO M 102, Classes B, C and D, or AASHTO M 169, Grades 1016 thru 1030 inclusive.

SUBSECTION M8.04.3 High Tensile Strength Bolts.
(page 383 English, page III.73 Metric) Replace this Subsection with the following:

M8.04.3 High Strength Bolts.

Bolts, nuts and washers shall conform to the appropriate material specification ASTM A325, AASHTO M 291M (M 291), M 292M/M 292 and M 293M (M 293) as amended herein.

Material.

Hardness for bolts with diameter ½ to 1 inch (13 to 25 mm) inclusive shall be Brinell HB-minimum of 248; HB-maximum of 311 or Rockwell HRC-minimum of 24; HRC-maximum of 33.

Plain (un-galvanized) nuts shall be grades 2, C, D or C3 with a minimum Rockwell hardness of 89 HRB (or Brinell hardness 180 HB) or heat treated grades 2H, DH or DH3. Galvanized nuts shall be heat treated grades 2H or DH.

For galvanized fasteners, the nuts shall be tapped oversize, the minimum amount required for the fastener assembly. The amount of overtap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the mechanical requirements of AASHTO M291 (M291M), and the rotational-capacity tests herein. Galvanized nuts shall be lubricated with a lubricant containing a dye of any color that contrasts with the color of the galvanizing. Black fasteners must be "oily" to the touch when installed. Weathered or rusted fasteners shall be cleaned and re-lubricated prior to installation.

Testing.

The tests need not be witnessed by a representative of the Department; however, the manufacturer or distributor that performs the tests shall certify that the results recorded are accurate. Documentation shall be in accordance with Subsection 960.61.

Bolts.

Proof load tests in accordance with ASTM F606 Method 1 are required. The minimum frequency of the tests shall be as specified in ASTM A325.

Wedge tests on full size bolts (ASTM F606) are required. If the bolts are to be galvanized, the tests shall be performed after galvanizing. Minimum frequency of the tests shall be as specified in ASTM A325.

If galvanized bolts are supplied, the thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats or the top of the bolt head.

Nuts.

Proof load tests (ASTM F606) are required. Minimum frequency of tests shall be as specified in AASHTO M 291 or AASHTO M 292. If nuts are to be galvanized, the tests shall be performed after galvanizing, overtapping and lubricating.

If galvanized nuts are supplied, the thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats.

Washers.

If galvanized washers are supplied, hardness testing shall be performed after galvanizing. (Coating shall be removed prior to taking hardness measurements.) The thickness of the zinc coating shall be measured.

Assemblies.

Rotational-capacity tests are required and shall be performed on all black or galvanized (after galvanizing) bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Washers are required as part of the test even though they may not be required as part of the installation. The rotational capacity test is intended to evaluate the presence of a lubricant, the efficiency of the lubricant and the compatibility of assemblies as represented by the components selected for testing.

This test shall be performed in accordance with the requirements of ASTM A325 except as modified herein:

1. Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly.
2. A rotational-capacity lot number shall be assigned to each combination of lots tested.

SUBSECTION M8.04.3 (continued)

3. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.
4. The bolt, nut and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For bolts that are too short to be assembled in a Skidmore, a steel joint shall be used.
5. There is a different method for testing short bolts. Bolts are considered short when, after placing in the Skidmore, there is not a sufficient number of threads protruding to fully engage the nut.

Test Methods - Normal Length and Long Bolts

1. Install the bolt assembly in the Skidmore Calibrator making sure that 3 to 5 threads of the bolt are located between the bearing face of the nut and the underside of the bolt head. Spacers and/or washers with holes not exceeding 1/16 inch (2 mm) greater than the bolt diameter may be used to achieve the 3 to 5 thread requirement. Tighten the bolt to the snug tight condition. The snug tight tensions are listed below. (-0 kN, +9 kN (-0 kips, +2 kips)).

Bolt Diameter, millimeters	13	16	19	22	25	29	32	35	38
Snug Tension, kN	5	9	14	18	23	27	31	40	45

Bolt Diameter, inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Snug Tension, kips	1	2	3	4	5	6	7	9	10

2. After the snug tight condition is reached, further tighten the bolts to the following minimum rotation:
   240° (2/3 turn) for bolt lengths ≤ 4 diameters
   360° (1 turn) for bolt lengths > 4 diameters and ≤ 8 diameters
   480° (1 1/3 turn) for bolt lengths > 8 diameters
3. The tension reached at the above rotation shall be equal to or greater than the turn test tension shown below.

Bolt Diameter, millimeters	13	16	19	22	25	29	32	35	38
Turn Test Tension, kN	62	98	142	200	262	285	365	436	525

Bolt Diameter, inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Turn Test Tension, kips	14	22	32	45	59	64	82	98	118

4. After the turn test tension requirement has been met, one reading of tension and torque shall be taken and recorded. Using a calibrated manual torque wrench, record the torque. For proper torque readings, the nut must be in motion. The measured bolt tension can be read off the Skidmore. The torque value shall conform to the following:

Torque ≤ 0.25 PD where: Torque = measured torque (Newton meter (foot-pounds))
P = measured bolt tension (Newton (pounds))
D = bolt diameter (meter (feet))

5. Loosen and remove nut and examine the threads on the nut and the bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt shall be evident.

Test Methods - Short Bolts

Procedure for performing rotational capacity test on bolts too short to fit in a tension calibrator is as follows:

Equipment Required.

1. Calibrated torque wrench and a spud wrench.
2. Spacers and/or washers with hole size no larger than 1/16 inch (2 mm) greater than bolt to be tested.
3. Steel section with normal size hole to install bolt. Any available splice hole can be used with a plate thickness that will provide the number of threads under the nut required in step 1 below. Mark off a vertical line and lines 1/3 of turn, 120 degrees; ½ of a turn, 180 degrees; and 2/3 of a turn 240 degrees, from vertical in a clockwise direction on the plate.

SUBSECTION M8.04.3 (continued)

Procedure

1. Install nut on bolt and measure stick out of bolt when 3 to 5 full threads of the bolt are located between the bearing face of the nut and bolt head. Measure the bolt length, the distance from the end of the threaded shank to the underside of the bolt head.
2. Install the bolt into the hole and install the required number of shim plates and/ or washer (one washer under the nut must always be used) to produce the thread stickout measured in step 1.
3. Snug the bolt using a hand wrench. The snug tight tensions are listed under No. 1 of Test Methods – Normal Length and Long Bolts.
4. Match mark the nut to the vertical stripe on the plate.
5. Tighten the bolt by turning the nut using the torque wrench to the rotation listed below. A second wrench must be used to prevent rotation of the bolt head during tightening. Record the torque required to reach this rotation. Torque must be measured with the nut in motion.

Bolt Length as measured in step 1	4 bolt diameters or less	Greater than 4, but not more than 8 bolt diameters	Greater than 8 bolt diameters
Required Rotation	1/3 of a Revolution	½ of a Revolution	2/3 of a Revolution

The measured torque should not exceed the values listed below. Assemblies which exceed the listed torque have failed the test.

Bolt Diameter, mm	13	16	19	22	25	29	32	35	38
Torque, Newton-meters	200	390	680	1110	1670	2030	2900	3810	5000

Bolt Diameter, inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 ½
Torque, foot-pounds	150	290	500	820	1230	1500	2140	2810	3690

6. Tighten the bolt further to the rotation listed below. The rotation is measured from the initial marking in step 4. Assemblies that fail prior to this rotation either by stripping or fracture fail the test.

Bolt Length as measured in step 1	4 bolt diameters or less	Greater than 4, but not more than 8 bolt diameters	Greater than 8 bolt diameters
Required Rotation	2/3 of a Revolution	1 Revolution	1 1/3 Revolutions

7. Loosen and remove nut and examine the threads on the nut and the bolt. No signs of thread shear failure, stripping, or torsional failure of the bolt should be evident. Assemblies which have evidence of stripping have failed the test.

SUBSECTION M8.05.0 Structural Steel.

(page 383 English, page III.74 Metric) Replace this Subsection with the following:

All structural steel shall conform to the requirements of AASHTO M 270 Grades 36, 50, or 50W or 70HPS.

Orientation of the test bars for the Charpy V-Notch (CVN) test specimens shall be longitudinal to the direction of final rolling. The "H" frequency of testing shall be used. CVN impact testing temperatures shall be in accordance with those specified for Zone 2. CVN tests are required for main members only. Secondary members typically including stiffeners and diaphragms do not require CVN tests.

All welding shall comply with the provisions of the AASHTO/AWS Bridge Welding Code (ANSI/AASHTO/AWS D1.5).

SUBSECTION M8.05.1 Steel Piles.
(page 384 English, page III.74 Metric) Replace this Subsection with the following:

M8.05.1 Steel H-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 M 270 Grade 36 (Grade 250 MPa). Copper bearing steel will not be required.

SUBSECTION M8.05.2 Steel Shells, Cast-in-Place Piles.
(page 384 English, page III.74 Metric) Delete the entire Subsection.

SUBSECTION M8.05.3 Steel Baffles and Drainage Troughs.
(page 384 English, page III.74 Metric) Replace this Subsection with the following:

Steel used for the manufacture of baffles and drainage troughs shall conform to the requirements of AASHTO M 270 Grade 50W (Grade 345W) with the additional requirement that the steel shall exhibit a corrosion resistance at least 4 times that of AASHTO M 270 Grade 36 (Grade 250) Steel.

SUBSECTION M8.05.5 Steel Pipe Piles.
(page 384 English, page III.75 Metric) Replace this Subsection with the following:

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 those Specifications shall govern.

Pipe having seams of spiral-lap welded construction will not be permitted under this specification. Pipes having spiral welded butt joint construction will not be permitted except where the pipe is concrete filled.

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 4000 psi, ¾ inch, 610 lbs (30 MPa - 20 mm - 390 kg) 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 tension.

The bottom end of the pipe shall be beveled in accordance with ASTM A252 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.

SUBSECTION M8.05.6 Precast-Prestressed Piles.
SUBSECTION M8.05.7 Pressure Injected Footing Piles.
(page 385 English, page III.75 Metric) Replace these Subsections with the following:

M8.05.6 Steel Casing.

This specification covers cylindrical steel casings of uniform cross section and diameter throughout its length in which the cylindrical casing acts as either a temporary or permanent load-carrying member.

Permanent steel casings shall conform to the requirements of ASTM A252. Temporary casings shall be of a grade selected by the Contractor. Temporary casings that are used and are in good condition without strength impairing defects are acceptable for use as temporary casings. Permanent casings shall not have been previously used. Temporary casings that are left in place and connected to permanent casings shall meet the requirements of permanent casings.

Casings having seams of spiral-lap welded construction will not be permitted for use as permanent steel casings.

The outside diameter and wall thickness of the permanent steel casings shall be as shown on the plans. When permanent casings are used to carry part of the design load, all joints shall have full-penetration welds. All welds shall be inspected using ultrasonic testing. Any attachment between permanent and temporary casings shall be welded with full penetration welds using an approved backing ring, which shall develop the full strength of the casings in compression and tension.

Temporary casings shall be the responsibility of the Contractor and shall be of sufficient strength to resist the handling, transportation, installation, and external stresses of the subsurface materials.

M8.05.7 Steel Extrusions.

Material utilized to produce steel extrusions suitable to mechanically lock elastomeric strip seals shall conform to properties of AASHTO M 270 Grade 36 or Grade 50 (ASTM A709 Grade 36 or Grade 50) and shall be hot dipped galvanized after attachment of anchorage devices. Steel extrusions shall have a minimum thickness of ¼ inch (6 mm) as measured from the internal locking mechanism cavity to the top surface of the steel extrusion shape and shall be capable of resisting HS-25 wheel loading. Steel shapes shall be monolithic with the extrusion cavity.

SUBSECTION M8.07.0 Steel Beam Highway Guard.
(page 385 English, page III.75 Metric) Replace the subsection with the following;

M8.07.0 Guardrail

The materials for this work shall conform to AASHTO M180 and the following requirements:

The manufacturer of guardrail and guardrail components shall have an audit certificate indicating compliance with the NTPEP Guardrail Technical Committee Project Work Plan.

All steel components and hardware shall be galvanized. All metal fabrication work shall be done in the shop. No punching, cutting or welding shall be done in the field. 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 coats of paint, high zinc dust content, conforming to the requirements of M7.04.11.

A. Posts.
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.

Posts shall conform to the requirements of ASTM A36. Galvanizing shall meet the requirements of M7.10.0.

Wood Posts.

The posts shall be rough sawn (unplaned) with nominal dimensions as indicated on the plans and with tolerances of 1 inch in length and 1/4 inch in width and thickness. All holes in the posts shall be drilled prior to pressure application of the preservative at a wood preserving facility.

The stress grade shall be 1000 psi or more in extreme fiber bending. Grading for stress-graded timber shall be in accordance with AASHTO M168.

Prior to treatment, all posts shall be seasoned, conditioned and completely machined in accordance with AWPA M1.

Posts shall be treated with chromated copper arsenate, type C (CCA-C) conforming to AWPA P23, to a minimum retention of 0.60 pcf (9.6 kg/m3). Treatment shall be full length under pressure by the empty-cell or full-cell process in accordance with AWPA U1.

Manufacturers shall adhere to the processing and treatment limitations in AWPA T1. No unnecessary cutting of treated posts will be allowed after treatment. All posts with surfaces damaged by cutting, drilling or any other cause shall be field treated with a preservative solution in accordance with AWPA M4.

Certificates of compliance and certificates of inspection bearing the independent inspection agency's verification for each lot of wood must be presented before installation and contain the species of wood, the type of preservative, the retention rate and penetration of the preservative.

The certificates of inspection and compliance do not signify mandatory acceptance of the entire lot. The Department still has the option of rejecting posts (included in any particular lot) that the Engineer considers sub-standard because of unsound knots and shakes, excessive checking or other defects that may be detrimental to the structural integrity of the posts.

The fabricator shall retain an independent inspection agency to inspect and certify the treated posts in accordance with these specifications and AWPA M2, Part A.

All treated posts shall be marked in accordance with AWPA U1 (and M6 as required). (The mark is to include the identifying lot and/or charge number). The post shall also be stamped with the Inspector's identification. The mark is to be placed on the upper side head 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 M2 and the above.

B. Offset Blocks.

The blocks shall be of the same type throughout the project. Requirements for specific material types are as follows;

Wood Offset Blocks - Wood offset blocks shall meet the requirements of B. Posts, Wood Posts. above. When wood offset blocks are used on wood posts, they shall be the same species as the posts.

Plastic Offset Blocks - Plastic offset blocks shall meet all applicable performance requirements of MASH and be listed on the Qualified Traffic Control Equipment list. Each block shall be stamped at the factory with the manufacturer's identification and lot number and conform to the dimensions shown on the plans.

Prior to approval and use of the plastic guardrail offset blocks, the manufacturer shall submit to the Engineer, the manufacturers name, the product brand name and/or model number, a copy of the MASH test results, a Material Safety Data Sheet, and a sample block. Acceptance of the material will be based on the manufacturer's certification.

C. Rail Element and Terminal Sections.

The steel rail element, transition panels, terminal sections and connecting hardware shall conform to AASHTO M 180, Type II, Class A with the following additions:

The length of the rail shall be according to the plans.

Each end of the steel rail for every stretch of guard shall be fitted with a terminal section as shown on the plans.

The projecting heads of all connection and splice bolts shall be button head type so no appreciable projection will obstruct a vehicle sliding along the rail. Steel rail elements with a radius of 150 feet or less shall be shop bent.

The manufacturers are required to submit a Brand Registration and Guarantee document annually to MassDOT Research and Materials Section (RMS) showing compliance of the Guardrail Components with AASHTO M 180 Specification.

SUBSECTION M8.07.1 Steel Beam Highway Guard End Treatments.
(page 387 English, page III.77 Metric) Replace this subsection with the following;

M8.07.1 Guardrail End Treatment.

The same type of tangent end or flared end treatment shall be used throughout the project.

All steel components and hardware shall conform to Section M8.07.0. All metal work shall be done in the shop.

The approach end shall have Type 3 Object Marker sheeting that conforms to the requirements of Section 2C.65 of the MUTCD. The sheeting material shall meet the requirements of M9.30.0, Type VIII (High Intensity Prismatic) or better.

SUBSECTION M8.09.0 Chain Link Fences and Gates.
(page 387 English, page III.77 Metric) Replace this Subsection with the following:

Materials for this work shall conform to the following requirements:

A. General.

All material used shall conform to AASHTO M 181 except as noted herein. The fence fabric shall be Type II - Aluminum Coated Steel or Type IV -- Polyvinyl Chloride (PVC) - Coated Steel. All tubular posts and rails, and roll-formed "C" section posts and rails shall be zinc coated steel. All wire shall have a diameter tolerance of ± 0.005 inches diameter. For chain link fabric used on bridge protective screens Type I and II see M8.13.3. Spring tension wire shall be aluminum coated steel. Aluminum coated fence fabric and spring tension wire shall be tested in accordance with AASHTO T 213. All zinc coated posts, hardware, and fittings shall be in conformance with AASHTO M 232. Polyvinyl Chloride (PVC) coated steel fence fabric, posts, rails, gates and accessories shall conform to M8.09.1. Post caps, rail end and other fittings and appurtenances shall be pressed steel or malleable iron. All materials shall be new and undamaged when installed. Imperfectly coated materials will be rejected.

B. Posts.

Steel round pipe posts and "C" sections shall have a tolerance of ±10% from specified weight and ±5% from specified dimensions.

Type B round pipe shall conform to AASHTO A 1011. Roll-formed "C" section shall conform to ASTM F1043.

Galvanized steel Line, End, Corner and Intermediate Posts shall conform to the sizes in the following table:

Post Dimensions		
Post Type	Under 5 Feet in Height	5 Feet and Over in Height
Line Post	1) Round Pipe - 1.90" O.D. Type B @ 2.29 lb./f t, or 2) "C" section - 1.875 x 1.625 inches @ 2.28 lb./ft	1) Round Pipe - 2.375" O.D. Type B @ 3.117 lb./ft, or 2) "C" section - 2.25 x 1.70 inches @ 2.64 lb./ft
End Post and Corner Post	1) Round Pipe - 2.375" O.D. Type B @ 3.117 lb./ft	1) Round Pipe - 2.875" O.D. Type B @ 4.64 lb./ft
Intermediate Brace Posts	1) Round Pipe - 2.375" O.D. Type B @ 3.117 lb./ft, or 2) "C" section - 2.25 x 1.70 inches @ 2.64 lb./ft	1) Round Pipe - 2.875" O.D. Type B @ 4.64 lb./ft

Gate posts shall be 4 inch O.D. pipe, Type B with a weight of 6.56 pounds per foot.

The galvanizing for "C" sections shall not be less than 2.0 oz. per square foot of metal surface as per AASHTO M 232. For Type B round pipe the external coating shall be 0.9 oz. of galvanizing per square foot minimum, 15 micrograms of chromate per square inch minimum, plus 0.3 mils minimum of clear cross-linked polyurethane acrylic coating. The internal surface shall be coated with zinc-rich based organic coating containing not less than 87% zinc powder and capable of providing galvanic protection. All round 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 and Spring Tension Wire.

1) Rail shall have a tolerance of ±10% from specified weight and ± 5% from specified dimensions. Steel top rails shall be Type B 1.66 inch O.D. tubular pipe with a weight of 1.83 pounds per foot, or 1.625 x 1.25 inch roll-formed "C" section with a weight of 1.40 pounds per foot.
The protective coating for top rails shall meet the requirements of paragraph B above.
Couplings or expansion sleeves shall be outside sleeve type and at least six inches long.

2) Spring tension wire shall be coil spring steel 7 gage (0.177 inch). The base metal shall have a minimum breaking strength of 1,950 pounds coated with aluminum applied at a rate of not less than 0.40 ounces per square 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 5/16 inch minimum round rods with drop forged turnbuckles, or other approved type of adjustments.

E. Fence Fabric.

The fabric shall consist of 9 gage (0.148 inch) wire having a minimum breaking strength of 1,290 lb coated with aluminum applied at the rate of not less than 0.40 ounces per square foot of uncoated wire surface. It shall be woven into approximately 2 inch diamond mesh. The width of the fabric shall be specified or shown on current standard drawings. Fabric for chain link fence less than 6 feet in height shall be finished at top and bottom with a "knuckled" selvage. All other fence sizes shall have a knuckled selvage at the bottom and twisted selvage at the top. Barbing shall be done by cutting the wire on the bias.

F. Bands and Stretcher Bars.

All bands shall be a minimum of 12 gage (0.106 inch) and at least 3/4 inch in width. Tension or stretcher bars shall be no less than 3/16 x 3/4 inch stock. Galvanizing shall conform to the requirements of AASHTO M 232.

G. Tie Wire and Hog Rings.

Aluminum tie wire shall be a minimum of 6 gage (0.192 inch) round wire Alloy 1350-H19 or equal. Aluminum hog rings shall be a minimum of 11 gage (0.120 inch) round wire Alloy 1350-H19 or equal.

H. Barbed Wire.

Barbed wire shall consist of two strands of 0.0985 inch diameter wire with 0.08 inch diameter 4 point barbs approximately 5 inches apart, shall be aluminum coated and conform to the requirements of AASHTO M 305.

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 inches 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 galvanized 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 inch O.D. pipe galvanized steel conforming to Section C of this specification.

Single gate frames over 6 feet wide shall be 1.90 inch O.D. galvanized steel pipe conforming to Section B of this specification.

Cross trussing shall be 5/16 inch galvanized iron adjustable rods.

Chain link fence fabric for filling the gage frame shall conform to Section E of this specification.

SUBSECTION M8.09.0 (continued)

Each gate shall be furnished complete with necessary hinges, latch and drop bar locking device designed for the type of gate post 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 galvanized steel angle iron or extruded aluminum alloy 6061-T6. Minimum dimensions shall be 1¼ x 1¼ x 1/8 inches. The weight of zinc for galvanized components shall be 1.5 oz. per square foot of metal surface.

Shoes for drive anchors shall be galvanized cast or malleable steel, or extruded aluminum alloy 6061-T6. The weight of zinc for galvanized components shall be 2.0 ounces per square foot of metal surface.

SUBSECTION M8.09.1 Woven Wire Fence.

(page 389 English, page III.77 Metric) Replace this Subsection with the following:

M8.09.1 Bonded Vinyl Coated Chain Link Fences, Posts, Rails, Fabric, Gates and Accessories.

The fence shall have a bonded polyvinyl chloride (PVC) coating over aluminum coated or galvanized steel. All material used shall conform to AASHTO M 181. Polyvinyl chloride coated by dipping, thermal fusion or any other method that meets the requirements of this specification.

The fence fabric shall be PVC coated wire that is woven into a 2 inch (50 mm) diamond mesh. The coating shall not crack, craze, or peel. The color of the PVC coated fabric and accessories shall be medium green as defined in AASHTO M 181.

All materials shall have dimensions and weights as specified in M8.09.0 except as follow:

Spring Tension Wire .....9 gage.
Ties .....Aluminum 10 gage
Hog Rings .....Aluminum 11 gage

The bonded PVC coating shall be a minimum of 0.007 inches 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.

SUBSECTION M8.09.2 Bonded Vinyl Coated Chain Link Fences, Posts, Rails, Fabric, Gates and Accessories.

(page 390 English) Delete this Subsection:

SUBSECTION M8.10.0 Steel Pipe Rail or Fence.

(page 390 English, page III.78 Metric) Add the following sentence to the end of the paragraph under A. Rails and Posts.

For rails and posts, a tolerance of ±10% from the specified weight and ±5% from the specified dimension is allowed.

(page 390 English) Replace ASTM A153 with AASHTO M 232 in the last sentence of the paragraph under B. Fittings.

SUBSECTION M8.10.1 Aluminum Pipe Rail or Fence.

(page 390 English, page III.78 Metric) Replace the first sentence with the following.

Materials for this work shall conform to ASTM F1183 with 2 inch (50 mm) diamond mesh and the following requirements:

SUBSECTION M8.13.1 Bridge Railing, Steel, Types ST-1 & ST-3.
(page 392 English, page III.80 Metric) Replace this Subsection with the following:

M8.13.1 Bridge Railing, Steel, Type S3-TL4.

All steel shall be new and fabrication shall conform to Section 960.61. The fabricator shall be approved by the Department in compliance with the requirements of Section 960.61A.

Posts and base plates shall conform to the requirements of AASHTO M 270 Grade 50. CVN tests are required.

Rails shall be made from hollow structural tubing and shall conform to the requirements of ASTM A500 Grade B or C with a minimum yield (F_y) of 50 ksi. CVN tests are required.

Anchor plates and splice tube plates shall conform to AASHTO M 270 Grade 36. CVN tests are not required.

Picket tubes shall conform to the requirements of ASTM A513 with a certified yield (F_y) of 36 ksi or ASTM A500 Grade B. CVN tests are not required.

Carrier angles shall conform to the requirements of AASHTO M 270 Grade 36. CVN tests are not required.

Round headed bolts shall conform to the chemical and physical requirements of ASTM A325. Rotational capacity tests are not required.

High strength bolts shall conform to Section M8.04.3.

Anchor bolts shall conform to the requirements of Section M8.01.5 of these Specifications.

Molded fabric bearing pad shall conform to M9.16.2.

Screws shall be hardened countersunk machine screws.

SUBSECTION M8.13.2 Metal Bin-Type Retaining Wall.
(page 392 English, page III.81 Metric) Delete the word "spelter" from the second sentence of the first paragraph.

SUBSECTION M8.13.3 Aluminum Handrail and Protective Screen Type I and Type II.
(page 392 English, page III.81 Metric) Add the following new Subsection:

M8.13.3 Aluminum Handrail and Protective Screen Type I and Type II.

Material used in the fabrication of Handrail and Protective Screen Type I and Type II shall conform to the following requirements (see Section 975 for anodizing and powder coating requirements):

A. All materials shall be new and free of oil, mill coating, and other materials. All castings shall be sound, free from blowholes or other imperfections, and shall have smooth surfaces.
B. Aluminum extrusions and plates shall conform to ASTM B221, Alloy 6061-T6.
C. Chain link fabric shall conform to AASHTO M 181 Type III (aluminum alloy 6061-T89 or T94). Prior to bending and coating, the wire shall meet the minimum tensile strength of 54 ksi (370 MPa) as specified in AASHTO M 181. After fabrication and coating, the minimum tensile strength of the wire shall be 43 ksi (300 MPa).
D. Protective Screen Type II self-tapping screws shall be tempered 410 stainless steel with a hardness of 32 to 35 HRC.
E. Anchor bolts and washers shall conform to ASTM A325. No rotation-capacity testing shall be required. The bolts and washers shall be galvanized in accordance with AASHTO M 232. The anchor cage shall be galvanized in accordance with AASHTO M 111 or shall be electroplated with zinc in accordance with ASTM B633, Service Condition 1, Type III.
F. Tee Bolts shall conform to ASTM A307 and shall be galvanized in accordance with AASHTO M 232. Type 304 stainless steel Tee Bolts may be substituted for the galvanized A307 Tee Bolts.
G. All other fasteners, nuts and washers shall be as called for on the drawings.
H. Protective Screen Type I posts, rails, bars, splices and clamps shall conform to ASTM B211, Alloy 6061-T6.

SUBSECTION M8.16.8 Type 8 Direct Burial Wire (USE).
(page 393 English) Change Type 8 to Type 7.

SUBSECTION M.8.18.0 Signal Posts.
SUBSECTION M.8.18.1 Octagonal Bases.
SUBSECTION M.8.18.2 Pedestal Bases.
SUBSECTION M.8.18.3 Aluminum Signal Posts and Bases.
SUBSECTION M.8.18.4 Mast Arms.
SUBSECTION M.8.18.5 Steel Supports.
SUBSECTION M8.18.6 Aluminum Supports.
(pages 394 to 396 English, page III.83 toIII.85 Metric) Replace these Subsections with the following:

M8.18.0 Traffic Signal, Highway Lighting and Sign Supports.

This section covers the poles, posts, masts, arms and bases for traffic signals, highway lighting and sign supports.

M8.18.1 Traffic Signal Supports.

POSTS

Steel signal posts shall be 4 inch diameter Schedule 40 seamless pipe conforming to ASTM A53, 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.

Aluminum signal posts shall be 4 inch diameter Schedule 40 pipe conforming to aluminum alloy 6063-T6 (ASTM B221, B429 or B241).

POLES AND MAST ARMS

Structures shall be made of steel. Structural steel material over ½ inch thick that is part of main load carrying tension members shall meet the Charpy V Notch impact requirements of 15 ft-lbs at 40º F.

Tapered shafts shall conform to ASTM A595, Grade A, or AASHTO M270 Grade 50.

The arms shall conform to ASTM A595, Grade A; or ASTM A1011/A1011M, or ASTM A500 Grade B. Steel shall have a minimum yield of 50 ksi.

The shaft cap shall conform to ASTM A126, Class A.

All hardware shall be stainless steel or ASTM A325, fully galvanized.

Baseplates and all other standard structural shapes shall conform to AASHTO M 270 Grades 36 or 50.

Anchor bolt covers shall meet the requirements of ASTM A181/A181M or ASTM A126, Class A or AASHTO M 103M/M 103, Grade 450-240 (Grade 65-35) or ASTM A36/A36M.

Galvanizing shall be in accordance with Section M7.

BASES

Bases shall be the same materials as the poles.

Octagonal bases are for use with posts and shall be cast iron conforming to AASHTO M 105 or cast aluminum alloy conforming to Aluminum Association No. 356.0 T-6 (ASTM B26, B108).

Pedestal bases are for use with posts and poles and shall be made of not less than No. 10 gage steel and galvanized in accordance with Section M7 or cast aluminum alloy conforming to Aluminum Association No. 356.0 T-6 (ASTM B26, B108).

M8.18.2 Highway Lighting Poles and Arms.

Aluminum

Tapered aluminum poles shall conform to ASTM B221, alloy 6063-T6 or 6061-T6. Structural aluminum shapes shall conform to ASTM B308, alloy 6061-T6. Bases shall conform to ASTM B108, alloy 356.0-T6.

Steel

Structural steel material over ½ inch thick that is part of main load carrying tension members shall meet the Charpy V Notch impact requirements of 15 ft-lbs at 40º F.

Tapered components shall be fabricated from steel conforming to ASTM A595, Grade A; or ASTM A1011M, Grade 55; or AASHTO M 270, Grade 50.

SUBSECTION M8.18 (continued)

Gussets, flanges, baseplates, wing plates, connecting end plates, and all other standard structural shapes shall conform to AASHTO M 270 Grades 36 or 50.

Anchor Bolts

Anchor bolts shall conform to Subsection M8.01.5 and be fully galvanized in accordance Subsection M7.

M8.18.3 Sign Supports

Structural steel material over ½ inch thick that is part of main load carrying tension members shall meet the Charpy V Notch impact requirements of 15 ft-lbs at 40º F.

Supports shall be fabricated from steel conforming to ASTM A595, Grade A; ASTM A1011M, Grade 55; AASHTO M 270, Grade 50; ASTM A500, Grade B; or API-5LX-52.

Gussets, flanges, baseplates, wing plates, connecting end plates, and all other standard structural shapes shall conform to AASHTO M 270 Grades 36 or 50.

Truss and cantilever beam connections shall be furnished with the necessary beam support clamps. The ends of beams shall have a mounting clevis and closure plate fabricated from steel plate as an assembly.

All structural steel and steel hardware shall be galvanized in accordance with Section M7. Anchor bolts, nuts, and washers shall conform to Subsection M8.01.5 and be fully galvanized in accordance with Subsection M7.

Sign Posts – P5.

Square Tube Posts.

Square tube posts shall be square tube fabricated from 12 gage hot-rolled carbon steel conforming to the requirements of ASTM A1011, Grade 50.

Galvanizing shall be in accordance with ASTM A653, Coating Designation G140 with a minimum coating of 1.4 ounces per square foot total of zinc on both sides under triple spot tests; or a minimum coating of 1.15 ounces per square foot total of zinc on both sides under triple spot tests and after all fabrication and re-galvanizing the posts shall be coated with a chromate conversion coating and sealed with an air-dried clear organic polymer topcoat.

Posts shall be welded directly in the corner by high frequency resistance welding or equal and externally scarfed to agree with standard corner radius of 5/32 inch ± 1/64 inch. The corner weld and holes shall be zinc coated after scarfing operations. Holes shall be 7/16 inch in diameter and shall be placed 1 inch on center.

U Channel Posts.

U-channel posts shall be fabricated from re-rolled rail steel or an equivalent steel and shall conform to the mechanical requirements of ASTM A499, Grade 60 and the mechanical requirements of ASTM A1. All steel U-channel posts shall weigh at least 4 pounds per foot and be entirely galvanized in accordance with Section M7. Holes shall be 7/16 inch in diameter spaced at 1 inch on center and be punched prior to the galvanizing of the posts.

All bolts, nuts and washers shall conform to the requirements of ASTM A307, Grade A. Bolts, nuts and washers shall be galvanized in accordance with the requirements of Section M7.

Steel posts, sign post anchors, anchor sleeves, slipbases, lap splices, and any related hardware shall all be from the same manufacturer. No mixing of brands shall be allowed.

SUBSECTION M8.19.0 Steel Sign Panels.

(page 396 English) Delete this Subsection:

SUBSECTION M8.20.3 Modular Guidance Systems.

(page 396 English, page III.85 Metric 65) Delete this subsection.

SUBSECTION M8.21.0 Stay-in-Place Bridge Deck Forms.
(page 397 English, page III.85 Metric) Replace this Subsection with the following:

Stay-in-Place Bridge Deck Forms and supports shall be fabricated from steel conforming to ASTM A653 (Grades 33, 37, 40, 50 Class 1 and 2, and 80 English and Grades 230, 255, 275, 340 Class 1 and 2, and 550 Metric) having a coating class of G165 according to ASTM A924.

SUBSECTION M8.22.0 Cross Hole Sonic Testing Access Pipes.
(page 397 English, page III.85 Metric) Add this new Subsection:

Steel pipe for cross hole sonic testing access pipes shall be Schedule 40 and shall conform to ASTM A53, Grade B.

SECTION M9
MISCELLANEOUS MATERIALS

SUBSECTION M9.04.4 Field Stone Masonry.
(page 400 English, page III.89 Metric) Replace this Subsection with the following:

M9.04.4 Stone for Stone Masonry Walls.

Stone for stone masonry walls 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 consist of angular blasted or field stones having 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 (200 mm). Stretchers shall have a depth in the wall at least 1½ 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 (300 mm) more than the stretchers into the backing.

SUBSECTION M9.05.01 Treated Timber.
(page 401 English, page III.90 Metric) Replace the existing Subsection with the following:

M9.05.1 Wood Products.

Timber shall conform to the requirements of AASHTO M 168, Wood Products, Structural Timber, Lumber, and Piling.

Preservative treatment shall meet the requirements of M9.05.5.

SUBSECTION M9.05.02 Wood Posts and Braces.
SUBSECTION M9.05.03 Wooden Rails and Posts.
SUBSECTION M9.05.04 Wooden Pegs.
(page 401 English, page III.90 Metric) Delete these Subsections.

SUBSECTION M9.05.05 Timber Preservatives.
(page 402 English, page III.91 Metric) Replace the existing Subsection with the following:

M9.05.5 Wood Preservatives.

Preservative treatment shall meet the requirements of AASHTO M133 and AWPA U1, except that only preservative materials meeting current EPA or DEP regulations will be allowed.

Certificates of compliance and certificates of inspection bearing the independent inspection agencies verification for each lot of wood must be presented before installation and contain the species of wood, the type of preservative, the retention rate and penetration of the preservative.

SUBSECTION M9.05.06 Timber Piles.
(page 402 English, page III.91 Metric) Under A. General Requirements., replace the second paragraph with the following:

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 95% of the inner bark well distributed over the outer surface of the pile shall be removed.

(page 402 English, page III.91 Metric) Under C. Specific Requirements., replace the first and second paragraphs with the following:

All treated piles shall have not less than 1 inch of sapwood at any point on the butt end for Douglas-fir and not less than 2 inches of sapwood at any point on the butt end for Southern Pine.

Treated timber piles shall be Douglas-fir treated with ACZA or Southern Yellow Pine treated with CCA-C in accordance AWPA U1 Treated timber piles used in a marine environment shall be Southern Yellow Pine or Douglas-fir treated with creosote in accordance with AWPA U1 Certificates of compliance and certificates of inspection bearing the independent inspection agencies verification for each lot of wood must be presented before installation and contain the species of wood, the type of preservative, the retention rate and penetration of the preservative.

(page 403 English, page III.92 Metric) Delete D. Preservative Treatment and the paragraph under it.

SUBSECTION M9.06.4 Polyethylene Coated Burlap.
(page 403 English, page III.93 Metric) Replace this subsection with the following:

The material shall conform to the requirements of AASHTO M 171, Sheet Materials for Curing Concrete.

SUBSECTION M9.14.2 Closed Cell Foam Joint Filler.
(page 406 English, page III.96 Metric) Add this new Subsection.

This specification covers the requirements for closed cell foam used as a joint filler between different components of bridges and walls. Closed Cell Foam Joint Filler shall have a compact closed cell structure composed of synthetic isomeric polymers and shall be gray in color. It shall offer sufficient heat resistance so that it is compatible with hot applied sealing compounds. Closed Cell Foam Joint Filler shall meet the requirements of Section 5.1 through 5.4 of ASTM D1752, with the compression requirement modified to 10 psi minimum to 25 psi maximum (70 to 170 kPa). Typical physical properties, as determined using test method ASTM D545, shall be as follows:

Compression, 50% .....13 psi (89.6 kPa)
Extrusion .....0.1 inch (2.5 mm)
Recovery.....99.21 %
Water Absorption, Volume .....0.246 %

The Contractor shall provide certified test data which documents compliance with the required physical properties. The certified test data shall be submitted to the Engineer for approval.

SUBSECTION M9.14.3 Polyurethane Joint Sealer.
(page 406 English, page III.96 Metric) Change the "Federal Specification TT-C-00227E, Type I, Class A" to "ASTM C920".

SUBSECTION M9.14.4 Polyurethane Joint Sealer, Non-Sag.
(page 406 English, page III.96 Metric) Change the "Federal Specification TT-C-00230, Type II, Class A" to "ASTM C920".

SUBSECTION M9.14.5 Elastomeric Bridge Bearing Pads.
(page 406 English, page III.96 Metric) Replace this Subsection with the following:

Elastomeric bearing pads shall consist of plain pads (consisting of elastomer only) and laminated bearings (consisting of layers of elastomers restrained at their interfaces by bonded metal laminates). The elastomeric compound shall be composed of 100% low temperature Grade 3 virgin crystallization resistant polychloroprene (neoprene) meeting the requirements of AASHTO M 251 and Division II, Section 18 of the AASHTO Standard Specifications for Highway Bridges. The type of bearing (plain or laminated), hardness, dimensions, design compressive load, design compressive stress, and whether the bearings are subject to shear deformation shall be as specified on the Plans. All bearings shall be tested by a nationally recognized testing laboratory approved by the Engineer to ensure compliance with all applicable requirements of AASHTO M 251.

The Contractor shall provide the Department with written notification 30 days prior to the start of bearing production. The notification shall include the contract number, quantity, type, and size of bearing being produced, manufacturer's name, and the representative who will coordinate production, inspection, sampling, and testing with the Department. At least 30 days prior to the scheduled date of beam erection, the Contractor shall deliver to the job site all bearings called for on the plans plus one additional elastomeric bearing pad of each size and type identified on the Plans. Certified test result data that demonstrates compliance with all applicable requirements of AASHTO M 251 shall also be provided to the Engineer at least 30 days prior to the scheduled date of beam erection. One elastomeric bearing pad of each size and type identified on the Plans shall be randomly sampled from the job site by the Engineer for additional destructive testing at least 30 days prior to the scheduled date of beam erection. No beams shall be erected until the bearings have been accepted by the Engineer.

All components of the elastomeric bearing pad shall be molded together as an integral unit and all surfaces of the steel laminations shall be covered with a minimum of 3/16" (5 mm) of elastomer. The finished pads shall be free of cuts, blemishes, and molding defects. All bearings that are delivered to the job site with exposed steel laminations are rejected. All imperfections or exposed laminations that result in either less than 3/16" of elastomer cover over any surface of the steel laminations shall be repaired by the manufacturer at the point of manufacture. The repair shall consist of sealing the imperfections flush on the finished pad with a bonded vulcanized patch material compatible with the elastomeric bearing pad. Repairs employing caulking type materials or repairing the bearings in the field shall not be permitted.

SUBSECTION M9.14.6 Bonded Closed Cell Joint System.
(page 406 English, page III.97 Metric) Add this new Subsection.

The joint seal shall be composed of either closed cell cross linked ethylene vinyl acetate polyethylene copolymer or of closed cell polychloroprene (neoprene). The joint seal shall feature grooves or ribs which run the full length of the joint. The joint seal shall be bonded to the concrete surfaces on each side of the joint using a two-component epoxy based adhesive.

The joint seal shall have the following typical physical properties:

Tensile Strength, (ASTM D412)	115 psi (790 kPa), Minimum
Elongation @ Break (ASTM D3575)	200 %, Minimum
Water Absorption, Volume %	5 %, Maximum

The two-component epoxy based adhesive shall conform to ASTM C881, Type I & II, Grade 2, Class B & C, and shall have the following physical properties:

Tensile Strength, (ASTM D638)	3,500 psi (21.4 MPa), Minimum
Compressive Strength	7,000 psi (42.8 MPa), Minimum
Bond Strength	430 psi (2965 kPa), Minimum

The Contractor shall provide certified test data which documents compliance with the required physical properties. The certified test data shall be submitted to the Engineer for approval.

SUBSECTION M9.16.0 Sheet Lead Bearing Pad.
(page 407 English) Delete this Subsection.

SUBSECTION M9.16.2 Moulded Fabric Bearing Pad.
(page 407 English, page III.97 Metric) Change Moulded to Molded in the title.

SUBSECTION M9.17.0 Asphaltic Binder for Asphaltic Bridge Joint System.
SUBSECTION M9.17.1 Aggregate for Asphaltic Bridge Joint System.
SUBSECTION M9.17.2 Backer Rod.
SUBSECTION M9.17.3 Bridge Plate for Asphaltic Bridge Joint System.
SUBSECTION M9.17.4 Neoprene Seals.
(page 407 English, page III.97 Metric) Add these new Subsections.

M9.17.0 Asphaltic Binder for Asphaltic Bridge Joint System.

The thermoplastic polymeric modified asphalt binder shall conform to the following physical properties based on the designated ASTM testing methods:

TEST	ASTM TEST METHOD	REQUIRED PROPERTIES
Softening Point	D36	180ºF minimum
Tensile Adhesion	D5329	700% minimum
Ductility, @ 77ºF	D113	400 mm minimum
Penetration @ 77ºF, 150g, 5 seconds	D3407	7.0 mm maximum
Flow, 5 hours @ 140ºF	D3407	3.0 mm maximum
Resiliency, @77ºF	D3407	70% maximum
Asphalt Compatibility	D3407	Pass
Low Temperature Penetration @ 0ºF, 200g, 60 seconds	D5 with cone*	1.0 mm minimum
Flexibility, @ -10ºF	D5329	Pass
Bond 3 Cycles @ -20ºF, 50% Elongation	D3405	Pass
Bond 3 Cycles @ 0ºF, 100% Elongation	D3405	Pass
Recommend Installation Range		360ºF - 390ºF
Safe Heating Temperature Range		390ºF - 420ºF

* Use Method D 5, however replace the standard penetration needle with a penetration cone conforming to the requirements given in Test Method D217, except the interior construction may be modified as desired. The total moving weight of the cone and attachments shall be 150.0 g ± 0.10.

M9.17.1 Aggregate for Asphaltic Bridge Joint System.

The aggregate shall be granite, basalt or gabbro. The aggregate shall be selected, crushed, processed, double-washed and dried at the source. It shall be delivered to job site in prepackaged waterproof containers. The supplier shall certify the above requirements are met.

The aggregate shall be made available in 3/4, 1/2 and 3/8 inch (19, 12 and 10 mm) sizes and shall meet gradation requirements specified by the manufacturer for the joint system.

M9.17.2 Backer Rod.

The backer rod shall be closed cell foam expansion joint filler, compatible with polymeric binder and the elevated temperatures of the polymeric binder application. The size of the backer rod shall be in accordance with the manufacturer's recommendations for the gap width.

The backer rod shall meet ASTM D1752 and have the following typical physical properties using a ½ inch (12 mm) specimen and the test method ASTM D545:

Compression, 50%.....13.3 psi (91.7 kPa)
Extrusion .....0.1 inch (2.54 mm)
Recovery.....99.21 %
Water Absorption, Volume .....0.246 %

M9.17.3 Bridge Plate for Asphaltic Bridge Joint System.

The bridge plate shall be AASHTO M 270 Grade 36 steel, minimum width and thickness of 8 x ¼ inch (200 x 6 mm) and shall be galvanized in accordance with AASHTO M 111. Holes for the locating pins shall be 12 inches (300 mm) on center. Locating pins shall be 16d common nails or larger, hot dipped galvanized.

M9.17.4 Neoprene Seals.

Neoprene seals shall be composed of flexible, non-reinforced, extruded neoprene compound exhibiting the physical properties listed in the table below. All neoprene seals shall incorporate a matching locking lug that mechanically snaps into the corresponding extrusion shape cavity to ensure watertightness and proper joint performance. All mitering and/or splicing of the neoprene seal shall be performed under controlled conditions at the place of manufacturer. The neoprene seal shall be supplied and installed in one continuous length without field splices.

PROPERTY	TEST METHOD	REQUIREMENT
Tensile Strength	ASTM D412	2000 psi
Tensile Strength, Elongation @ break		250%, minimum
Hardness, Durometer Type A	ASTM D2240 Modified	50 – 65
Oven Aging 70 hrs @ 212°F	ASTM D573	
-Loss of Tensile Strength		20% loss maximum
-Loss of Elongation		20% loss maximum
-Maximum Change in Hardness		-0 to +10 points
Oil Swell, ASTM Oil #3, 70 hrs @ 212°F	ASTM D471	45% maximum weight increase
Low Temperature	ASTM D746,	Not Brittle
Ozone Resistance, 70 hrs @ 104°F, 20% elongation, 300 pphm, in air, Wipe Surfaces to Remove Contamination	ASTM D1149	No Cracks
Low Temperature Stiffening, 7 days @ 14°F, Hardness, Durometer Type A	ASTM D2240	0 to +15 points change
Compression Set, 70 hrs @ 212°F	ASTM D395 Method B	40% maximum

SUBSECTION M9.30.0 Reflective Sheeting.
(page 407 English, page III.97 Metric) Replace the entire Subsection with the following:

This specification covers retroreflective sheeting designed to reflectorize traffic control signs, delineators, barricades, and other devices. All reflective sheeting shall meet the requirements of ASTM D4956 and AASHTO M268, and as listed below:

High Intensity (H/I) Sheeting for permanent traffic signs shall conform to ASTM Type III or IV.

High Intensity Prismatic (HIP) Sheeting for permanent traffic signs and temporary rigid construction signs shall meet or exceed the requirements of ASTM Type VIII.

Flexible High Intensity (H/I) Sheeting for drums, cones, and barricades shall conform to ASTM Type VI.

Flexible High Intensity Prismatic (HIP) Sheeting for rollup signs shall conform to ASTM Type VI.

SUBSECTION M9.30.4 Acrylic Plastic 3¼ inch Diameter Center-Mount Reflector (Type A). (English)
SUBSECTION M9.30.4 Acrylic Plastic 82.5 Millimeter Diameter Center-Mount Reflector (Type A). (Metric)
(page 407 English, page III.97 Metric) Replace this Subsection with the following:

M9.30.4 Acrylic Plastic 3¼ Inch Diameter Center-Mount Reflectors. (English)
M9.30.4 Acrylic Plastic 82.5 Millimeter Diameter Center-Mount Reflectors. (Metric)

Acrylic plastic 3¼ inch (82.5 mm) diameter center-mount reflectors shall be a material previously approved by the Department for the purpose intended and listed on the QCML.

SUBSECTION M9.30.6 Temporary Raised Pavement Markers.
(pages 408-409 English, page III.98 Metric) Replace this Subsection with the following:

Temporary raised pavement markers shall consist of a durable plastic or another type of durable material and have the following characteristics.

- Color: (ASTM D1535) White or Yellow.
- Dimensions are to be at least 4" wide and a minimum reflective area of 1.5 square inches of reflective sheeting meeting M9.30.0, Type C.
- Markers shall contain one way or two way retro reflective faces as required by the Engineer.

Markers shall provide daytime delineation and shall adhere to HMA or PCC surfaces using adhesives and/or methods recommended by the manufacturer. Markers shall be removable from HMA and PCC pavements without the use of heat, solvents, grinding or blasting. After removal, permanent marks, scars or damage to the pavement surface shall be minimal, free from dirt or any other contaminants.

SUBSECTION M9.30.7 Demountable Reflectorized Delineator-Guard Rail..
(page 409 English, page III.98 Metric) Replace this subsection with the following;

M9.30.7 Guardrail Delineator.

Guardrail delineators shall be fabricated from galvanized steel, polycarbonate plastic or thermoplastic and shall allow a minimum of 8 square inches of retroreflective sheeting per face, conforming to M9.30.0, Type VIII (High Intensity Prismatic) or better.

Guardrail delineators shall be trapezoid shaped, mounted in the valley of the W shape at the button-head post bolt. Circular holes shall be used for the bolt connecting the delineator to the W beam. Adhesive connections shall not be allowed.

SUBSECTION M9.30.9 Reflectorized Plastic Drum.
(page 409 English, page III.98 Metric) Replace this Subsection with the following:

M9.30.9 Reflectorized Drum.

Reflectorized drums shall be plastic and shall meet the applicable requirements of the MUTCD.
Reflective sheeting for drums shall meet the requirements of M9.30.0, Type VI and be six inches wide.
Reflectorized drums are listed on the MassDOT Qualified Construction Materials list.

SUBSECTION M9.30.10 Delineation for Guardrail Termini.
(page 409 English, page III.98 Metric, page Supplement C2015-259) Replace this subsection with the following;

M9.30.10 Guardrail Termini Delineator

Guardrail termini delineators shall be fabricated in accordance with the Plans. The panel shall consist of Type A aluminum sign panel. Reflectorized sheeting shall conform to M9.30.0, Type III (High Intensity).

SUBSECTION M9.30.11 Traffic Cones.
(page 409 English, page III.98 Metric) Add this new Subsection:

M9.30.11 Traffic Cones.

Traffic cones shall be orange in color, 36 inches tall and with reflective sheeting that meets all MUTCD criteria. Reflective sheeting for cones shall meet the requirements of M9.30.0, Type VI.
Traffic cones are listed on the MassDOT Qualified Construction Materials list.

SUBSECTION M9.40.0 Drilling Slurry.
(page 409 English, page III.98 Metric) Add this new Subsection:

Drilling slurry shall conform to one of the following specifications. Reports of all required tests shall be furnished to the Engineer upon completion of each drilled shaft.

Mineral Slurry.

Mineral slurry shall be premixed thoroughly with water and adequate time, as prescribed by the manufacturer, shall be allotted for hydration prior to introduction into the shaft hole. Slurry tanks of adequate capacity are required for slurry circulation, storage, and treatment. Control tests shall be performed on the mineral slurry by the Contractor to determine density, viscosity, sand content and pH. Properties of mineral slurry (Bentonite or Attapulgite) in water shall meet the following range of values:

Property	Value Required	Test Method
Density (Unit Weight)*	64-75 lb/ft^3 (1030-1200 kg/m^3)	Mud Density API 13B-1 Section 1
Viscosity	26-50 sec/qt (27.5-53 sec/l)	Marsh Funnel and Cup API 13B-1 Section 2.2
pH	8-11	Glass Electrode, pH Meter, or pH Paper
Sand Content	4.0% by volume maximum	Sand Content API 13B-1 Section 5

* To be increased by 2 lb/ft^3 (32 kg/m^3) in salt water or brackish water.

Tests to determine density, viscosity and pH shall be performed during shaft excavation to establish a consistent working pattern. Four sets of tests shall be made during the first 8 hours of slurry use. When the results show consistent behavior, one set of testing shall be made every 4 hours of slurry use thereafter.

Water Slurry.

The use of water slurry without full length steel casings will only be allowed if approved in writing by the Engineer. In that case, all of the properties of mineral slurry shall be met, except that the maximum density shall not exceed 70 lb/ft^3 (1120 kg/m^3). Mixtures of water and on-site soils shall not be allowed for use as a drilling slurry, since particulate matter falls out of suspension easily and can contaminate the concrete.

Polymer slurry.

Natural or synthetic slurry shall have specific properties at the time of mixing and of concreting that are in conformance with the written recommendations of the manufacturer and the Contractor's Drilled Shaft Installation Plan. The Contractor shall perform the required tests at the specified frequency and shall provide slurry that complies with the maximum and/or minimum property requirements for the subsurface conditions at the site and with the construction methods that are used. Whatever product is used, the sand content at the base of the shaft excavation shall not exceed 1% when measured by the API sand content test, immediately prior to concreting.

SUBSECTION M9.50.0 Geotextile Fabrics.
(page 410 English, page III.98 Metric) Replace existing Subsection with the following:

Geotextile fabric used for subsurface drainage, separation, stabilization, permanent erosion control, temporary silt fences, or paving fabric shall conform to requirements of AASHTO M 288 for the intended application.

****

END OF DOCUMENT

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930.*	Prestressed Concrete Deck Beam (S*)	Foot	288
930.1*	Prestressed Concrete Box Beam (B*)	Foot	288
931.*	Prestressed Concrete Bulb-Tee Beam (NEBT*)	Foot	288
955.	Treated Timber	MBF	305
975.1	Metal Bridge Railing (3 Rail), Steel (Type S3-TL4)	Foot	319
975.2	Metal Bridge Railing (3 Rail), Aluminum (Type AL-3)	Foot	319
975.3	Protective Screen Type I	Foot	319

DELETE THESE PAY ITEMS

			English Page
223.	Frame and Grate (or Cover) Removed and Reset	Each	95
*231.-	-Inch Asphalt Coated Corrugated Metal Pipe (Aluminum)...Gage	Foot	97
*231.6-	-Inch Asphalt Smooth Steel Linear Helically Corrugated Shell Metal Pipe …Gage (of outer shell)	Foot	97
*231.7-	-Inch Asphalt Coated Corrugated Metal Pipe (Aluminum) End Section	Each	97
234.-	Pipe-Option	Foot	97
*262.	Perforated Corrugated Aluminum Pipe ...Gage (Subdrain)	Foot	101
*263.	Perforated Asphalt Coated Corrugated Metal Pipe ...Gage (Subdrain)	Foot	101
*264.	Perforated Asphalt Coated Corrugated Aluminum Pipe ...Gage (Subdrain)	Foot	101
*279.	Half Circle ACCMP Pipe (Waterway)	Foot	104
300.	Cast Iron Water Pipe (Rubber Gasket)	Foot	109
304.	Cast Iron Water Pipe (Cement Lined)	Foot	109
308.	Cast Iron Fittings for Water Pipe	Pound	109
464.	Asphalt Emulsion for Tack Coat	Gallon	127
602.	Individual Post	Each	160
620.1	Steel Beam Highway Guard – Type SS (Single Faced)	Foot	160
620.3	Steel Beam Highway Guard – Type SS (Single Faced) (Curved)	Foot	160
620.4	Steel Beam Highway Guard – Type SS Buried End (Single Faced)	Each	160
621.1	Steel Beam Highway Guard – Type SS (Double Faced)	Foot	160
621.3	Steel Beam Highway Guard – Type SS (Double Faced) (Curved)	Foot	160
621.4	Steel Beam Highway Guard – Type SS Buried End (Double Faced)	Each	160
622.1	Steel W Beam Highway Guard – Type SS (Single Faced/Wood Posts)	Foot	160
622.3	Steel W Beam Highway Guard – Type SS (Single Faced/ Wood Posts) (Curved)	Foot	160
622.5	Steel Beam Highway Guard - Type SS Buried End (Single Faced/ Wood Posts)	Each	160
624.1	Steel Thrie Beam Highway Guard – Type SS (Single Faced)	Foot	160
624.3	Steel Thrie Beam Highway Guard – Type SS (Single Faced) (Curved)	Foot	160
624.4	Steel Thrie Beam Highway Guard – Type SS Buried End (Single Faced)	Each	160
625.1	Steel Thrie Beam Highway Guard – Type SS (Double Faced)	Foot	160
625.3	Steel Thrie Beam Highway Guard - – Type SS (Double Faced) (Curved)	Foot	160
625.4	Steel Thrie Beam Highway Guard – Type SS Buried End (Double Faced)	Each	160
626.1	Steel Beam Highway Guard – Type SS (Single Faced / SP Base Anchor)	Foot	160
626.2	Steel Beam Highway Guard – Type SS (Double Faced / SP Base Anchor)	Foot	160
626.3	Steel Thrie Beam Highway Guard – Type SS (Single Faced / SP Base Anchor)	Foot	160
626.4	Steel Thrie Beam Highway Guard – Type SS (Double Faced / SP Base Anchor)	Each	160
627.1	Steel Beam Terminal Section (Single Faced)	Each	160
627.2	Steel Beam Terminal Section (Double Faced)	Each	160
627.3	Steel Thrie Beam Terminal Section (Single Faced)	Each	160
627.4	Steel Thrie Beam Terminal Section (Double Faced)	Each	160
627.5	Special Beam Terminal Section (Single Faced)	Each	160
628.	Leading End for Steel Thrie Beam Highway Guard at Bridge	Each	160
628.1	Leading End for Steel Beam Highway Guard at Bridge	Each	160
628.2	Trailing End for Steel Beam Highway Guard at Bridge	Each	160
628.4	Trailing End for Steel Thrie Beam Highway Guard at Bridge	Each	160
635.	Highway Guard Remove and Stacked	Foot	165
636.	Anchor Remove and Stacked	Each	165
637.	Individual Post Remove and Stacked	Each	165

DELETE THESE PAYMENT ITEMS (continued)

			English Page
644.2	-Inch Chain Link Fence (Spring Tension Wire) Ty 1 - (Line Post - Option)	Foot	169
644.3	-Inch Chain Link Fence (Spring Tension Wire) Vinyl Coated - (Line Post - Option)	Foot	169
645.2	-Inch Chain Link Fence (Pipe Top Rail) Ty 1 - (Line Post - Option)	Foot	169
645.3	-Inch Chain Link Fence (Pipe Top Rail) Vinyl Coated - (Line Post - Option)	Foot	169
646.1	-Inch Chain Link Fence (Cable Top) Ty 1 - (Line Post - Option)	Foot	169
646.2	-Inch Chain Link Fence (Cable Top) Ty 2 - (Line Post - Option)	Foot	169
646.3	-Inch Chain Link Fence (Cable Top) Vinyl Coated - (Line Post - Option)	Foot	169
647.1	-Inch Chain Link Fence (Pipe Top Rail) with Barbed Wire Ty 1 - (Line Post - Option)	Foot	169
647.2	-Inch Chain Link Fence (Pipe Top Rail) with Barbed Wire Ty 2 - (Line Post - Option)	Foot	169
648.1	-Inch Chain Link Fence (Cable Top) with Barbed Wire Ty 1 - (Line Post - Option)	Foot	169
648.2	-Inch Chain Link Fence (Cable Top) with Barbed Wire Ty 2 - (Line Post - Option)	Foot	169
649.1	-Inch Chain Link Fence (Spring Tension Wire) with Barbed Wire Ty 1 - (Line Post - Option)	Foot	169
649.2	-Inch Chain Link Fence (Spring Tension Wire) with Barbed Wire Ty 2 - (Line Post - Option)	Foot	169
650.1	-Inch Chain Link Gate, Type 1 with Gate Posts	Foot	170
650.2	-Inch Chain Link Gate, Type 2 with Gate Posts	Foot	170
651.1	-Inch Chain Link Gate, Type 2 with Gate Posts and Barbed Wire	Foot	170
651.2	-Inch Chain Link Gate, Type 2 with Gate Posts and Barbed Wire	Foot	170
*673.	In. Chain Link Gate with Gate Posts Removed and Stacked	Each	172
702.2	Bituminous Concrete Wheelchair Ramp	Ton	179
751.2	Plantable Soil Borrow	Cubic Yard	193
759.	Processed Planting Material	Cubic Yard	193
770.1	Field Sodding	Square Yard	204
770.2	Natural Growth Sod - Lowbush Blueberry	Each	204
770.3	Natural Growth Sod - Bearberry	Each	204
770.4	Natural Growth Sod - Mountain Laurel	Each	204
770.5	Natural Growth Sod - Sweet Fern	Each	204
802.2 to 802.4	Electrical Conduit Type NM - Bituminous Fibre	Foot	215
803.2 to 803.6	Electrical Conduit Type NM - CEM., ABS., or Fire Clay Cement	Foot	215
805.2 to 805.6	__ Inch Electrical Conduit Type NM - Plastic (NEMA)	Foot	215
807.05 to 807.6	__ Inch Electrical Conduit Type RM - Aluminum	Foot	215
815.1 to 815.83	Traffic Control Signal Type ____* *(from 1. 1P.1W to 8.8P.8W.8D)	Lump Sum	238
815.89 to 815.95	Traffic Control Signal Type ____* *(9 to 15)	Lump Sum	238

DELETE THESE PAYMENT ITEMS (continued)

			English Page
817.30	Signal Post Standard __ 6 ft. __ 10 in.	Each	238
817.31	Signal Post Standard __ 8 ft. __ 10 in.	Each	238
817.32	Signal Post Pedestal __ 6 ft. __ 10 in.	Each	238
817.33	Signal Post Pedestal __ 8 ft. __ 10 in.	Each	238
817.70 to 817.73	Signal land Lighting Mast Arm __ ft. x __ ft.	Each	238
819.01 to 819.38	Traffic Signal Controller Type ____* *(Types 1.1P.1W. thru Type 15)	Lump Sum	239
819.40	Directional Detector Relay- Pressure Sensitive	Each	239
819.841 to 819.843	Nondirectional Detector *(_ft.) - Pressure Sensitive	Each	239
819.844 to 819.846	Directional Detector *(_ft.) - Pressure Sensitive *(4, 6, 8)	Each	239
822.80 to 822.82	Area Lighting Hinged Pole *__ft. Mounting Height *(40-50 ft.)	Each	245
823.72	Highway Lighting Pole and Luminaire Removed and Transported	Each	246
827.3	Abutment Warning Sign (H1-3) – Option	Each	255
827.31	Abutment Warning Sign (H1-2) – Plywood Panel	Each	255
828.	Overhead Guide Sign - Option	Square Foot	255
828.2	Overhead Guide Sign – Plywood Panel	Square Foot	255
829.	Roadside Guide Sign – (MR) - Option	Square Foot	255
829.2	Roadside Guide Sign – (MR) – Plywood Panel	Square Foot	255
830.	Roadside Guide Sign – (FR) – over 20 square feet - Option	Square Foot	255
830.2	Roadside Guide Sign – (FR) – over 20 square feet – Plywood Panel	Square Foot	255
831.	Roadside Guide Sign – (FR) – over 20 square feet and under - Option	Square Foot	255
831.2	Roadside Guide Sign – (FR) – over 20 square feet and under – Plywood Panel	Square Foot	255
833.1	1-WH Demountable Reflectorized Delineator (H1-4)	Each	256
833.11	1-AM Demountable Reflectorized Delineator (H1-8)	Each	256
833.2	2-WH Demountable Reflectorized Delineator (H1-7)	Each	256
833.3	2-AM Demountable Reflectorized Delineator (H1-5)	Each	256
833.4	3-AM Demountable Reflectorized Delineator (H1-6)	Each	256
834.1	Demountable Reflectorized Tenth of a Mile Marker	Each	256
834.11	Demountable Reflectorized Tenth of a Mile Marker (Excluding Post)	Each	256
836.1	Demountable Reflectorized Project Marker (Excluding Post)	Each	256
841.1*	Supports for Guide Sign (D6-*) Steel	Each	258
842.1*	Supports for Guide Sign (D9-*) Steel	Each	258
843.1*	Supports for Guide Sign (D10-*) Steel	Each	258
851.	Safety Controls for Construction Operations	Lump Sum	265
853.4	Temporary Impact Attenuator	Each	265
853.5	Temporary 24-Inch Anti-Glare Screen (Paddle Type)	Foot	265
853.6	Temporary Anti-Glare Screen Removed and Reset	Foot	265
853.7	Temporary Anti-Glare Screen Removed and Stacked	Foot	265
854.014	Temporary Pavement Markings – 4 In. (Painted)	Foot	265
854.024	Temporary Pavement Markings – 4 In. (Non-Removable Tape)	Foot	265
854.026	Temporary Pavement Markings – 6 In. (Non-Removable Tape)	Foot	265
854.034	Temporary Pavement Markings – 4 In. (Removable Tape)	Foot	265
854.036	Temporary Pavement Markings – 6 In. (Removable Tape)	Foot	265
854.2	Pavement Marking Removal - Thermoplastic	Square Foot	265
854.3	Pavement Marking Removal - Tape	Square Foot	265
855.1	Hazard Identification Beacon Type B	Each	265
855.2	Hazard Identification Beacon Type D	Each	265

DELETE THESE PAYMENT ITEMS (continued)

			English Page
857.	Illuminated Portable Barricade	Each	266
858.	Illuminated Portable Barricade Relocated	Each	266
859.1	Reflectorized Drum with Flasher (Type A)	Drum Day	266
859.2	Reflectorized Drum with Light (Type C)	Drum Day	266
860.04-860.12	*___ inch reflectorized white line (painted)	Foot	268
861.04-861.12	*___ inch reflectorized yellow line (painted)	Foot	268
864.00	Pavement arrow reflectorized white (painted)	Square Foot	268
864.01	Pavement arrow and legends reflectorized white tape (inlay)	Square Foot	268
864.02	Pavement arrow and legends (surface applied tape)	Square Foot	268
866.04-866.12	*___ inch reflectorized white line (thermoplastic)	Foot	268
867.04-867.12	*___ inch reflectorized yellow line (thermoplastic)	Foot	268
870.04	4 In. white reflective tape (inlay)	Foot	268
871.04	4 In. yellow reflective tape (inlay)	Foot	268
872.04	4 In. white reflective tape (surface applied)	Foot	268
873.04	4 In. yellow reflective tape (surface applied)	Foot	268
946.	Precast-Prestressed Concrete Pile	Foot	302
975.	Metal Bridge Railing (1 Rail) - Option	Foot	319
976.2	Metal Bridge Railing (3 Rail), Steel (Type ST-3) - Galvanized	Foot	320
999.995	Increase in Concrete Quantity	Cubic Yard	324
999.996	Decrease in Concrete Quantity	Cubic Yard	324

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