

DOCUMENT 00715



## SUPPLEMENTAL SPECIFICATIONS

(English Units)

SEPTEMBER 30, 2023

The 2023 *Standard Specifications for Highways and Bridges* are amended by the following modifications, additions and deletions. This Supplemental Specifications prevail over those published in the Standard Specifications.

The Specifications Committee has issued these Supplemental Specifications for inclusion into each proposal until such time as they are updated or incorporated into the next Standard Specifications.

Contractors are cautioned that these Supplemental Specifications are dated and will change as they are updated.

### DIVISION I

#### GENERAL REQUIREMENTS AND COVENANTS

##### SECTION 1: DEFINITION OF TERMS

Subsection 1.02: References, Abbreviations, Acronyms, Measurement Units and Symbols  
*Under B. Abbreviations and Acronyms delete the line containing NTPEP.*

##### SECTION 2.00: PROPOSAL REQUIREMENTS AND CONDITIONS

Subsection 2.04: Preparation of Proposals  
*Replace the fourth paragraphs with the following:*

At the designated time of the bid opening the Department will accept as the official bid, the set of proposal forms generated from the electronic proposal which includes the bid item sheets, bid bond, addendum acknowledgement, and affidavit of non-collusion.

##### SECTION 4: SCOPE OF WORK

Subsection 4.03: Extra Work  
*Replace the third and fourth paragraphs with the following:*

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

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

If the Contractor disputes the scope, cost or time associated with the executed Extra Work Order or the determination by the Engineer for requested extra work, then the Contractor must deliver to the Department written notice of a claim in accordance with Subsection 7.16: Claims of Contractor for Compensation.

**Subsection 4.04: Changed Conditions**

*Add new paragraph (b) and re-letter existing paragraphs (b) through (e) to (c) through (f):*

- (b) In the event the Engineer's report finds no material or substantial change in conditions, the Contractor may file a Notice of Claim in accordance with Subsection 7.16: Claims of Contractor for Compensation.

**SECTION 5: CONTROL OF WORK**

**Subsection 5.02: Plans and Detail Drawings**

*Replace the 7<sup>th</sup> paragraph from the top with the following:*

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 Project Number; name of the contractor, the subcontractor; 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.

**Subsection 5.09: Inspection of Work**

*Replace the first paragraph of this subsection the following:*

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

**SECTION 6: CONTROL OF MATERIALS**

**Subsection 6.01: Source of Supply and Quality**

*Replace this subsection with the following:*

The Engineer may approve material at the source of supply before delivery to the project.

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

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

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

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. 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.

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

The rules referred to require a preference in the purchase of supplies and materials, other considerations being equal, in favor first, of supplies and materials manufactured and sold within the Commonwealth, and second, of supplies and materials manufactured and sold within the United States.

All iron and steel products, manufactured products, and construction materials shall comply with all Federal Buy America and Federal Build America Buy America (BABA) requirements, where applicable.

In Contracts requiring structural steel, precast, or prestress concrete, the Contractor shall furnish approved shop drawings, and fabrication procedures to the Department's inspector at the supply source or fabrication site.

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.

If testing finds that an approved supplier does not furnish a uniform product, or if the product from such source proves unacceptable at any time, the Contractor shall, at their own expense, take any and all steps necessary to furnish approved materials.

The Contractor shall submit to the Department for approval a notarized Certificate of Compliance (COC) from the Manufacturer or Supplier for each kind of manufactured or fabricated material furnished.

The COC shall certify compliance with the specifications and shall contain the following information:

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

These 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. The Contractor shall attach to the COC a document listing the contract bid item number(s), sub item(s), or lump sum breakdown item number(s), as applicable, under which the material will be compensated. 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.

If the Contractor has new materials purchased for use on a previous Department Contract which have never been used and which comply with the specifications, these materials may be furnished and used. The Contractor shall submit their own sworn statement certifying that such materials were purchased for use on a previous Contract (naming and identifying such Contract) and shall attach the original COC.

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

**Subsection 6.03: Delivery and Storage of Materials**

*Replace this subsection with the following:*

Materials and equipment shall be progressively delivered to or removed from the site so that there will be neither delay in the progress of the work nor an accumulation of materials that are not to be used or removed within a reasonable time. All materials shall be stored in pre-approved locations per the conditions of the property owner.

Delivered materials and materials originating from the site shall be stored to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located to facilitate their prompt inspection.

Approved portions of the State Highway Layout (SHLO) may be used for storage of project materials and for the placing of the Contractor's plant and equipment upon obtaining a state highway access permit. All storage sites shall be restored to their original condition by the Contractor. No additional compensation shall be given for the design, construction, preparation, or restoration of the storage site(s) or obtaining the access permit which may include but is not limited to a Traffic Management Plan (TMP), utilities, and lighting.

The application for a permit shall contain a locus map identifying the proposed location, a description of the specific activities and uses of the staging area, a TMP in accordance with Subsection 7.10 depicting minimum setbacks from the roadway and any existing structures for stored materials and equipment and how equipment will safely access and exit the staging area.

Any additional space required must be provided by the Contractor at their expense. Municipal, private, or other state-owned property shall not be used for storage purposes without written permission of the owner or lessee, and copies of such written permission shall be furnished to the Engineer.

**SECTION 7: LEGAL RELATIONS AND RESPONSIBILITY TO (THE) PUBLIC****Subsection 7.09: Public Safety and Convenience**

*Delete the word Prime.*

**Subsection 7.10: Barricades and Warning Signs**

*Replace the entire subsection with the following:*

**Subsection 7.10: Traffic Management Plan**

The Contractor shall submit a Traffic Management Plan to the Department This Plan shall include:

- Contact information for the person(s) responsible for the implementation, oversight, and quality control of the Traffic Management Plan.
- Temporary Traffic Control Plans for all phases of construction.
- Detour Plans (if applicable).
- Public Involvement and Communication Plan (if required by Special Provision).

No work impacting traffic shall commence until the Traffic Management Plan has been approved by the Department.

**Temporary Traffic Control Plans (TTCP)**

The TTCP shall consist of plans depicting the location of all temporary traffic control devices, including but not limited to: channelization devices, barricades, signs, pavement markings, lighting, traffic signals, flashing lights, temporary barrier, temporary attenuators, truck or trailer mounted attenuators, flashing arrow boards, portable changeable message signs, work zone ITS equipment, temporary portable rumble strips, Roadway Flaggers, and Traffic Officers. Specialized short-term conditions such as rolling roadblocks or road/ramp closures lasting for less than 24 hours will also require individual TTCPs.

The TTCP shall also include, as needed, a description or plan of Contractor access and egress to and from the work zones, staging areas and material stockpile and equipment laydown areas. See Subsection 6.03 for material stockpile requirements.

For each phase of construction, the Contractor may choose to use:

- the TTCPs included in the Contract Documents (if provided),
- MassDOT Construction Standards,
- a separate TTCP design from the Contractor,
- or a combination thereof.

The Contractor shall identify the TTCPs they will use in their project TMP Submission, including the use of the Contract specified TTCPs or Construction Standards. All Contractor proposed TTCPs must be approved by MassDOT prior to implementation.

Any TTCP design that varies from the Contract Documents or the Construction Standards shall be stamped and signed by a Professional Engineer registered in Massachusetts.

#### **Detour Plans**

Detour Plans shall be required if access for motor vehicles, heavy vehicles, bicyclists, or pedestrians is temporarily restricted and an alternate route is necessary. Detour plans shall show locations of barricades, signs, portable changeable message signs, and other temporary traffic control devices that are needed to provide directional information to the affected road user(s).

All pedestrian detours shall be on ADA and AAB compliant routes. Any pedestrian detour plans shall be stamped and signed by a Professional Engineer registered in Massachusetts.

#### **Public Involvement and Communication Plans**

Public Involvement and Communication Plans shall be required as noted in the contract Special Provisions. These plans shall include outreach measures and notification to the public to increase awareness of pending traffic impacts.

#### **Additional Contractor Duties**

The Contractor shall maintain all temporary traffic control devices erected or installed as a part of the approved Traffic Management Plan. The Contractor shall furnish staff that will oversee all components of the approved Traffic Management Plan.

All costs associated with the development, submission and implementation of the Traffic Management Plan shall be incidental to the Contract.

#### **Subsection 7.16: Claims of the Contractor for Compensation**

*Replace this subsection with the following:*

No person or corporation, other than the signer of the Contract as Contractor, now has any interest hereunder, and no claim shall be made or be valid; and neither the Department nor any member, agent or employee thereof, shall be liable for, or be held to pay, any money except as provided in Subsections 4.02: Alterations, 4.03: Extra Work, 4.04: Changed Conditions, 4.06: Increased or Decreased Contract Quantities and 9.02: Scope of Payments of these Specifications and Clause 3 of the Contract.

All disputes between the Contractor and the Department shall be resolved as provided by this subsection.

At all times during the claims review process or any subsequent administrative or court proceeding, the Contractor shall proceed with the Work diligently, without delay, in accordance with the Contract, and as directed by the Department. In addition, all parties shall continue to comply with all provisions of the Contract documents.

#### **A. Contractor Claims Submission to the Department (Step 1)**

##### **Notice of Claim**

All claims of the Contractor for compensation other than as provided for in the Contract on account of any act of omission or commission by the Department or its agents must be made in writing to the Engineer within seven (7) days after the beginning of any work or the sustaining of any damage on account of such act.

The Contractors written notice to the Engineer shall contain the following:

- 1) a description of the nature of the work performed or damage sustained
- 2) the time and date the event was first identified
- 3) the location of the impacted work
- 4) the Contractual basis for the Contractor's claim

**Itemized Statement of Claim**

The Contractor shall within thirty (30) days after the beginning of any work or the sustaining of any damage on account of such act shall submit to the Engineer an itemized statement containing the following:

- 1) a detailed description of the Work claimed and sequence of events and location
- 2) a breakdown of actual costs and damages sustained including all supporting documentation
- 3) a Time Entitlement Analysis, if the Contractor is claiming for an extension of Contract time

If the work to be claimed is not completed within the initial thirty (30) days, the Contractor shall submit on a monthly basis the actual costs to-date and an estimated cost to complete. Upon completion of the work a final actual cost shall be submitted in thirty (30) days.

All costs shall be prepared and submitted in accordance with Subsection 9.03: Payment for Extra Work. Any costs associated with the preparation, negotiation, litigation and/or settlement of the claim are not allowable.

Unless such notice and statement shall be made as required, any claim for compensation or additional time shall be forfeited and invalidated, and the Contractor shall not be entitled to payments on account of any such work or damage.

Such notice by the Contractor and the keeping of costs by the Engineer shall not in any way be construed as providing the validity of the claim. The provisions of this paragraph shall not apply to changes in quantities as provided under Subsection 4.06: Increased or Decreased Contract Quantities or to Extra Work ordered by the Engineer in writing.

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

Upon receipt of a Notice of Claim and itemized statement of costs, the Department and Contractor shall attempt to resolve the issue(s) presented through a review of the materials submitted, and an evaluation of the contract documents. After a complete review, the Department will issue a written decision on the Contractor's claim.

**B. Construction Claims Committee Determination (Step 2)**

Within fourteen (14) Days after the receipt date of the Department's written decision denying a claim, the Contractor may file a request with the Chief Engineer for a hearing before the Department's Claims Committee. The Contractor shall also provide any additional information, at the Department's request, that the Department's Claims Committee determines is necessary for its evaluation of the claim. The Contractor's claim information must be enhanced to include sufficient description and information to enable understanding by a third party who has no knowledge of the dispute or familiarity with the Project and this documentation must also include a description of the efforts undertaken to resolve the dispute.

The Contractor shall present the claim to the Claims Committee at a meeting to be scheduled after the filing of the request. After the meeting, the Chief Engineer will provide to the Contractor a written determination on each claim.

### C. Appeal to the Administrative Law Judge (Step 3)

The determination of the Engineer may be appealed to the Department's Administrative Law Judge as established in MGL Ch.6c, s.40, as amended.

The appeal shall set forth the contract number, city or town project is in, the name and address of the Contractor, the amount of the claim (and breakdown of how the amount was computed), a clear, concise statement of the specific determination being appealed, including the reasons for appealing the determination and shall be signed by the Contractor. The Office of the Administrative Law Judge shall record the date and time any such appeal is received, shall keep the appeal on record, and schedule the appeal for a hearing before the Administrative Law Judge.

At any time after the determination by the Claims Committee, the Contractor at its sole discretion may appeal the Claims Committee's determination to the Superior Court Department of the Commonwealth of Massachusetts in the County of Suffolk for further consideration. The Contractor agrees that either on appeal of a decision from the Department's Administrative Law Judge or on direct appeal, the exclusive jurisdiction and venue for any legal action or proceeding, at Law or in equity, arising out of or relating to the Contract Documents or the Project, shall be the Superior Court Department of the Commonwealth of Massachusetts in the County of Suffolk. The Contractor waives all objections it might have to the jurisdiction or venue of such court and hereby consents to such jurisdiction, regardless of the Contractor's residence or domicile, for any such action or proceeding. This subsection does not relieve the Contractor's obligation to submit the Dispute to Superior Court within the applicable statutes of limitations or repose and the Department does not hereby waive its rights to assert defenses based upon such statutes.

Interest on judgments for Contractor claims filed with the Superior Court of Massachusetts shall be calculated pursuant to the provisions of MGL c. 231, s.61 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.

Throughout the course of any work that is the subject of any claim the Contractor shall keep complete records of the extra costs and time incurred related to the claim. These records shall be retained for a period of not less than seven (7) years from the date of resolution of the claim.

The acceptance by the Contractor of the final payment made under the provisions of Subsection 9.05: Final Acceptance and Final Payment shall operate as and shall be a release to the Department and every member, agent and employee thereof, from all claim and liability to the Contractor for anything done or furnished for, or relating to, the work, or for any act or neglect of the Department or of any person relating to or affecting the work, except the claim against the Department for the remainder, if any there be, of the amounts kept or retained as provided in Subsection 7.15: Claims Against Contractors for Payment of Labor, Materials and Other Purposes. For claims for extensions of time see Subsection 8.10: Determination and Extension of Contract Time for Completion (Time Extensions).

## SECTION 8: PROSECUTION AND PROGRESS

### Subsection 8.05: Claim for Delay or Suspension of the Work

*Replace the second paragraph with the following:*

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

*Replace the fifth paragraph with the following:*

Any dispute concerning whether the delay or suspension is unreasonable or any other question of fact arising under this paragraph shall be determined by the Engineer, and such determination and decision, in case any question shall arise, shall be a condition precedent to the right of the Contractor to receive any money hereunder. The determination by the Engineer shall be in accordance with Subsection 7.16 Claims of Contractor for Compensation.

Subsection 8.10: Determination and Extension of Contract Time for Completion (Time Extensions)

*Under D. Disputes, replace the second paragraph with the following:*

The Contractor may dispute a determination by the Engineer by filing a claim notice within seven (7) 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. A determination on the Contractor's claim shall be in accordance with Subsection 7.16 Claims of Contractor for Compensation. The Contractor's claim notice shall include a revised 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.

**DIVISION II**

**CONSTRUCTION DETAILS**

**SUBSECTION 430: CEMENT CONCRETE BASE COURSE**

Subsection 430.40: General

*Revise this subsection to read as follows:*

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

Materials:

Cement Concrete.....	M4
Preformed Joint Filler.....	M9.14.0
Hot Applied Crack Sealer.....	M3.05.2

**SUBSECTION 450: HOT MIX ASPHALT PAVEMENT**

Subsection 450.61: Contractor Quality Control Plan

*Replace the fourth sentence in the first paragraph with the following:*

The QC Plan shall sufficiently document the QC processes of all Contractor parties (i.e. Contractor, Subcontractors, Producers) performing work required under this specification.

**SUBSECTION 460: HOT MIX ASPHALT PAVEMENT FOR LOCAL STREETS**

Subsection 460.61: Contractor Quality Control Plan

*Replace the fourth sentence in the first paragraph with the following:*

The QC Plan shall sufficiently document the QC processes of all Contractor parties (i.e., Contractor, Subcontractors, Producers) performing work required under this specification.

**SUBSECTION 466: STRESS ABSORBING MEMBRANE & STRESS  
ABSORBING MEMBRANE INTERLAYER**

Subsection 466.61: Contractor Quality Control Plan

*Replace the second sentence in the first paragraph with the following:*

The QC Plan shall sufficiently document the QC processes of all Contractor parties (i.e. Contractor, Subcontractors, Producers) performing work required under this specification.



## SUBSECTION 476: CEMENT CONCRETE PAVEMENT

### Subsection 476.64: Placing Concrete

Delete the third paragraph from the bottom of this subsection.

### Subsection 476.81: Basis of Payment

Delete the last paragraph of this subsection.

## SUBSECTION 480: PAVEMENT CRACK SEALING

### Subsection 480.61: Contractor Quality Control Plan

Replace the first paragraph with the following:

The Contractor shall provide and maintain a QC Plan which shall sufficiently document the QC processes of all Contractor parties (i.e., Contractor, Subcontractors, Producers) performing work required under this specification.

## SUBSECTION 629: CONCRETE BARRIER

### SECTION 629: Concrete Barrier

Replace this subsection with the following:

#### DESCRIPTION

#### 629.20: General

This item shall consist of furnishing and placing Portland cement concrete barrier on an accepted prepared subgrade or sub-base in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans.

#### MATERIALS

#### 629.40: General

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

Cement and Cement Concrete Materials.....	M4
Precast Concrete Highway Units .....	M4.02.14
Cement Concrete Blocks .....	M4.05.1
High Performance Concrete .....	M4.06.1
Steel Reinforcement .....	M8.01.0
Epoxy Coated Reinforcing Bars .....	M8.01.7
Preformed Joint Filler .....	M9.14.0
Demountable Reflectorized Delineators.....	M9.30.7

Plain dowel bars shall conform to ASTM A36 and shall be galvanized according to AASHTO M 111M/M 111.

#### CONSTRUCTION METHODS

#### 629.60: General

Concrete barrier shall be either precast or cast-in-place and conform to M4: Cement and Cement Concrete Materials.

The subgrade shall be properly shaped and compacted as specified in Subsection 170: Grading.

#### 629.61: Precast Barrier

Precast barrier shall meet M4.02.14 Precast Concrete Highway Units.

**629.62: Cast-in-Place Barrier****A. Conventionally Formed Barrier.**

Forms shall be accurately set to the required line and grade, secured by a method not detrimental to the roadway pavement and maintained in a true position during concrete placement.

Form removal shall meet M4.02.14: Precast Concrete Highway Units.

**B. Slipformed Barrier.**

Concrete traffic barriers may be constructed by the use of slipform equipment provided that the finished barrier is true to the specified line and grade within a tolerance of  $\pm\frac{1}{4}$  in. in 10 ft.

The barrier shall present a smooth, uniform appearance in its final position, and shall conform to the horizontal and vertical lines shown on the plans or as directed by the Engineer. Any unsatisfactory section of the barrier shall be removed and replaced at the Contractor's expense.

The concrete shall be vibrated and worked until adequately consolidated and free of honeycomb. The concrete shall be of such consistency after slipforming that it will maintain the shape of the barrier without support. Prior to the beginning of operations, the Contractor shall ensure that a continuous supply of concrete is available to the slipform machine to minimize starting and stopping. The slump of concrete shall not exceed 1.5 in.

The slipform machine shall be guided by vertical and horizontal sensors that ride along a wire line. A grade line gauge or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line. The slipform machine shall not exceed the speed recommended by the manufacturer. In lieu of sensor controls, the slipform machine may be operated on rails or supports set at the required grade.

**629.63: Concrete Median Barrier Cap**

The work consists of constructing a 4-in.-thick cast-in-place cap between the single face median barriers as shown on the plans.

The cap shall be cast in place on a gravel foundation with the length of each section being 30 ft. A  $\frac{1}{2}$ -in. premolded joint filler will be placed between these 30-ft sections. A  $\frac{1}{2}$ -in. premolded joint filler will be placed around bridge pier columns and along the joints between the barrier and the cap where required.

**629.64: Placement of Barriers**

Precast concrete barrier units shall be placed on a previously compacted gravel foundation utilizing 24-in. by 24-in. by 8-in. concrete leveling blocks conforming to the provisions of M4.05.1 set flush with the top of the gravel to control setting of the unit to the proper grade.

The Contractor shall schedule their operation and sequence of installation of the barriers so that a minimum amount of closure pieces will be required.

Expansion and construction joints shall be as shown on the Construction Standards.

Any units showing cracks or other damages due to curing, transportation, installation or other acts of the Contractor shall be removed and replaced by the Contractor at no additional compensation.

**629.65: Finishing, Curing, and Protective Sealing**

Cast-in-place barrier shall be finished, cured, and sealed according to the applicable specifications of M4.02.14: Precast Concrete Highway Units.

**629.66: Delineators**

Delineators shall be installed in conformance with manufacturer's recommendations at beginnings and ends of each continuous run of barrier with intermediate placement at intervals shown on the Plans.

Delineators shall be mounted at appropriate angles to provide maximum retroreflectivity.

**COMPENSATION**

**629.80: Method of Measurement**

Concrete barrier will be measured by the foot along the center line of top of barrier.

Cast-in-place median barrier cap concrete will be measured by the cubic yard in place.

**629.81: Basis of Payment**

Concrete Barrier will be paid for at the contract unit price per foot which includes full compensation for all labor, equipment; materials including finishing, curing, protective sealing, delineators, reinforcing steel, premolded filler, concrete leveling blocks and all incidental work necessary to complete the work as specified.

Cast-in-place Concrete Median Barrier Cap will be paid for at the contract unit bid price per cubic yard. This unit price shall include full compensation for all labor, tools, equipment, materials, including reinforcing steel, finishing, curing, protective sealing, premolded joint filler, and all incidental work necessary to complete the work as specified.

Gravel borrow for the foundation of the barriers and between the sections will be paid for under Item 151; Gravel Borrow.

**629.82: Payment Items**

629.1	Precast Concrete Barrier - Single Faced .....	Foot
629.2	Precast Concrete Median Barrier - Double Faced.....	Foot
629.3	Cast-in-Place Concrete Barrier - Single Faced.....	Foot
629.4	Cast-in-Place Concrete Median Barrier - Double Faced.....	Foot
629.5	Cast-in-Place Median Barrier Cap.....	Cubic Yard
629.11	32-in. Concrete Barrier, TL-3.....	Foot
629.12	36-in. Concrete Barrier, TL-4.....	Foot
629.13	42-in. Concrete Barrier with Highway Light, TL-4.....	Each
629.14	42-in. Concrete Barrier, TL-5.....	Foot
629.15	54-in. Concrete Barrier, TL-5.....	Foot
629.21	32- to 36-in. Concrete Barrier Transition .....	Each
629.22	36- to 42-in. Concrete Barrier Transition .....	Each
629.23	42- to 54-in. Concrete Barrier Transition .....	Each

**SUBSECTION 701: CEMENT CONCRETE SIDEWALKS, PEDESTRIAN CURB RAMPS AND DRIVEWAYS**

Subsection 701.61: Contractor Quality Control Plan

*Replace the second sentence with the following:*

The QC Plan shall sufficiently document the QC processes of all Contractor parties (i.e., Contractor, Subcontractors, Producers) performing work required under this specification.

## **SUBSECTION 702: HOT MIX ASPHALT SIDEWALKS AND DRIVEWAYS**

### Subsection 702.61: Contractor Quality Control Plan

*Replace the second sentence with the following:*

The QC Plan shall sufficiently document the QC processes of all Contractor parties (i.e. Contractor, Subcontractors, Producers) performing work required under this specification.

## **SUBSECTION 717: METAL BIN-TYPE RETAINING WALL**

### Subsection 717: METAL BIN-TYPE RETAINING WALL

*Delete this subsection.*

## **SUBSECTION 820: HIGHWAY LIGHTING**

### Subsection 820.20: General

*Replace the last paragraph of this subsection with the following:*

It is not intended that every fitting, minor detail or feature be shown and described, as the Contractor or the Subcontractor is assumed to be an expert in the particular area of responsibility and is capable of interpreting the Plans, Specifications and Special Provisions so that the bid shall include all items required and that they shall be provided and installed in a neat and workmanlike manner.

## **SUBSECTION 945: DRILLED SHAFTS**

### Subsection 945.61: Drilled Shafts and Load Tests

*Delete the last sentence of paragraph B., 2., c.*

*Delete the last sentence in the fourth paragraph under B., 4.*

## **SUBSECTION 965: MEMBRANE WATERPROOFING FOR NEW BRIDGE DECKS**

### Subsection 965.61: Contractor Quality Control Plan

*Change the word should to shall and delete the word Prime in the first paragraph.*

## DIVISION III

### MATERIALS SPECIFICATIONS

#### SECTION M1: SOILS AND BORROW MATERIALS

##### Subsection M1.06.0: Organic Soils Additives

*Replace this subsection with the following:*

##### **M1.06.0: Compost**

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 per US Compost Council Seal of Testing Assurance (STA) Program.

In addition, the Contractor shall provide representative 1-gallon 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. Compost tests shall be performed by STA-certified laboratory.

(<https://www.compostingcouncil.org/page/CertifiedLabs>)

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 are acceptable source materials. Biosolids and peat are not acceptable source materials.

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:

**Table M1.06-1: Compost Properties by Type of Compost**

Parameter	Units	Type 1 Organic Amendment to Loam	Type 2 Compost Blanket and Compost for Modified Rock	Type 3 Compost Filter Berm	Type 4 Sediment Barrier Media
pH	pH units	6.0-8.5	6.0-8.5	6.0-8.5	5.0-8.5
Soluble Salt Concentration (Electrical Conductivity)	dS/m	Max 10	Max 5	Max 5	Max 10
Moisture Content	%, wet weight	30-60	30-60	30-60	< 60
Organic Matter Content	%, dry weight	30-65	25-65	25-65	25-100
Particle Size % passing a selected mesh size, dry weight basis	3 inch	-	100% passing	100% passing	2 inch, 99% to 100% passing
Particle Size % passing a selected mesh size, dry weight basis	1 inch	-	90% to 100% passing	90% to 100% passing	-
	3/4 inch	-	65% to 100% passing	70% to 100% passing	3/8 inch, max of 50% passing
	3/8 inch	95% passing	-	-	-
	1/4 inch	95% passing	0% to 75% passing	30% to 75% passing (no more than 60% passing 1/4 inch in high rainfall/flow rate situations)	-
	Particle length	Max. 6 inch	Max. 6 inch	Max. 6 inch	Max. 2 inch
Stability					
Carbon Dioxide Evolution Rate	mg CO <sub>2</sub> -C per g OM per day	< 4	< 4	< 4	< 8
Maturity (plant bioassay)	%, germination and vigor	> 80 / 80	> 80 / 80	N/A	N/A
Physical Contaminants (Man-made inert materials)	%, dry weight	< 0.5% (0.25% film plastic)	< 0.5 (0.25 film plastic)	< 0.5 (0.25 film plastic)	< 0.5 (0.25) film plastic)



## SECTION M3: ASPHALTIC MATERIALS

Subsection M3.01.6: Asphalt Release Agents

Replace this subsection with the following:

Approved asphalt release agents shall be tested in accordance with AASHTO T 383 and be listed on the 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.

Subsection M3.06.4: Hot Mix Asphalt Mixture Design

Replace the first sentence in paragraph G. OGFC Design Requirements with the following:

Each OGFC asphalt mixture shall be designed in accordance with AASHTO R 113, as modified herein.

In Table 3.06.4-7, OGFC Mixture Requirements, Note 2, replace TP 108 with T 401.

Subsection M3.06.5: Verification of Laboratory Trial Mix Formula

In Table 3.06.5-2 OGFC LTMF Verification Limits, replace TP 108 with T 401.

## SECTION M4 CEMENT AND CEMENT CONCRETE MATERIALS

Subsection M4.02.00: Cement Concrete

Replace this subsection with the following:

Producers shall report proposed mix design formulations onto the Department issued mix design sheet in its entirety and submit to the Department for review. Mix design formulations shall meet the requirements specified in the construction standard specifications, contract document special provisions, design plans, and herein. Mix design formulations shall be approved by the Department prior to construction.

Mix design formulations shall be designed with precise proportions of constituent materials, yielding 27.0 ft<sup>3</sup> (1 cubic yard) of cement concrete. All required mix design targets shall be reported on the Department issued mix design sheet for each proposed mix design. Mill certifications and technical data sheets of the constituent materials incorporated into the proposed mix design formulation shall accompany the mix design formulation submission.

Cement concrete shall be classified and reported according to the mix design formulation’s 28-day compressive strength ( $f'_c$ ), nominal maximum aggregate size (NMAS), total cementitious content (lb), air content (%), water-cementitious (w/cm) ratio, paste content (%), paste content-void content (PC/VC) ratio, slump (in.), unit weight (lb/ft<sup>3</sup>), and mix type. Nominal maximum aggregate size (NMAS) shall be determined from the combined aggregate system of the proposed mix design formulation, and is defined as the sieve size immediately above the first sieve size that cumulatively retains more than 10% by mass.

**Table M4.02.00-1: Classifications of Concrete Mixes**

Class 28-Day Compressive Strength	Minimum Total Cementitious Content (Pounds per Cubic Yard of Concrete)		
	1 ½ in.	¾ in.	⅜ in.
2,500 psi	425	470	520
3,000 psi	470	520	565
3,500 psi	520	565	610
4,000 psi	565	610	660
5,000 psi	660	705	760



Subsection M4.02.01: Cement

Delete the second paragraph.

Subsection M4.02.14: Precast Units

Replace this subsection with the following:

**M4.02.14: Precast Concrete Highway Units**

The following Precast Concrete Highway Units shall meet the requirements specified herein:

- (a) Standard Temporary Barriers
- (b) Standard Permanent Barriers
- (c) Box Culverts (Spans ≤ 10 ft)
- (d) Catch Basins
- (e) Drainage Pipes (Non-Dry Cast)
- (f) Manholes
- (g) Retaining Wall Systems
- (h) Traffic Light Pole Bases
- (i) Luminaire Bases

**A. Materials.**

Materials shall meet the requirements specified in Section M4: Cement and Cement Concrete Materials, the following Subsections of Division III, Materials, and specified herein:

Self-Consolidating Concrete for Precast Products.....	M4.02.17
High Performance Cement Concrete.....	M4.06.1
Reinforcing Bars .....	M8.01.0
Epoxy Coated Reinforcing Bars.....	M8.01.7
Galvanized Reinforcing Bars .....	M8.01.8
Primer and Damp-Proofing.....	M9.09.0
Liquid Penetrant/Sealant .....	M9.15.0

**1. Cement Concrete Mix Design Formulation.**

Fabricators shall report proposed mix design formulations onto the Department issued mix design sheet in its entirety and submit to the Department for evaluation. Mix design formulations shall be designed with precise proportions of constituent materials, yielding 27.0 ft<sup>3</sup> (1 cubic yard) of cement concrete. All required mix design targets shall be reported on the Department issued mix design sheet for each proposed mix design.

Cement concrete mix designs shall be classified and reported according to the specified compressive strength of the concrete structure ( $f_c$ ), nominal maximum aggregate size (NMAS), and mix type. The specified compressive strength of the concrete structure ( $f_c$ ) shall be identified from the construction standard specifications, contract document special provisions, and design plans. Nominal maximum aggregate size (NMAS) shall be determined from the combined aggregate system of the proposed mix design formulation, and is defined as the sieve size immediately above the first sieve size that cumulatively retains more than 10% by mass.

Proposed mix design formulations will be evaluated for quality and conformance to the requirements specified herein.

**a. High Performance Cement Concrete for Precast Concrete Barrier.**

Precast concrete barrier shall be fabricated with cement concrete meeting Section M4.06.1: High Performance Cement Concrete.

**b. Self-Consolidating Concrete.**

Precast concrete highway units fabricated with self-consolidating concrete shall meet Section M4.02.17: Self-Consolidating Concrete for Precast Products.

## **2. Cement Concrete Mix Design Verification Testing.**

Upon Department Acceptance of the mix design evaluation, Fabricators proposing new mix design formulations shall select an AASHTO accredited independent laboratory to conduct mix design verification testing. The sampling and testing conducted by the independent laboratory shall be witnessed by the Department. Fabricators shall report the source, type, quantity, and design target for each constituent material incorporated into the proposed mix design onto batch tickets meeting AASHTO M 157 Standard Specification for Ready-Mixed Concrete. Fabricators shall provide Batch tickets to the Department for review. Mix design verification test results shall be within the limits specified in Table M4.02.14-1. Proposed mix design formulations for high performance concrete shall meet the additional requirements specified in Section M4.06.1: High Performance Cement Concrete and self-consolidating concrete shall meet the additional requirements specified in Section M4.02.17: Self-Consolidating Concrete for Precast Concrete Products.

**Table M4.02.14-1: Mix Design Verification Testing Requirements**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Uniformity	T 119 <sup>[1]</sup>	Slump (in.)	< 4 in.	Target -1.0	Target +1.0
			4 - 8 in.	Target -1.5	Target +1.5
	T 121 <sup>[1]</sup>	Unit Weight (lb/ft <sup>3</sup> )	For Information		
Workability	T 119 <sup>[2]</sup>	Segregation Resistance		Pass	
Thermal	T 309	Concrete Temperature (°F)		50	90
Strength	T 22 <sup>[1][3][4]</sup>	Compressive Strength (psi)	3 Days	-	-
			7 Days	-	-
			28 Days	f <sub>c</sub>	-
			56 Days	-	-
Durability	T 358 <sup>[3]</sup>	Surface Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	-	-
			28 Days	15	-
	T 121 <sup>[1]</sup> T 152 <sup>[1]</sup> T 196 <sup>[1]</sup>	Freezing, Thawing, and De-Icing Resistance: Air Content (%)	Target -1.0	Target +1.0	
	C 1567	Alkali Silica Reaction Resistance: Expansion of Accelerated Mortar Bar (%)	14 Days	M4.02.00	

[1] Prior to mix design verification testing, the Cement Concrete Producer shall identify and report the proposed mix design targets onto the Department issued cement concrete mix design sheet. Any adjustments made to the proposed mix design targets shall be based on the verification test results, and are subject to Department approval and the requirements specified herein.

[2] Testing for segregation resistance shall be performed while the concrete is being discharged and during AASHTO T 119 Standard Method of Test for Slump of Hydraulic Cement Concrete. Visual signs of segregation include coarse particles advancing in front of or behind the fine particles and mortar and a tendency for coarse aggregate to separate from the mortar, particularly when the mixture is being consolidated.

[3] Three (3) 4 x 8 in. cylinders shall be cast for each set specified for maximum aggregate size less than 1-1/2 inches. Two (2) 6 x 12 in. cylinders shall be cast for each set specified for maximum aggregate size greater than 1 inch.

**3. Reinforcement for Precast Concrete Barrier.**

Reinforcement for precast concrete barrier shall meet Section M8.01.7: Epoxy Coated Reinforcing Bars or Section M8.01.8: Galvanized Reinforcing Bars, and Grade 60 of the AASHTO M 31 Standard Specification for Deformed and Plain Carbon and Low-Alloy Steel Bars for Concrete Reinforcement. The 1-in. plain dowel bars shall conform to ASTM A36 and shall be galvanized according to AASHTO M 111M/M 111.

## **B. Fabrication Methods.**

Precast Concrete Highway Units shall be fabricated by a Department approved precast or prestressed concrete Fabricator, under the controlled settings of the approved Fabricator's facility, with a Department approved mix design formulation, as specified herein. Fabricators and concrete mix design formulations shall maintain valid listing on the MassDOT Qualified Construction Materials List (QCML). Precast Concrete Highway Units shall be fabricated in conformance with:

- (a) MassDOT Standard Details and Drawings
- (b) Approved Shop Drawings
- (c) Latest edition of the American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Construction Specifications
- (d) Latest edition of the National Precast Concrete Association (NPCA) Quality Control Manual for Precast Concrete Plants
- (e) Latest edition of the Precast Concrete Institute (PCI) MNL-116 Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
- (f) Requirements specified herein

Circular vertical precast reinforced concrete manholes and structures used in sewer, drainage, and water works shall meet AASHTO M 199 Standard Specification for Precast Reinforced Concrete Manhole Sections. Reinforced concrete drainage pipes intended to be used for the conveyance of sewage, industrial wastes, and storm water shall meet AASHTO M 170 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

### **1. Standard Drawings and Details.**

Prior to fabrication of precast concrete highway units, the Fabricator shall prepare shop drawings in accordance with:

- (a) MassDOT Construction Standard Details
- (b) Traffic Standard Drawings for Traffic Signals and highway Lighting
- (c) Signal Structure and Foundation Standard Drawings
- (d) Standard Drawings for Signs and Supports

### **2. Shop Drawings.**

Prior to fabrication of non-standard precast concrete highway units, the Fabricator shall prepare shop drawings in accordance with the relevant provisions of Subsection 5.02 and shall, at a minimum, contain the following, where applicable:

- (a) Fabricator's name and address on each sheet
- (b) Category and Type of Product, Unit Identification Number
- (c) Overall length, width, and height
- (d) Location, size, and geometry of all steel reinforcement, including mechanical reinforcing bar splicers to be used for connecting products together in the field (if called for on plans).
- (e) Location and details of all inserts, anchors, vertical adjustment assemblies, and any other items required to be cast into the product (whether detailed on the plans by the Engineer of Record or provided for the Contractor's convenience).
- (f) Locations and details of the lifting devices, including supporting calculations, type and amount of any additional reinforcing required for lifting. The Fabricator shall design all lifting devices based on the no cracking criteria in the latest edition of the PCI Design Handbook.
- (g) The minimum concrete compressive strength required prior to handling the product.
- (h) Specified concrete design compressive strength ( $f'_c$ ), Nominal Maximum Aggregate Size (NMAS), and Mix Type.

Proposed shop drawings shall be drawn to scale and submitted to the Engineer of Record for review and approval. The shop drawings shall not include procedures for placement, finishing, and curing of concrete. These details shall be included in the Fabricator's Quality Control Plan as specified herein.

### **3. Control, Handling, and Storage of Constituent Materials**

Fabricators shall verify the conformance of the constituent materials to specifications from Quality Control testing and Manufacturer certificates of compliance and meet the control, handling, and storage of constituent materials requirements specified herein.

#### **a. Hydraulic Cement and Supplementary Cementitious Materials.**

Hydraulic cement and supplementary cementitious materials shall be sufficiently controlled, handled, and stored through prevention of moisture absorption, cement caking, and contamination. Hydraulic cement and supplementary cementitious materials shall be stored in weathertight, sufficiently ventilated structures to prevent absorption of moisture. The interior of a cement silo shall be smooth, with a minimum bottom slope of 50 degrees from the horizontal for a circular silo and 55 to 60 degrees for a rectangular silo. Silos shall be equipped with non-clogging air-diffuser flow pads through which small quantities of dry, oil-free, low-pressure air can be introduced intermittently at approximately 3 to 5 psi to loosen cement that has settled tightly in the silos. Storage silos shall be drawn down once per month to prevent cement caking. Each bin compartment from which cement is batched shall include a separate gate, screw conveyor, air slide, rotary feeder, or other conveyance that allows both constant flow and precise cutoff to obtain accurate batching of cement.

Sources of contamination include incorrect sources placed into storage structures and dust contaminants. Storage structures shall be sufficiently labeled to avoid contamination. Contamination shall be sufficiently monitored and controlled during loading and transferring.

#### **b. Aggregate.**

Aggregate shall be sufficiently controlled, handled, and stored through prevention of gradation variation due to segregation and undersized particles, moisture content variation, contamination, degradation, and fracture.

##### **(1) Variation in Gradation.**

Aggregate gradation shall be sufficiently monitored to maintain control of the mix design. Aggregate shall be stockpiled in thin horizontal layers of uniform thickness to limit segregation. Storing aggregate in large conical stockpiles causes segregation and shall be prohibited. Segregation is limited when the coarse aggregate is further divided into several different sized sub-groupings with smaller ranges to be batched separately. Segregation in the coarse aggregate is controlled when the maximum aggregate size to the minimum aggregate size for a given aggregate size grouping is limited to a 4 to 1 ratio for maximum aggregate size less than 1 in. and is limited to a 2 to 1 ratio for maximum aggregate size greater than or equal to 1 in.

Undersized particles for a given coarse aggregate size grouping is defined as material passing the sieve size with an opening  $5/6$  of the nominal minimum size of the coarse aggregate size grouping. Coarse aggregate shall be rescreened as it is charged to the bins to remove undersized particles and undesirable fines if handling and storage methods are unsatisfactory and variations in gradation exceed allowable tolerances.

Storage bins (hoppers) shall be circular or nearly square and their bottoms shall slope more than 50 degrees from the horizontal on all sides to a center outlet. During bin loading, the aggregate shall be discharged directly above and fall vertically into the center of the bin. Discharging aggregate against the side of the bin or baffle wall causes segregation and shall be prohibited. Baffle plates or dividers can minimize segregation. Bins shall be filled to limit variation in gradation caused by withdrawal of material, segregation, and breakage of aggregate particles. Dry fine aggregate when dropped from buckets or conveyors shall be sufficiently shielded from wind and other external forces to prevent loss of fines. Fine aggregate may require dampening to prevent segregation of material.

## **(2) Variation in Moisture Content.**

Aggregate moisture content shall be sufficiently monitored to maintain control of the mix design. Coarse aggregate shall be wetted to keep the aggregate in a constantly saturated condition, to compensate for aggregate absorption, and to provide cooling. Aggregate shall be sufficiently dewatered and drained to form a uniform moisture content and to prevent transfer of excessive free water to the bins. Fine aggregate, due to its surface area, contributes the largest amount of free water added to the mix design. Moisture meters can indicate variations in the moisture of aggregate and moisture compensators can be used for rapid batch weight adjustments, to limit moisture variations in the aggregate. Aggregates washed to remove contaminants shall be stockpiled well before use so that they can drain to a uniform moisture content.

## **(3) Contamination.**

Sources of contamination include overlapping of different aggregate sizes from adjacent stockpiles, aggregate leakage through or around bulkheads in storage bins, underlying soil, dislodged clay lumps and other contaminants from transporting unit, leaves and vegetation, freezing aggregate, incorrect delivery from aggregate manufacturer, and incorrect aggregate size placed into a bin or stockpile. Stockpiles shall be placed on a hard base with sufficient drainage to prevent contamination from underlying material. Bulkheads, dividers, and partitions with sufficient height and ample spacing between piles shall be utilized to avoid cross-contamination and overlapping of different aggregate sources, types, and size groupings between stockpiles. Storage areas shall be sufficiently labeled to avoid contamination. Clay lumps or clay balls shall be removed from the aggregate by placing a scalping screen over the batch plant bin. Aggregate may require washing to remove contaminants. During cold temperatures, bins shall be covered or underground to prevent the freezing of aggregate. Frozen aggregate shall be prohibited from use. Aggregates may require heating to maintain an acceptable aggregate temperature and prevent freezing. Trucks, loaders, dozers, and other heavy transport equipment shall not be operated on the stockpiles due to the potential for aggregate particle fracture and contamination of track dirt onto the piles. Additional measures, including storage area coverings, shall be instituted in cases where storage areas are subject to other sources of contamination.

### **c. Mixing Water.**

Mixing water shall be sufficiently controlled, handled, and stored through prevention of contamination.

### **d. Chemical Admixtures.**

Chemical admixtures shall be sufficiently controlled, handled, and stored through prevention of contamination. Sources of contamination include freezing, evaporation, sunlight, and incorrect chemical admixture sources placed into chemical admixture tanks. Chemical admixtures shall be stored in heated environments to prevent freezing. Frozen chemical admixtures shall be reblended. Long-term storage of liquid admixtures in vented tanks shall be prohibited due to evaporation of the liquid negatively affecting the performance of the mix design. Certain chemical admixtures are prone to sunlight and shall be sufficiently protected in the storage tanks. Storage tanks shall be sufficiently labeled to avoid contamination. Chemical admixtures shall be stored in accordance to the chemical admixture manufacturer's recommendations.

## **4. Temperature Control.**

Concrete shall be batched, mixed, delivered, placed, finished, and cured with ambient temperatures greater than or equal to 40°F and less than or equal to 85°F. The temperature of plastic concrete shall be greater than or equal to 50°F and less than or equal to 90°F. At no point shall the temperature of the concrete exceed 158°F.

Temperature measuring devices shall record and report to the nearest 1°F. The Fabricator shall continuously monitor, record, and report the ambient temperatures surrounding the concrete without interruption, at a minimum frequency of once per hour, until 100% of f'c is attained. The Fabricator shall confirm all temperature requirements meet the specifications herein. Fabricator temperature monitoring records shall be provided to the Department upon request.

**5. Protection from Adverse Conditions.**

The concrete shall be protected from all adverse conditions, including precipitation, cold conditions, and hot conditions, until 100% of  $f'_c$  is attained, as specified Section 901.64: Protection from Adverse Weather.

**6. Batching and Mixing.**

Equipment, measurement, tolerances, procedures, sequencing, and batch ticketing used for the batching and mixing of cement concrete shall meet the applicable standards of AASHTO M 157 Standard Specification for Ready-Mixed Concrete, Concrete Plant Manufacturers Bureau (CPMB), Truck Mixer Manufacturers Bureau (TMMB), National Institute of Standards and Technology (NIST), and the requirements specified herein.

Weigh batch equipment shall be categorized as manual, partially automatic, semiautomatic, and fully automatic. Scales and volumetric devices for measuring quantities of constituent materials shall be calibrated for accuracy through certified field standard weights and product substitute loading. Scales shall be accurate to the greater of  $\pm 0.15\%$  of the scale capacity or  $\pm 0.4\%$  of the applied test load in all quarters of the scale capacity through its range of use. The accuracy of scales and batching equipment shall be inspected routinely and adjusted when necessary. Equipment shall be isolated from plant vibration. Automatic controls shall be protected from dust and weather. Scale and beam pivot points shall be routinely inspected and cleaned. Equipment shall operate within the specified batch-weight tolerances specified in Table M4.02.14-2. Equipment shall be made accessible to the Department for inspection.

**Table M4.02.14-2: Allowable Batching Tolerances of Mix Design Target Weights**

Specification	Constituent Material	Batch Weights > 30% of Scale Capacity		Batch Weights $\leq$ 30% of Scale Capacity	
		Individual Batching Tolerances	Cumulative Batching Tolerances	Individual Batching Tolerances	Cumulative Batching Tolerances
<b>M 157</b>	Hydraulic Cement (%)	$\pm 1.0$ or $\pm 0.3\%$ of scale capacity, whichever is greater		Not less than required weight or 4% more than required weight	
	Hydraulic Cement + Supplementary Cementitious Materials (%)	$\pm 1.0$ or $\pm 0.3\%$ of scale capacity, whichever is greater		Not less than required weight or 4% more than required weight	
	Aggregate (%)	$\pm 2.0$	$\pm 1.0$	$\pm 2.0$	$\pm 3.0$ or $\pm 0.3\%$ of scale capacity whichever is less
	Mixing Water (%)	$\pm 1.0$	Prohibited	$\pm 1.0$	Prohibited
	Chemical Admixtures (%)	$\pm 3.0$	Prohibited	$\pm 3.0$	Prohibited

Cement concrete shall be mixed by stationary mixers, truck mixers, volumetric (continuous) mixers, or portable mixers. Cement concrete shall be mixed thoroughly until the constituent materials are uniformly distributed. Mixers shall be adequately designed with blade or fin arrangements and drum shapes that ensure an end-to-end exchange of materials parallel to the axis of rotation or a rolling, folding, and spreading movement of the batch over itself as it is being mixed. Mixing blades shall be free of wear and hardened concrete.

Modifications to Department approved mix design formulations, including source of constituent materials, design quantities, mix type, combined aggregate system targets, paste system targets, slump targets, air content targets, and compressive strength targets shall be prohibited. However, if slump or air content test results are not within the specified design target ranges, the Fabricator is permitted to submit to the Department a request to review and approve proposed adjustments of chemical admixture dosages. At no point shall the total water or water-cementitious (w/cm) ratio exceed the approved mix design formulation targets. The Producer shall report the adjustments onto the batch ticket. Chemical admixture adjustments without Department approval shall be prohibited. Department approval is subject to performance at the plant, as well as conformance to the requirements specified herein.

#### **7. Formwork.**

Precast Concrete Highway Units shall meet Section 901.61: Forms, Falsework, and Centering and PCI Manual 116-21, Section 2.4 Forms/Molds. Precast concrete barrier shall be cast with the forms in a 180° inverted position and compacted with an approved vibrator.

#### **8. Reinforcement.**

Precast Concrete Highway Units shall meet Section 901.62: Reinforcement and the reinforcement materials requirements specified herein.

#### **9. Handling and Placing of Concrete.**

Precast Concrete Highway Units shall meet Section 901.63: Handling and Placing Concrete.

#### **10. Finishing.**

As-cast formed surface finishes shall be acceptable in appearance, color, and texture. Exposed unformed surface finishes shall be finished by screeding or floating, unless otherwise noted. Under no circumstances shall bleed water or initial curing materials be worked into the surface. The addition of water, spreading of cement, or the use of unacceptable tools, including steel trowels and fresnos to the surface of the concrete shall be prohibited. The concrete shall not be overworked, to prevent premature degradation from excess water and fine material rising to surface. Defects shall be addressed per Section M4.02.14,B.,15: Repairs and Replacement.

#### **11. Final Curing.**

Final curing materials, methods, and procedures shall be applied to all exposed cement concrete surfaces immediately after the completion of finishing operations and final set to prevent the loss of moisture and surface drying. Exposed surfaces from form removal shall be wetted immediately and kept moist until final curing materials are applied.

Final curing materials applied to the concrete shall allow the concrete to mature sufficiently to achieve its designed and desired properties, including strength, volume stability, permeability, durability, and resistance to freezing, thawing, and de-icing cycles. Curing water shall be free of deleterious impurities, causing staining and deterioration. The potential staining ability of curing water shall be evaluated by means of US Army Corps of Engineers CRD-C401 Method of Test For The Staining Properties of Water for instances where curing water quality is questioned.

The Fabricator shall maintain a continuous application of moisture or moisture retention throughout the entire duration of the final curing method cycle and meet the minimum sustained ambient temperature, concrete temperature, duration, and strength requirements as specified herein. Controlled, gradual, and uniform termination of the final curing method cycle shall begin only after all specified conditions are met. The concrete temperature shall be reduced at a rate not to exceed 36°F per hour until the concrete temperature is within 20°F of the ambient temperature.



Termination of final curing methods shall not occur until both the duration and compressive strength requirements are met, as specified in Table M4.02.14-2.

**Table M4.02.14-3: Termination of Final Curing Method**

Product Categories	Methods	Duration	Compressive Strength
Precast Concrete Highway Products (Excluding Barrier)	Form Cure <sup>[1]</sup>	-	≥ 70% of $f'_c$
Precast Concrete Barrier	Liquid Membrane-Forming Compounds <sup>[2]</sup> Saturated Covers Sheet Materials	≥ 3 Days	≥ 80% of $f'_c$
	Curing Water Nozzles	≥ 5 Days	
<p>[1] Final curing materials, methods, and procedures shall be applied to all exposed surfaces not being cured by the form.</p> <p>[2] If the liquid membrane-forming compound is to be removed due to compatibility or bonding concerns, removal shall not take place until the specified application duration is met.</p>			

Concrete cured by way of curing water nozzles, saturated covers, sheet materials, or liquid membrane-forming compounds shall be cured with sustained ambient temperatures greater than or equal to 40°F and less than or equal to 85°F.

Curing water shall not exceed a temperature differential of more than 20°F from the internal concrete temperature, to prevent cracking due to temperature gradients causing strain that exceeds the strain capacity of concrete. Curing water shall remain above freezing temperatures throughout the duration of the curing cycle. Compressive strength cylinders for termination of curing cycle shall be cast and field cured with the same environmental conditions that the concrete is subjected to throughout the entire duration of the curing cycle.

All procedures, operations, materials, and equipment required for adequate curing shall be present and ready for use prior to concrete production.

**a. Curing Water Nozzles.**

Curing water nozzles shall provide the surface of cement concrete with a continuous fine spray of water.

**b. Saturated Covers.**

Saturated covers shall meet AASHTO M 182, Class 3. Saturated covers shall be in good condition, free from holes, tears, or other defects that would render it unsuitable for curing cement concrete. Saturated covers shall be dried to prevent mildew when storing. Saturated covers shall be of sufficient thickness to maximize moisture retention. Saturated covers shall be free of harmful substances that are deleterious or cause discoloration to cement concrete and cementitious materials. Saturated covers shall have the ability to retain sufficient moisture from continuous watering so that a film of water remains on the surface of cement concrete.

Prior to application, saturated covers shall be thoroughly rinsed in water and free of harmful substances that are deleterious or cause discoloration to cement concrete. The Fabricator shall maintain sufficient moisture with continuous watering so that a film of water remains on the surface of the cement concrete throughout the entire duration of the final curing method cycle. Saturated covers shall be properly positioned, secured, and maintained on the surface of the concrete to maximize moisture retention and to prevent moisture loss. The Fabricator shall prohibit saturated covers from drying out and prevent the absorption of curing water from the surface of the concrete. Polyethylene film may be applied over the saturated cover to limit the amount of continuous watering required for sufficient moisture retainage.

**c. Sheet Materials.**

Sheet materials shall meet ASTM C171 Standard Specification for Sheet Materials for Curing Concrete. Sheet materials shall inhibit moisture loss and reduce temperature rise in concrete exposed to radiation from the sun. Adjoining sheet materials shall overlap not less than 12 inches. All edges of the sheet materials shall be secured to maintain a moist environment.

**(1) Polyethylene Film.**

Polyethylene film shall be clear, white, or black in color and consist of a single sheet manufactured from polyethylene resins, be free of visible defects, including tears, wrinkles, and discontinuity. The film shall prohibit mottling and uneven spots from appearing on the surface of concrete, due to variations in temperature, moisture content, or both. Polyethylene film shall accommodate concrete surfaces with constant contact without damage. White polyethylene film shall minimize heat gain caused by absorption of solar radiation. Clear and black polyethylene films shall inhibit absorption of solar radiation and be exclusively applied during cold conditions.

The Fabricator shall prohibit mottling and uneven spots from appearing on the surface of concrete, due to variations in temperature, moisture content, or both. Application of additional curing water under the film or application of a polyethylene film bonded to absorbent fabric to the concrete surface may be required to prevent mottling and to retain and evenly distribute the moisture. The Polyethylene film shall be applied to concrete surfaces with constant contact without damage. The film shall extend beyond the edges of the concrete surface. Edges of adjacent polyethylene film shall overlap a minimum of 6 inches and be tightly sealed with the use of sand, wood planks, pressure-sensitive tape, mastic, or glue to maintain close contact with the concrete surface, retain moisture, and prevent the formation of air pockets.

**(2) White Burlap-Polyethylene Sheeting.**

White burlap-polyethylene sheeting shall be securely bonded to the burlap so to avoid separation of the materials during handling and curing of the concrete.

**(3) Reinforced Impervious Paper.**

Reinforced impervious paper shall be white in color, consist of two sheets of kraft paper cemented together with a bituminous adhesive, and reinforced with embedded cords or strands of fiber running in both directions. Reinforced impervious paper shall be free of holes, tears, and pin holes from deterioration of the paper through repeated use. Reinforced impervious paper shall be treated to prevent tearing when wetted and dried. Reuse of reinforced impervious paper shall be permitted so long as it is able to retain moisture on the surface of concrete. The paper shall be discarded and prohibited from use when moisture is no longer retained in the material.

**d. Liquid Membrane-Forming Compounds.**

Liquid membrane-forming compounds, including compounds with curing properties and compounds with both curing and sealing properties, shall maintain valid listing on the Department Qualified Construction Materials List (QCML) and meet the requirements specified herein.

Compounds shall form a continuous, non-yellowing, and durable film with quality moisture-retention properties. Compounds shall maintain the relative humidity of the concrete surface above 80% for greater than or equal to three (3) days to sustain cement hydration. Compounds shall not affect the original color of the concrete surface. Compounds shall not degrade due to exposure to ultraviolet light from direct sunlight. Compounds shall meet the local and federal allowable Volatile Organic Compound (VOC) content limits.

Liquid membrane-forming compounds shall be applied per the Manufacturer's instructions and recommendations as specified herein. Prior to use, compounds shall be thoroughly mixed, stirred, and agitated. Compounds shall be applied immediately after final finishing and the disappearance of the surface water sheen, but before the free water on the surface has evaporated, to prevent the formation of cracks and loss of moisture at the surface. Careful considerations shall be made by the Fabricator to determine if the evaporation rate is exceeding the rate of bleeding, thus causing the surface to appear dry even though bleeding is still occurring. To diagnose and prevent this condition, the Fabricator shall place a transparent plastic sheet over a test area of the uncured and unfinished concrete surface and shall determine if any bleed water accumulates under the plastic. Under such conditions, the application of liquid membrane-forming compounds to the concrete surface shall be delayed to prevent bleed water from being sealed below the concrete surface, map cracking of the membrane films, reduction in moisture-retention capability, and the need for reapplication of the compound.

When using compounds to reduce moisture loss from formed surfaces, the exposed surface shall be wetted immediately after form removal and kept moist until the compound is applied. The concrete shall be allowed to reach a uniformly damp appearance with no free water on the surface, and then application of the compound shall begin at once. Delayed application resulting in surface drying, absorption of the compound into the concrete, and forming of a discontinuous membrane shall be prohibited.

The concrete surface shall be damp when the compound is applied. Power-driven spray equipment shall be used for uniform application of compounds on large paving projects. Spray nozzles recommended by the compound Manufacturer and use of windshields shall be arranged by the Fabricator to prevent wind-blown loss of compound and to ensure proper coverage application rates are achieved. The compound shall be applied by power sprayer, using appropriate wands and nozzles with pressures between 25 and 100 psi. The Fabricator shall fill the power sprayer with curing compound from the Manufacturer's original container in the presence of the Engineer. Any dilution as recommended by the Manufacturer shall take place in the presence of the Engineer. For very small areas such as repairs, the compound shall be applied with a wide, soft-bristled brush or paint roller.

The Fabricator shall verify the application rate and procedures are in accordance with the Manufacturer's instructions and recommendations. At least one uniform coat shall be applied at a rate of 150 to 200 ft<sup>2</sup>/gallon. On very deeply textured surfaces, the surface area to be treated shall be at least twice the surface area of the surface. In such cases, two separate applications may be needed, each at 200 ft<sup>2</sup>/gallon or greater if specified by the Manufacturer to achieve the desired moisture retention rate, with the first being allowed to become tacky before the second is applied. If two coats are necessary to ensure complete coverage, for effective protection the second coat should be applied at right angles to the first. Complete coverage of the surface shall be attained due to the potential for formation of small pinholes in the membrane, which will result in loss of moisture from the concrete. Compounds shall not sag, run off peaks, or collect in grooves.

Compounds and procedures shall be compatible with concrete surfaces receiving subsequent applications or placements of concrete, overlays, coatings, paints, sealers, finishes or other toppings to ensure acceptable bonding to the concrete. Testing to establish compatibility among the curing compound, subsequent surface treatments, concrete moisture content and the actual finished surface texture of the concrete shall be conducted when compatibility is not known. The compound Manufacturer shall be consulted by the Fabricator to determine the compatibility of the application. Compounds shall not be applied to concrete surfaces where bonding of subsequent applications or placements is incompatible or is of concern. The use of wax-based curing compounds shall be prohibited in instances where concrete surfaces are subject to additional toppings and vehicular, pedestrian, or other traffic.

Deliberate removal of compounds in the presence of the Engineer and in accordance with Manufacturer's instructions and recommendations shall be conducted as an alternative to compatibility testing, incompatibility, or in instances where bonding is of concern. Bonding of subsequent materials may still be inhibited by the presence of the compound even after the moisture retention characteristics of the compound have diminished.

White-pigmented compounds shall be used in instances where solar-heat gain is concern to the concrete surface. White-pigmented compounds shall be agitated in the container prior to application to prevent pigment from settling out resulting in non-uniform overage and ineffective curing.

**(1) Liquid Membrane-Forming Compounds for Curing.**

Liquid membrane-forming compounds for curing shall meet ASTM C309 Standard Specifications for Liquid Membrane Forming Compounds for Curing Concrete and the requirements specified herein.

**Table M4.02.14-4: Types**

Type	Description
Type 1	Clear or translucent without dye
Type 1-D	Clear or translucent with fugitive dye
Type 2	White pigmented

**Table M4.02.14-5: Composition Classification**

Type	Description
Class A	Unrestricted composition, generally wax-based products
Class B	ASTM D883 resin-based products

**(2) Liquid Membrane-Forming Compounds for Curing and Sealing.**

Liquid membrane-forming compounds for curing and sealing shall meet ASTM C1315 Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete and the requirements specified herein. The protective sealing requirements specified in M4.02.14, .B.16 do not apply to cement concrete surfaces previously applied with liquid membrane-forming compounds for curing and sealing.

In addition to moisture-retention capabilities compounds shall exhibit specific properties, including alkali resistance, acid resistance, adhesion-promoting quality, and resistance to degradation by ultraviolet light.

**Table M4.02.14-6: Types**

Type	Description
Type I	Clear or translucent
Type II	White pigmented

**Table M4.02.14-7: Classification**

Type	Description
Class A	Non-yellowing

**12. Form Removal.**

The Fabricator shall not remove forms from the concrete until compressive strength cylinders attain 70% of  $f'_c$ . Compressive strength cylinders for removal of forms shall be cast and field cured with the same environmental conditions that the concrete is subjected to throughout the entire duration of the operation. Immediately following form removal, all exposed concrete surfaces shall be prepared and cured per the requirements specified in.

### **13. Handling and Storage of Concrete Products.**

Precast Concrete Highway Units shall not be handled until form removal strength has been attained. Concrete products shall be lifted at the designated points by approved lifting devices embedded in the concrete and in accordance with proper lifting and handling procedures. Storage areas shall be smooth and well compacted to prevent damage due to differential settlement. Concrete products shall be supported on the ground by means of continuous blocking, in conformance with the approved dunnage plan. The concrete shall be protected from all adverse conditions, including precipitation, cold conditions, and hot conditions, until 100% of  $f'_c$  is attained, as specified Section 901.64: Protection from Adverse Weather.

### **14. Primer and Damp-Proofing of Precast Concrete Drainage Structures.**

The Fabricator shall apply primer and damp-proofing materials, methods, and procedures to the outside surface of the tapered or cone section of precast concrete drainage structures. Precast concrete drainage structures shall be damp-proofed in accordance with Section 970: Damp-Proofing.

### **15. Repairs and Replacement.**

Defects identified during inspection shall be classified in the following categories and a non-conformance report (NCR) shall be initiated if required. The NCR shall be submitted to the Department for review and approval of the Fabricator's proposed NCR disposition. Defects shall be repaired per the approved NCR disposition, with approved materials listed on the MassDOT Qualified Construction Materials List (QCML), according to the PCI Northeast Region Guidelines for Resolution of Non-Conformances in Precast Concrete Bridge Elements, Report Number PCINE-18-RNPCBE, at the expense of the Contractor. Defects requiring Non-Conformance Report (NCR) submission shall be repaired in the presence of Department personnel. All defects regardless of category shall be documented by Quality Control personnel and made available to the Department upon request.

#### **a. Category 1 Surface Defects.**

Category 1 defects do not require repair or Non-Conformance Report (NCR) submission. However, documentation of the identified defects is required by the Fabricator. Surface defects are defined as the following:

- (a) Surface voids or bug holes that are less than 0.625 inches in diameter and less than 0.250 inches in depth, except when classified as Category 3
- (b) Cracks less than or equal to 0.006 inches in width

#### **b. Category 2 Minor Defects.**

Category 2 defects shall be documented. Repairs shall be documented, however, NCR submission is not required by the Fabricator. Minor defects are defined as the following:

- (a) Spalls, honeycombing, surface voids that are less than 2 inches in depth and have no dimension greater than 12 inches
- (b) Cracks greater than 0.006 inches and less than or equal to 0.060 inches in width (cracks shall be sealed according to the PCI Repair Procedure #14 in PCINE-18-RNPCBE)
- (c) Broken or spalled corners without exposed reinforcing steel

#### **c. Category 3 Rejectable Defects.**

Category 3 defects may be cause for rejection, as determined by the Engineer. Category 3 defects shall be documented and reported on the NCR and submitted to the Department. The Fabricator may include proposed repair procedures on the submitted NCR for Department review. However, if the proposed repair procedures are not accepted by the Department, the Precast Concrete Highway Unit shall be rejected. If accepted, proposed repair procedures shall not takeplace prior to Department approval. Rejectable defects are defined as the following, including, but not limited to:

- (a) Surface defects on more than 5% of the surface area
- (b) Minor defects that in total make up more than 5% of the surface area of the unit
- (c) Concentrated area of defects consisting of four or more Category 2 Defects within a 4-square foot area.

- (d) Exposed reinforcing steel
- (e) Spalls, honeycombing and surface voids that are deeper than 2 inches or have any dimension greater than 12 inches, when measured along a straight line
- (f) Cracks greater than 0.060" in width
- (g) Elements fabricated outside of the specified tolerances
- (h) Compressive strength that does not meet  $f'_c$

#### **16. Protective Sealing Compounds for Precast Concrete Barrier.**

The protective sealing requirements specified herein do not apply to cement concrete surfaces previously applied with liquid membrane-forming compounds for curing and sealing.

Protective sealing compounds meeting Section M9.15.0: Liquid Penetrant/Sealant shall be applied to precast concrete barrier per the Manufacturer's instructions and recommendations as specified herein. Protective sealing compounds shall not be applied to concrete while conditions meeting Section 901.64: Protection from Adverse Weather are present.

Curing materials, methods, and procedures shall be applied to the concrete prior to the application of protective sealing compounds. The surface shall be sufficiently prepared, clean, and dry for at least 24 hours with ambient temperatures exceeding 60°F. Protective sealing compounds shall not be applied to the concrete for a minimum of 28 days after the concrete is poured, unless otherwise noted in the manufacturer's instructions and recommendations. Periodic re-application shall be required for protective sealing compounds requiring multiple applications and for concrete surfaces exhibiting wear to ensure long-term protection of the concrete surface.

#### **17. Prior to Loading.**

Prior to the loading the concrete product on to the truck for shipping, the Fabricator shall provide the MassDOT Plant Inspector and RMS a minimum seven-day notice of the Fabricator's intent to load the concrete product. Inspection by the MassDOT Plant Inspector shall take place while the element is still on dunnage in the yard. The unit shall not be loaded onto the truck until the MassDOT Plant Inspector has performed the inspection.

#### **18. Loading.**

Concrete products shall be loaded on a trailer with continuous blocking, in accordance with the approved dunnage plan. Shock-absorbing cushioning material shall be used at all bearing points. Blocking shall be provided at all locations of tie-down straps. Concrete products shall not be subjected to damaging torsional or impact stresses.

#### **19. Shipping.**

Prior to shipment, the Fabricator shall perform the following actions and provide the required documentation to the MassDOT Plant Inspector:

- (a) Precast Concrete Highway Units shall remain at the Fabricator's plant for a minimum of 7 days after cast date.
- (b) QC Inspection Reports shall be signed by the Quality Control Manager and provided to the MassDOT Plant Inspector.
- (c) QC Compressive Strength Test Report Forms attaining Design Strength,  $f'_c$  for the Precast Concrete Highway Unit's representative Sublot shall be generated by the Fabricator and provided to the MassDOT Plant Inspector.
- (d) Certificate of Compliance shall be generated by the Fabricator as described under the Fabricator Quality Control section and provided to the MassDOT Plant Inspector.
- (e) All Department approved Corrective Actions submitted on the Non-Conformance Reports (NCR), shall be verified to have been completed by the MassDOT Plant Inspector and Quality Control Manager.
- (f) All NCRs shall be signed off by the Quality Control Manager and the Department Inspector and/or MassDOT RMS.
- (g) QC Inspection Stamp shall be applied to each unit after loading.

## 20. Delivery.

Upon Delivery, the following documentation shall be provided to the Engineer:

- (a) QC Compressive Strength Test Report Forms attaining Design Strength,  $f_c$  for the Precast Concrete Highway Unit's representative Sublot.
- (b) Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
- (c) QC Inspection Reports signed by the Quality Control Manager.

The Contractor shall inspect the concrete product upon receipt at the site. Concrete products damaged during delivery shall be repaired or replaced per the Department direction, at the Contractor's expense.

### C. Quality Assurance.

Quality Assurance is the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. The Quality Assurance Program is comprised of the six core elements including Contractor Quality Control, Department Acceptance, Independent Assurance, Dispute Resolution, Laboratory Accreditation and Qualification, Personnel Qualification and Certification. The Fabricator shall conduct Quality Control (QC) and the Department will conduct Acceptance throughout the fabrication process, independently from one another.

The quality of the material or product shall be determined through quality measurements from sampling, testing, and inspection. The sampling population for quality measurements shall be comprised of lots and sublots. A lot shall be defined as a specific quantity of material from a single source which is assumed to be produced or placed by the same controlled process. Lots shall be used to represent the population of the produced material and constructed product. The lot size shall be the specified quantity of material produced and placed. A subplot shall be defined as a subdivision of a lot. Sublots shall be used to assess the inspection attributes and quality characteristics of the lot. The subplot size shall be the specified subdivision of quantity for a given lot.

The sampling population for testing and inspection shall be randomly sampled in accordance with ASTM D3665 Standard Practice for Random Sampling of Construction Materials. Random sampling is defined as a small quantity of material or measurement obtained from a lot or subplot, whereby each sample obtained from the lot or subplot has an equal probability of being selected. Selective (non-random) sampling may also be conducted to provide supplemental information to assist in maintaining control of all production and placement processes. Selective sampling shall not replace random sampling and shall not be used in the Department Acceptance decision.

#### 1. Fabricator Quality Control.

Quality Control (QC) shall be established, maintained, and performed by the Fabricator to monitor, assess, and adjust manufacturing, production, fabrication, and construction processes, to maintain continuous control of the process, and to ensure that the final material or product will meet the specified level of quality, through:

- (a) Implementation of the Department approved Quality System Manual (QSM)
- (b) Proper Quality Control organization
- (c) Qualified Production Personnel, including equipment operators and craftsmen incorporated into the manufacturing, production, fabrication, and construction operations
- (d) Certified Quality Control Technicians and Quality Control Managers
- (e) Qualified Quality Control laboratory through the NETTCP Laboratory Qualification Program or accredited through the AASHTO Accreditation Program (AAP)
- (f) Routine QC inspection of equipment, environmental conditions, materials, and workmanship
- (g) Routine QC sampling and testing of material quality characteristics and properties
- (h) Timely analysis of QC results, through statistical analysis (mean, standard deviation, etc), control charts, and conformance to allowable limits
- (i) Immediate initiation of non-conformance reporting and corrective action for non-conforming inspection results, uncontrolled processes, and materials with test results not within allowable limits
- (j) Retention of QC records
- (k)** Conformance to specifications

**a. Quality Control Operating Documents.**

Quality Control operating documents shall be prepared, implemented, and maintained by the Fabricator and submitted to the Department for review and approval prior to the start of fabrication. The Fabricator shall adhere to all policies, practices, procedures, and activities identified in the following Department approved Quality Control operating documents.

**(1) Quality System Manual.**

The Fabricator shall submit a Quality System Manual (QSM) for Department review and approval. The Quality System Manual (QSM) shall document the overall internal Quality Control operating procedures of the Producer's Quality Control System and meet AASHTO R 18 Standard Recommended Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories, AASHTO R 38 Standard Practice for Quality Assurance of Standard Manufactured Materials, and the requirements specified by the Department.

**(2) Quality Control Plans for Contract Work Items.**

When applicable, a Quality Control Plan (QCP) shall be prepared for each contract work item by the Fabricator to document all Quality Control personnel and procedures utilized to maintain control of all production and placement processes. The Quality Control Plan for each contract work item shall meet the NorthEast Transportation Training and Certification Program (NETTCP) Model Quality Control Plan standard format and requirements specified by the Department.

**b. Fabricator Plant Certification.**

At a minimum, the Fabricator shall maintain an active National Precast Concrete Association (NPCA) Plant Certification or Precast/Prestressed Concrete (PCI) Plant Certification.

**c. Quality Control Laboratory.**

The Fabricator shall have all required sampling, testing, and inspection equipment on site and available for use during all phases of fabrication. The equipment shall meet all applicable AASHTO or ASTM standards, maintain required calibration schedules, and be in acceptable working condition.

The Fabricator shall provide a room of sufficient size to house all equipment and to adequately perform all required testing. The room shall include a desk and file cabinet for proper record keeping and have good lighting and ventilation. This room shall be kept for testing and quality control and not used for any other purpose. An additional desk and file cabinet shall be provided for exclusive use of the Engineer.

**d. Quality Control Organization.**

The Fabricator's Quality Control organization shall be comprised of trained, experienced, and qualified Production Personnel, Quality Control Technicians, and Quality Control Managers at the Fabricator's plant, per NPCA and/or PCI and as specified herein. Production Personnel, Quality Control Technicians, and Quality Control Managers shall maintain continuous communication to ensure conformance to specification requirements and to dictate corrective action for non-conformance.

**(1) Production Personnel.**

Production Personnel that are directly responsible for the fabrication of Precast Concrete Highway Units shall be comprised of sufficiently trained, qualified, and experienced craftsmen, equipment operators, foremen, and superintendents. Best practices meeting Department recognized standards, organizations, and programs and requirements specified herein shall be performed by Production Personnel throughout the entire fabrication process.

In addition to the fabrication activities, Production Personnel shall perform continuous self-inspection throughout the entire construction operation, to ensure quality workmanship is performed, through observation and verification of:



- (a) Proper tools and equipment are utilized to perform the work
- (b) Routine maintenance, calibration, and cleaning of tools and equipment is performed
- (c) Proper procedures for shipping, handling, and storage of materials are performed
- (d) Best practices for workmanship are incorporated throughout the construction operation
- (e) Quality appearance of finished material or product

Production Personnel shall be capable of identifying unacceptable materials and products prior to completing the construction operation and shall notify potential non-conformances to the Quality Control Technicians and Quality Control Manager. The Fabricator shall provide continual education, training, and qualification opportunities to Production Personnel to promote quality workmanship practices.

### **(2) Quality Control Technicians.**

Each Quality Control Technician shall be sufficiently trained, qualified, and certified through Department recognized qualification and certification programs or through relevant experience acceptable to the Department.

The Fabricator's Quality Control organization shall include an acceptable number of experienced, trained, and qualified Quality Control Technicians at the Production Facility. The number of Quality Control Technicians shall be determined according to the size of the production operation and the volume of material or product manufactured, produced, or fabricated for each work item. The principle responsibilities of each Production Facility Quality Control Technician include:

- (a) Performing Quality Control sampling, testing, and inspection at the production facility
- (b) Preparing and signing standard Quality Control test and inspection report forms
- (c) Providing routine feedback based on sampling, testing, and inspection results to the Production Personnel, Production Facility Quality Control Manager, and Prime Contractor Quality Control Manager

At a minimum, Quality Control Technicians shall maintain an active American Concrete Institute (ACI) Concrete Field Testing Technician – Grade I certification and Concrete Strength Testing Technician certification. Quality Control Technicians shall be on site and present during all phases of fabrication.

### **(3) Quality Control Manager.**

The principal responsibilities of each Quality Control Manager shall include:

- (a) Establishing the Quality Control system in accordance with the company's Quality System Manual (QSM)
- (b) Preparing Quality Control Plans (if applicable)
- (c) Managing and monitoring the activities of Quality Control technicians
- (d) Communicating routinely with production personnel
- (e) Initiating work suspension and corrective action in instances where materials or products are non-conforming or a process is not in control.
- (f) Ensuring proper Quality Control documentation and records retention

At a minimum, the Fabricator's Quality Control Manager shall meet the following requirements:

- (a) Maintain an active ACI Concrete Field Testing Technician – Grade I Certification
- (b) Maintain an active NETTCP Quality Assurance Technician Certification
- (c) A minimum of six (6) months continuous experience in the fabrication of precast concrete highway products

Quality Control Managers shall be employed full-time (or engaged consultants), on site, and present during all phases of fabrication.

**e. Quality Control Inspection.**

Quality Control inspection shall be performed by qualified Production Personnel and Quality Control Technicians to visually inspect equipment, environmental conditions, materials, and workmanship, per the Department approved Quality Control documents and specified herein. The results and findings of QC inspection shall be documented on the Fabricator’s Inspection Report Forms (IRFs). The Fabricator shall conduct immediate initiation of non-conformance reporting and corrective action for non-conforming inspection results and uncontrolled processes.

**f. Quality Control Sampling and Testing.**

Quality Control sampling and testing shall be performed and reported by qualified Quality Control Technicians, to provide measurement of properties and quality characteristics of the material, to determine the degree of uniformity or the measured variability of materials or products, to monitor the quality and acceptability of the material or product, and to evaluate the control during the production or placement process, per the Department approved Quality Control documents and specified herein. The minimum QC sampling and testing activities shall be in accordance with the requirements specified herein. The results and findings of QC sampling and testing shall be documented on the Fabricator’s Test Report Forms (TRFs). The Fabricator shall conduct immediate initiation of non-conformance reporting and corrective action for materials with test results not within allowable limits.

**(1) Aggregate Sampling and Testing.**

The Fabricator shall conduct routine Quality Control sampling and testing of aggregate quality characteristics and properties, to ensure uniformity and consistency of the material per the requirements specified herein.

**Table M4.02.14-8: QC Sampling and Testing Requirements for Aggregate**

Method	Quality Characteristic
T 27	Particle Size Distribution
T 84	Bulk Specific Gravity Dry
T 85	Bulk Specific Gravity SSD
	Apparent Specific Gravity
	Absorption (%)
T 19	Unit Weight (lb / ft <sup>3</sup> )
	Aggregate Void Content (%)
T 255	Moisture Content (%)

**(2) Concrete Production Sampling and Testing.**

Quality Control sampling and testing shall be conducted during production per the minimum requirements specified herein. Production test results shall be within the limits specified herein.

**Table M4.02.14-9: QC Sampling and Testing Frequency During Concrete Production**

Lot Size	Sublot Size	Frequency
Total quantity of concrete (cy) produced in a year, per approved mix design formulation	50 cy	One (1) per sublot or fraction thereof, minimum One (1) per day

**Table M4.02.14-10: QC Sampling and Testing Requirements During Production**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Uniformity	M 157 <sup>[1]</sup>	Batching Quantities of Constituent Materials		Table M4.07.0-4	
	T 119 <sup>[2][3]</sup>	Slump (in.)	< 4 in.	Target -1.0	Target +1.0
			4 – 8 in.	Target -1.5	Target +1.5
T 121 <sup>[2]</sup>	Unit Weight (lb/ft <sup>3</sup> )	For Information			
Workability	T 119 <sup>[4]</sup>	Segregation Resistance		Pass	
Filling Ability	T 347 <sup>[2][5]</sup>	Slump Flow (in.)	22.0 – 29.0 in. <sup>[6]</sup>	Target -2.0	Target +2.0
Thermal	T 309	Concrete Temperature (°F)		50	90
Strength	T 22 <sup>[2][7]</sup>	Compressive Strength (psi)	Form Removal	70% of $f'_c$ <sup>[8][9]</sup>	-
			Storage in Adverse Conditions	$f'_c$ <sup>[8]</sup>	-
			28 Days	$f'_c$ <sup>[8]</sup>	-
			56 Days	$f'_c$ <sup>[8][9]</sup>	-
Durability	T 121 <sup>[2]</sup>	Air Content (%)		Target -1.5	Target +1.5
	T 152 <sup>[2]</sup>				
	T 196 <sup>[2]</sup>				

[1] Batch tickets shall be provided to the Department by the Producer. Producers shall report the source, type, quantity, and design target for each constituent material incorporated into the proposed mix design onto batch tickets meeting AASHTO M 157 Standard Specification for Ready-Mixed Concrete.

[2] Mix design target shall be identified on the Department issued cement concrete mix design sheet.

[3] Required for non-self-consolidating concrete (SCC).

[4] Required for non-self-consolidating concrete (SCC). Testing for segregation resistance shall be performed while the concrete is being discharged and during AASHTO T 119 Standard Method of Test for Slump of Hydraulic Cement Concrete. Visual signs of segregation include coarse particles advancing in front of or behind the fine particles and mortar and a tendency for coarse aggregate to separate from the mortar, particularly when the mixture is being consolidated.

[5] Required for Self-Consolidating Concrete (SCC).

[6] Mix design target and production test results shall meet the specified range.

[7] Three (3) 4 x 8 in. cylinders shall be cast and tested for each set specified for maximum aggregate size less than 1-1/2 inches. Two (2) 6 x 12 in. cylinders shall be cast and tested for each set specified for maximum aggregate size greater than 1 inch.

[8] The specified compressive strength ( $f'_c$ ) is defined as the minimum compressive strength required to be attained at a specified age for a given concrete structure, as specified in construction standard specifications, contract document special provisions, and design plans.

[9] In instances where the 28-Day test results do not meet the specified limits, 56-Day test results shall meet the 28-Day limits.

**g. Quality Control Records, Documentation, and Analysis.**

The Fabricator shall organize, maintain, and retain Quality Control documentation, including the Quality System Manual, Quality Control Plans for contract work items, plant certification records, personnel qualification and certification records, laboratory accreditation and certification records, daily diaries, record books, databases, Department and Contractor correspondence, random sampling location report forms, test report forms, inspection report forms, certificates of compliance, non-conformance report forms, corrective actions, control charts, quality level analysis, Quality Control test result summary sheets, material quantities produced or placed by lot and subplot, and other Quality Control documentation per the Department Approved Quality System Manual, Quality Control Plan, and specified herein.

At a minimum, the Fabricator shall maintain a filing system for the following QC records and documentation:

- (a) Plant Certification
- (b) QC Laboratory NETTCP Qualification or AASHTO Accreditation
- (c) Qualifications and Certifications for QC Manager(s) and QC Technician(s)
- (d) Approved Quality System Manual (QSM)
- (e) Approved Quality Control Plan (if applicable)
- (f) MassDOT Approved Mix Design Sheet(s) and Approval Letter(s)
- (g) MassDOT Standard Shop Drawings
- (h) MassDOT Approved Shop Drawings
- (i) Manufacturer's Technical Data Sheet for each chemical admixture
- (j) Manufacturer's Mill Certification for hydraulic cement, supplementary cementitious materials, and steel reinforcement
- (k) Batch tickets
- (l) QC Inspection Report Forms (IRFs) for each fabricated concrete product
- (m) QC Test Report Forms (TRFs)
- (n) Non-Conformance Reports (NCRs)
- (o) Documentation of Repairs (if applicable)
- (p) Fabricator Certificate of Compliance (Division I, Subsection 6.01) for each fabricated concrete product
- (q) QC and Production equipment calibrations, verifications, and maintenance documentation.

All QC records and documentation shall be made available upon the request of the Department.

**2. Department Acceptance.**

Acceptance shall be performed by the Department, including consultants under direct contract with the Department independent of the Fabricator, to evaluate the degree of compliance with contract requirements, to monitor the Fabricator's Quality Control activities, to determine the corresponding value for a given product and the acceptability of all material produced and placed through Department acceptance sampling, testing, inspection, evaluation, and documentation.

**a. Acceptance of Quality Control Operating Documents.**

The Department will review all Quality Control operating documents, including the Quality System Manual and Quality Control Plans for contract work items submitted by the Fabricator. Department approval shall be subject to conformance with the requirements specified herein.

**b. Monitoring Fabricator Quality Control.**

The Department will monitor the adequacy of the Fabricator Quality Control System, to ensure Fabricator compliance to all items identified in Quality Control documents, including the Fabricator Quality System Manual and Quality Control Plans for contract work items. Failure to comply with these Quality Control documents may result in work suspension.

**c. Acceptance Inspection.**

Acceptance inspection will be performed and reported by qualified Department (or designee) Acceptance Technicians, to visually inspect equipment, environmental conditions, materials, and workmanship, per the requirements specified herein. The results and findings of Acceptance inspection will be documented on the Department’s Inspection Report Forms (IRFs). The Department will conduct immediate initiation of non-conformance reporting for non-conforming inspection results and uncontrolled processes.

**d. Acceptance Sampling and Testing.**

Acceptance sampling and testing will be performed and reported by qualified Department (or designee) Acceptance Technicians, to provide quality characteristic data used for Department Acceptance determination, per the requirements specified herein. The results and findings of Acceptance sampling and testing will be documented on the Department’s Test Report Forms (TRFs). The Department will conduct immediate initiation of non-conformance reporting and corrective action for materials with test results not within allowable limits.

**(1) Concrete Production Sampling and Testing.**

Acceptance sampling and testing will be conducted during production per the minimum requirements specified herein. Production test results shall be within the limits specified herein.

**Table M4.02.14-11: Acceptance Sampling and Testing Frequency During Concrete Production**

Lot Size	Sublot Size	Frequency
Total quantity of concrete (cy) produced in a year, per approved mix design formulation	50 cy	One (1) per sublot or fraction thereof, minimum One (1) per day

**Table M4.02.14-12: Acceptance Sampling and Testing Requirements During Production**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Uniformity	M 157 <sup>[1]</sup>	Batching Quantities of Constituent Materials		Table M4.08.0-1	
	T 119 <sup>[2][3]</sup>	Slump (in.)	< 4 in.	Target -1.0	Target +1.0
			4 – 8 in.	Target -1.5	Target +1.5
T 121 <sup>[2]</sup>	Unit Weight (lb/ft <sup>3</sup> )	For Information			
Workability	T 119 <sup>[4]</sup>	Segregation Resistance		Pass	
Filling Ability	T 347 <sup>[2][5]</sup>	Slump Flow (in.)	22.0 – 29.0 in. <sup>[6]</sup>	Target -2.0	Target +2.0
Thermal	T 309	Concrete Temperature (°F)		50	90
Strength	T 22 <sup>[2][7]</sup>	Compressive Strength (psi)	7 Days	-	-
			28 Days	f <sub>c</sub> <sup>[8]</sup>	-
			56 Days	f <sub>c</sub> <sup>[8][9]</sup>	-
Durability	T 121 <sup>[2]</sup> T 152 <sup>[2]</sup> T 196 <sup>[2]</sup>	Air Content (%)		Target -1.5	Target +1.5

[1] Batch tickets shall be provided to the Department by the Cement Concrete Producer. Producers shall report the source, type, quantity, and design target for each constituent material incorporated into the proposed mix design onto batch tickets meeting AASHTO M 157 Standard Specification for Ready-Mixed Concrete.

[2] Mix design target shall be identified on the Department issued cement concrete mix design sheet.

- [3] Required for non-self-consolidating concrete (SCC).
- [4] Required for non-self-consolidating concrete (SCC). Testing for segregation resistance shall be performed while the concrete is being discharged and during AASHTO T 119 Standard Method of Test for Slump of Hydraulic Cement Concrete. Visual signs of segregation include coarse particles advancing in front of or behind the fine particles and mortar and a tendency for coarse aggregate to separate from the mortar, particularly when the mixture is being consolidated.
- [5] Required for Self-Consolidating Concrete (SCC).
- [6] Mix design target and production test results shall meet the specified range.
- [7] Three (3) 4 x 8 in. cylinders shall be cast for each set specified for maximum aggregate size less than 1-1/2 inches. Two (2) 6 x 12 in. cylinders shall be cast for each set specified for maximum aggregate size greater than 1 inch.
- [8] The specified compressive strength ( $f'_c$ ) is defined as the minimum compressive strength required to be attained at a specified age for a given concrete structure, as specified in construction standard specifications, contract document special provisions, and design plans.
- [9] In instances where the 28-Day test results do not meet the specified limits, 56-Day test results shall meet the 28-Day limits.

Subsection M4.02.16: Precast Drainage Structures

*Delete this subsection.*

Subsection M4.06.1: High Performance Cement Concrete

*Replace this subsection with the following;*

**M4.06.1: High Performance Concrete**

High Performance (HP) Concrete shall meet the requirements of M4: Cement and Cement Concrete Materials and the requirements specified herein. HP Concrete shall be designed and produced with precise proportions of constituent materials to form a homogenous composition with a well distributed, spaced, and sized air void system and quality concrete properties. HP Concrete shall exhibit acceptable quality characteristics and material properties, including uniformity, workability, bleeding and settlement, setting, thermal effects, shrinkage control, strength, modulus of elasticity, aesthetics, long-term durability, and resistance to premature deterioration due to freezing, thawing, and de-icing cycles, alkali silica reaction, corrosion of steel reinforcement, abrasion, erosion, sulfate reaction, salt crystallization, acid disintegration, carbonation reaction, delayed ettringite formation, and marine environments for the expected service life of the structure.

The Contractor may elect to use fly ash, slag cement, silica fume, or a combination thereof provided that the dosage limits, permeability, and strength provisions contained herein are satisfied and the MassDOT Research and Materials Section (RMS) has approved the trial batches and mix design. Changing the mix design shall not be accepted and approved by RMS without the preparing, testing, and approval of trial batches for the revised mix design. HP Concrete shall meet AASHTO M 157 Standard Specification for Ready-Mixed Concrete.

**Table M4.06.1-1: Classifications of HP Concrete**

28 Day Compressive Strength	Nominal Maximum Coarse Aggregate Size (in.)	Maximum Total Cementitious Content (lb per yd <sup>3</sup> )
4,000 psi	¾	585
4,000 psi	⅜	610
5,000 psi	¾	685
5,000 psi	⅜	710
6,500 psi	⅜, ½, ¾	-
8,000 psi	⅜, ½, ¾	-

Prior to concrete placement, the Contractor shall develop and forward a copy of the HP 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.

Trial batch testing will be performed on samples of the same contents and proportions as the HP Concrete to be used in the proposed structures. AASHTO T 358 Standard Method of Test for Surface Resistivity Indication of Concrete’s Ability to Resist Chloride Ion Penetration or AASHTO TP 119 Standard Method of Test for Electrical Resistivity of a Concrete Cylinder Tested in a Uniaxial Resistance Test shall be conducted and meet the requirements specified in Table M4.06.1-2.

**Table M4.06.1-2: Durability Requirements**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Durability	T 358 <sup>[1][2][3]</sup>	Surface Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
			28 Days	21	-
	Or				
	TP 119 <sup>[1][2][3]</sup>	Uniaxial Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
28 Days			10.4	-	

[1] Three 4 x 8 in. cylinders shall be cast for each set specified.

[2] This test method has been known to have compatibility issues with mix designs containing calcium nitrite chemical admixtures or steel fibers. As a result, inclusion of these materials into the test specimens may negatively affect test results. An additional set of cylinders shall be cast and tested without the noted materials. The calcium nitrite shall be replaced by an equivalent quantity of water. A correction factor shall be determined by the following equation:

$$CF = PR_{REMOVED} / PR_{MIX DESIGN}$$

where  $PR_{REMOVED}$  = Penetration Resistivity with noted materials removed,  $PR_{MIX DESIGN}$  = Penetration Resistivity of original mix design with noted materials included, and CF = Correction Factor. The correction factor established during the mix design verification shall be applied to the penetration resistivity test results to compensate for the noted materials. The corrected penetration resistivity ( $PR_{CORRECTED}$ ) shall be determined by the following equation and meet the specified limits identified in the table:

$$PR_{CORRECTED} = PR_{MIX DESIGN} * CF$$

[3] Specimens shall be moist cured in accordance with AASHTO T 22 Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens and shall be in saturated surface dry (SSD) condition during testing.

**A. Supplementary Cementitious Materials.**

High Performance Concrete shall meet the supplementary cementitious materials (SCM) requirements specified in Section M4 and the content target requirements specified in Table M4.06.1-3. SCMs shall be incorporated into the mix design formulation to successfully mitigate alkali silica reaction (ASR) without exceeding the SCM content requirements. High Performance Concrete shall meet the ASR requirements specified in Section M4.02.00: Cement Concrete. SCM content is defined as the percent by mass replacement of hydraulic cement.

**Table M4.06.1-3: SCM Content Target**

<b>Supplementary Cementitious Material</b>	<b>SCM Content</b>
Blended Hydraulic Cement Content <sup>[1]</sup>	[2]
Fly Ash (Class F) Content	15 – 30
Slag Content	20 – 50
Silica Fume Content	7 – 15
Total Fly Ash and Silica Fume Content	≤ 35
Total SCM Content	≤ 50

<sup>[1]</sup> The SCM content of blended hydraulic cement shall be identified on the Manufacturer's certified mill test report.

<sup>[2]</sup> SCMs in blended hydraulic cement shall meet the total cementitious material requirements for fly ash, slag, and silica fume specified in the table.

#### **B. Water-Cementitious Ratio.**

The water-cementitious ratio shall be 0.40 maximum. The water content of all additives shall be included in the water-cementitious ratio.

#### **C. Air Content.**

Cement concrete shall meet the air content targets specified in Section M4.02.00, Table M4.02.06-1: Air Content Target.

#### **D. Chemical Admixtures.**

Chemical admixtures incorporated into cement concrete shall meet Section M4.02.05: Chemical Admixtures and be precisely dosed per admixture manufacturer recommendations to meet the required properties of HP Concrete.

HP Concrete shall be formulated with 3.0 gal of corrosion inhibiting admixture per yd<sup>3</sup> of concrete in order to increase the active corrosion threshold to 9.9 lb of chloride per yd<sup>3</sup> of concrete at the reinforcing bar level. Acceptance will depend upon the material's conformance, as documented by certified test results, to all applicable sections of AASHTO M 194M/M 194. The calcium nitrite solution shall contain 30 ± 2% calcium nitrite by weight. The calcium nitrite material shall have neutral set characteristics.

#### **E. Paste and Void Content.**

HP Concrete shall be designed with a paste content that decreases the tendency of shrinkage cracking, while also adequately filling the voids of the concrete to provide sufficient separation and effective bonding between the aggregate particles. HP Concrete shall meet Table M4.06.1-4.



**Table M4.06.1-4: Paste and Void Content Target**

Property	Design Parameter	Target
Shrinkage Resistance	Paste Content Target (%)	≤ 30 <sup>[1][2]</sup>
Workability	Paste Content to Void Content (PC/VC) Ratio	1.1 – 1.75 <sup>[2]</sup>
<p>[1] Not applicable to mix design formulations incorporating sufficiently designed dosages of S-SRA Shrinkage Reducing or Type S-CRA Crack Reducing chemical admixtures meeting Section M4.05.0.</p> <p>[2] Not applicable to specialized mix design formulations, including self-consolidating concrete.</p>		

Section M4.06.2: High Early Strength Concrete

*Add this new subsection:*

**M4.06.2: High Early Strength Concrete**

High Early Strength Concrete shall meet the requirements of Section M4: Cement and Cement Concrete Materials and the requirements specified herein. High Early Strength Concrete shall meet the requirements specified in Table M4.06.2-1.

**Table M4.06.2-1: Verification Testing Requirements**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Strength	AASHTO T 22 <sup>[1]</sup>	Compressive Strength (psi)	12 Hours	Informational	
			24 Hours	2500	-
			3 Days	4000	-
			7 Days	5000	-
			28 Days	Informational	
	AASHTO T 97 <sup>[2]</sup>	Flexural Strength (psi)	12 Hours	Informational	
			24 Hours	400	-
			3 Days	550	-
			7 Days	650	-
			28 Days	Informational	
	ASTM C882 <sup>[3]</sup>	Slant Sheared Bond Strength (psi)	24 Hours	1200	-
			7 Days	1900	-
			28 Days	2200	-
Setting	AASHTO T 197	Initial Set (min.)		Informational	
		Final Set (min.)		Informational	
Shrinkage Cracking Resistance <sup>[5]</sup>	AASHTO T 160 <sup>[4]</sup>	Unrestrained Volume Change (µε)	28 Days	-	420
	ASTM C1581 <sup>[6]</sup>	Restrained Shrinkage	28 Days	No Cracking <sup>[7]</sup>	
	Or				
	AASHTO T 363 <sup>[8]</sup>	Restrained Shrinkage (psi)	7 Days	-	0.6T <sup>[9]</sup>
Durability	AASHTO T 358 <sup>[1][10]</sup>	Surface Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
			28 Days	21	-
	Or				
	AASHTO TP 119 <sup>[1][10]</sup>	Uniaxial Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
			28 Days	10.4	-

[1] Three (3) 4 x 8 in. cylinders shall be cast and tested for each age specified for maximum aggregate size less than 1-1/2 inches. Two (2) 6 x 12 in. cylinders shall be cast and tested for each age specified for maximum aggregate size greater than 1 inch.

[2] For applications where the concrete is subject to flexural stresses: Two (2) 6 x 6 x 20 in. beams shall be cast for each age specified.

[3] For applications where bond strength is desired.

[4] For applications where the concrete is not subject to restraining stresses.

[5] Not applicable to mix design formulations incorporating sufficiently designed dosages of Type S-SRA Shrinkage Reducing or Type S-CRA Crack Reducing chemical admixtures meeting Section M4.02.05.

[6] For nominal maximum aggregate sizes less than or equal to 1/2 in and for applications where the concrete is subject to restraining stresses.

[7] Cracking is defined as the sudden decrease in compressive strain greater than 30  $\mu\epsilon$ .

[8] For any nominal maximum aggregate size and for applications where the concrete is subject to restraining stresses. The circumferential residual stress in the specimen at the inner face of the specimen ( $\sigma\theta$ (RIC)) shall be calculated according to AASHTO T 363.

[9] The splitting tensile strength (T) at 28 days shall be determined by AASHTO T 198 Standard Method of Test for Splitting Tensile Strength of Cylindrical Concrete Specimens.

[10] Specimens shall be moist cured in accordance with AASHTO T 22 Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens and shall be in saturated surface dry (SSD) condition during testing.

**Section M4.06.3: Rapid Hardening Concrete**

*Add this new subsection:*

**M4.06.3: Rapid Hardening Concrete**

Rapid Hardening Concrete shall meet the requirements of M4: Cement and Cement Concrete Materials and the requirements specified herein. Rapid Hardening Concrete shall meet the requirements specified in Table M4.06.3-1.

**Table M4.06.3-1: Verification Testing Requirements**

Property	Method	Quality Characteristic		Limits	
				Min.	Max.
Strength	AASHTO T 22 <sup>[1]</sup>	Compressive Strength (psi)	2 Hours	Informational	
			4 Hours	2500	-
			6 Hours	Informational	
			24 Hours	4000	-
			7 Days	5000	-
			28 Days	Informational	
	AASHTO T 97 <sup>[2]</sup>	Flexural Strength (psi)	2 Hours	Informational	
			4 Hours	400	-
			6 Hours	Informational	
			24 Hours	550	-
			7 Days	650	-
			28 Days	Informational	
	ASTM C882 <sup>[3]</sup>	Slant Sheared Bond Strength (psi)	24 Hours	1200	-
			7 Days	1900	-
			28 Days	2200	-
Setting	AASHTO T 197	Initial Set (min.)		Informational	
		Final Set (min.)		Informational	
Shrinkage Cracking Resistance	AASHTO T 160 <sup>[4]</sup>	Unrestrained Volume Change ( $\mu\epsilon$ )	28 Days	-	420
	ASTM C1581 <sup>[5]</sup>	Restrained Shrinkage	28 Days	No Cracking <sup>[6]</sup>	
	Or				

	AASHTO T 363 <sup>[7]</sup>	Restrained Shrinkage (psi)	7 Days	-	0.6T <sup>[8]</sup>
Durability	AASHTO T 358 <sup>[1][9]</sup>	Surface Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
			28 Days	21	-
	Or				
	AASHTO TP 119 <sup>[1][9]</sup>	Uniaxial Chloride Ion Penetration Resistance (kΩ-cm)	7 Days	Informational	
28 Days			10.4	-	

- [1] Three (3) 4 x 8 in. cylinders shall be cast and tested for each age specified for maximum aggregate size less than 1-1/2 inches. Two (2) 6 x 12 in. cylinders shall be cast and tested for each age specified for maximum aggregate size greater than 1 inch.
- [2] For applications where the concrete is subject to flexural stresses: Two (2) 6 x 6 x 20 in. beams shall be cast for each age specified.
- [3] For applications where bond strength is desired.
- [4] For applications where the concrete is not subject to restraining stresses.
- [5] For nominal maximum aggregate sizes less than or equal to 1/2 in and for applications where the concrete is subject to restraining stresses.
- [6] Cracking is defined as the sudden decrease in compressive strain greater than 30 µε.
- [7] For any nominal maximum aggregate size and for applications where the concrete is subject to restraining stresses. The circumferential residual stress in the specimen at the inner face of the specimen (σ<sub>θ</sub>(RIC)) shall be calculated according to AASHTO T 363.
- [8] The splitting tensile strength (T) at 28 days shall be determined by AASHTO T 198 Standard Method of Test for Splitting Tensile Strength of Cylindrical Concrete Specimens.
- [9] Specimens shall be moist cured in accordance with AASHTO T 22 Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens and shall be in saturated surface dry (SSD) condition during testing.

**Section M4.06.2: Lightweight High Early Strength Concrete**

Add this new subsection:

**M4.06.4: Lightweight Concrete**

Lightweight Concrete shall meet the requirements of Section M4: Cement and Cement Concrete Materials and the requirements specified herein. Lightweight Concrete shall be formulated with lightweight aggregate meeting Section M4.02.03: Lightweight Aggregates. Lightweight Concrete shall meet the requirements specified in Table M4.06.4-1.

**Table M4.06.4-1: Verification Testing Requirements**

Property	Method	Quality Characteristic	Limits	
			Min.	Max.
Unit Weight	ASTM C567	Calculated Equilibrium Density, E <sub>c</sub> (lb/ft <sup>3</sup> ) <sup>[1]</sup>	-	115.0

[1] Measured Oven Dry Density (O<sub>m</sub>) shall be used for Calculated Equilibrium Density (E<sub>c</sub>).

## SECTION M7: PAINTS, PROTECTIVE COATINGS AND PAVEMENT MARKINGS

### Section M7.00.0: General Requirements for Paints and Protective Coatings

*Replace this subsection with the following:*

All paint shall conform to the following general requirements.

#### **1. Materials.**

The raw materials used in the following specifications for paints and protective coatings shall conform to the ASTM or AASHTO specifications.

#### **2. Proportions.**

Paint proportions and percentages given in the following specification are expressed by weight.

#### **3. Condition in the container.**

Paint and protective coatings shall be homogeneous, free of contaminant and of a consistency suitable for use in the capacity for which it is specified. The finished product shall be well ground and the pigment shall be properly dispersed and suspended in the vehicle according to the requirements of the paint or protective coating. The dispersion shall be of such nature that the pigment does not settle badly, does not cake or thicken in the container, and does not become granular, jelled or curdled. Any settlement of pigment in the paint or protective coating shall be a thoroughly wetted soft mushy mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily dispersed, with a minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.

#### **4. Packaging.**

The finished paint or protective coating shall be furnished in new 5-gal, round, non-tapered containers. The containers shall meet U.S. Department of Transportation Hazardous Materials Shipping Regulations.

The following information shall be labeled on each container in a clear legible manner:

- a) Name of Manufacturer
- b) Place of Manufacture
- c) Manufacturer's Batch Number
- d) MassDOT Specification Number
- e) Date of Manufacture

Precautions concerning the handling and the application of the paint or protective coating shall be shown on the label.

#### **5. Testing.**

Testing of paints will be done by the Department in accordance with the methods of Federal Test Method Standard Number 141, AASHTO and ASTM methods described below.

In addition, the Department reserves the right to make use of any information or methods of testing to determine the quality of paint and paint materials.

### M7.01.3: Liquid Thermoplastic Striping Material

*In the first paragraph of B. Sampling and Testing, 2. Testing replace AASHTO M 249 with AASHTO T 250.*

### M7.01.07: Glass Beads

*Replace this subsection with the following:*

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 QCML.

All glass beads shall meet the requirements of AASHTO M 247, and be tested in accordance with 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 and shall meet the AASHTO concentration for heavy metals, 200 ppm maximum, as tested in accordance with EPA test methods 3052, 6010B and 6010c, or AASHTO T 392. The silica content shall be 60% minimum (ASTM C169).
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 M 247, 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-lb or greater polyethylene-lined burlap paper 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 Department accompanied by:

- a. Certificate of Compliance stating that the material complies with AASHTO M 247, and tested in accordance with AASHTO T 346 and all applicable MassDOT requirements;
- b. Independent lab test results; and
- c. One bag of glass beads per batch in sample bags meeting the specifications above for verification testing.

#### M7.02.: Structural Paint

*Replace this subsection with the following:*

##### **1. General**

New coatings systems shall be a low VOC that meets current VOC regulations. Coating systems shall be selected from the MassDOT QCML-NEPCOAT Qualified Products List "B". Structural paint will be tested according to the following:

- ASTM D 562 Consistency,
- ASTM D 1475 Density,
- ASTM D3723 Pigment
- ASTM D 2369 Volatile Content
- AMS STD 595 Federal color Index

