DESIGNER NOTES

*All notes to the designer are highlighted. Please read the notes carefully. This special provision has been developed by MassDOT and shall be used for all Prefabricated Bridge Units. Please only modify content highlighted in yellow. Un-highlighted content shall not be modified.*

*Special provisions content highlighted in yellow that may need to be modified includes the following:*

* *Include applicable special provision (galvanizing or Metalizing) for steel beam coating (Page 10).*
* *Indicate requirements for closure pour concrete on the plans (Page 22).*
* *Delete the entire* COMPENSATION *section when used as part of Item 995. (Page 22 – COMPENSATION). However, the Unit of Measurement for the Item 995. Schedule of Basis for Partial Payment shall be each (EA) and the quantity shall be the number of individual prefabricated bridge units to be supplied and assembled to into the bridge structure. DO NOT break the prefabricated bridge units into their constitutive components (e.g. CY of concrete, LB of structural steel) and lump these quantities with the field installed materials as this creates needless work for the resident engineer to separate them when paying contractors. See Bridge Manual, Part I, Chapter 5 for more information.*

*DELETE ALL DESIGNER NOTES, AND REMOVE HIGHLIGHTING PRIOR TO SUBMITTAL*

# PREFABRICATED BRIDGE UNITS (PBUs)

### General.

The work under this Heading consists of fabricating, transporting, and erecting Prefabricated Bridge Units (PBUs) and includes all labor, materials, equipment and incidentals necessary to complete the work as shown on the Plans. PBUs consist of shop assembled pairs of structural steel beams and associated diaphragms with shop cast reinforced concretedeck slabs that are fabricated off site and shipped as units. The work shall conform to the MassDOT Standard Specifications and the requirements of the current AASHTO LRFD Bridge Construction Specifications, supplemented by the current relevant provisions of the latest edition of PCI MNL-116 (The Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products), except as noted herein. MassDOT contract documents shall take precedence over the AASHTO LRFD Bridge Construction Specifications and PCI MNL-116. Subsection M4.02.14 of the MassDOT Standard Specifications is superseded in its entirety by the requirements specified below.

## QUALITY ASSURANCE FOR STRUCTURAL STEEL

### General.

Quality Assurance requirements for the fabrication of structural steel shall be as specified in Section 960 and shall be performed at the structural steel plant during fabrication, at the precast concrete plant during PBU assembly, and in the field for final erection and assembly. Quality Assurance requirements for the assembly of the structural steel elements and fabrication of precast concrete deck slabs shall be as specified below.

### Quality Control for Structural Steel.

The work under this subheading shall conform to the relevant provisions of Section 960 and shall include the supply, fabrication, and assembly of beams and diaphragms into PBUs. Fabricators shall be approved by MassDOT in accordance with Standard Specifications, Division I, Section 6.01. The steel Fabricator shall provide qualified work crew(s) and QC inspectors to the precast concrete plant as needed to perform all steel fabrication and assembly work that is required to be performed for the fabrication of the PBUs.

### Acceptance for Structural Steel.

Structural steel elements shall conform to the requirements of the specifications and shall be accepted by MassDOT prior to being released from the steel Fabricator for shipment to the precast plant. The structural steel for the PBUs shall be assembled at the precast concrete plant and the assembly shall be accepted by MassDOT at the precast concrete plant prior to casting the deck.

## QUALITY ASSURANCE FOR PRECAST CONCRETE

### General.

Quality Assurance includes all the planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. It is an all-encompassing term that includes Quality Control (performed by the Fabricator) and Acceptance (performed by MassDOT). Quality Control is the system used by the Contractor and Fabricator to monitor and assess their production processes at the plant facility and installation activities at the project site to ensure that the final product will meet the specified level of quality. Acceptance includes all factors used by MassDOT to determine the corresponding value for the product. MassDOT Acceptance inspection at the plant facility is intended as a means of evaluation of compliance with contract requirements. Contractor and Fabricator Quality Control activities and MassDOT Acceptance activities shall remain independent from one another. MassDOT Acceptance activities shall not replace Fabricator Quality Control activities.

### Fabricator Quality Control.

Quality Control shall be performed by the Fabricator to ensure that the product is fabricated in conformance with the specifications herein. The Fabricator shall maintain a Quality Control system to monitor, assess, and adjust placement and fabrication processes to ensure the PBU(s) meet the specified level of quality, through sufficient Quality Control sampling, testing, inspection, and corrective action (where required). The Fabricator’s Quality Control system shall address all key activities during the placement and fabrication and shall be performed in conformance with the Fabricator’s NPCA or PCI Certification. Quality Control documentation shall meet the requirements of the *Fabricator Quality Control – Documentation* section below. Upon request, Fabricator Quality Control documentation shall be provided to the MassDOT Plant Inspector.

#### Plant.

Prior to the fabrication of PBUs, the Fabricator’s precast concrete plant shall obtain the following:

1. Certification by the National Precast Concrete Association (NPCA) Plant Certification Program or Precast/Prestressed Concrete Institute (PCI) Plant Certification Program, for PBU fabrication
2. MassDOT Prequalification
3. MassDOT Mix Design Approval

All concrete for a given PBU shall be produced by a single company and plant, unless otherwise approved by the Engineer.

#### Personnel.

The Fabricator shall provide adequate training for all QC personnel in accordance with NPCA or PCI certification. There shall be sufficient personnel trained and certified to perform the tests listed under Subsection M4.02.13, Part D. At a minimum, the Fabricator’s Quality Control Personnel shall maintain the following qualifications and certifications:

1. QC Manager with an active NETTCP Field Technician or ACI Concrete Field Testing Technician – Grade I certification or higher, and a minimum of 5 years continuous experience in the manufacture of PBUs for state transportation departments. The QC Manager shall be on site while the batch plant is producing and placing concrete for MassDOT projects.
2. A Technician/Inspector having the Precast/Prestressed Concrete Institute (PCI) Technician/Inspector Level I or NorthEast Transportation Training and Certification Program (NETTCP) Precast Concrete Inspector, or higher.

The Contractor shall submit to the Engineer a copy of the Fabricator’s Quality Control Personnel required qualifications, as specified above.

#### Laboratory.

The Fabricator shall provide a room of sufficient size to house all equipment and to adequately perform all testing. The room shall have either a separate moisture storage room or curing box for concrete cylinders, and it shall be thermostatically controlled to maintain temperatures consistent with AASHTO T 23. It shall include a desk and file cabinet for proper record keeping, and have good lighting and ventilation. This room shall be kept for testing and quality control and not used for any other purpose. An additional desk and file cabinet shall be provided for exclusive use of the Engineer. No exception from these requirements will be allowed without the express written permission of the Engineer.

#### Testing Equipment.

At a minimum, the Fabricator’s plant facility shall have the following testing equipment:

1. Air Content Meter Type A or B: AASHTO T 152
2. Air Content Meter Volumetric Method: AASHTO T 196 (Required for Lightweight Concrete)
3. Slump Cone: AASHTO T 119
4. Cylinder Molds AASHTO M 205
5. Concrete Testing Machine: AASHTO T 22
6. Screening Sieve: AASHTO T 27, AASHTO T 11
7. Curing Box: AASHTO T 23
8. Spread Test Base Plate for Self-Consolidating Concrete (SCC): ASTM C1611
9. All other equipment prescribed by AASHTO and ASTM standards for the tests to be performed by the Fabricator as specified

#### Inspection.

Quality Control personnel shall monitor and inspect the fabrication of each PBU. Quality Control personnel shall report all inspection activities on Quality Control Inspection Reports and non-conformances on Non-Conformance Reports (NCRs) throughout the entire fabrication process, as speciefied herein.

#### Temperature Monitoring.

At a minimum, the Fabricator shall monitor, record, and report the temperatures of the form, ambient temperatures surrounding the concrete, and temperatures of the concrete continuously, without interruption as specified below:

1. Prior to placement of concrete to verify that Ti ≥ 50°F.
2. Immediately after placement to verify that Ti ≥ 50°F is maintained.
3. Throughout the entire duration of the curing cycle, at regular intervals not to exceed one hour until 100% Design Strength (f’c) is attained and concrete has cooled to within 40°F of the ambient temperature surrounding the Prefabricated Bridge Unit.

At a minimum, the temperature measuring devices shall record and report the temperature of the concrete to the nearest 2°F. At least two temperature sensors (thermocouples) shall be positioned to record the maximum and minimum anticipated concrete temperatures. The anticipated minimum temperature shall be measured with one or more thermocouples at a distance no greater than 2 inches from the surface of the thinnest section. The anticipated maximum temperature shall be measured with one or more thermocouples at the center of the thickest section. Proposed temperature measurement locations shall be submitted to the Engineer for approval. Temperature recording devices shall be located within the curing enclosure and calibrated as required by PCI MNL-116 Section 4.18.4. Maximum heat increase and cool down rates shall comply with PCI MNL-116, Section 4.19. The Contractor shall furnish temperature logs recorded at a minimum frequency of once per hour to the Inspector as required, with each post-pour QC inspection report.

#### Sampling and Testing.

At a minimum, the Fabricator shall perform random Quality Control sampling and testing as specified in *Table 1: Quality Control Sampling and Testing*. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during fabrication. Test Specimens shall conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60, with the exception of the Stripping (80% f’c) set of cylinders. Stripping (80% f’c) cylinders shall be cured in the same location and environment as the PBU they represent. If approved by the Engineer, compressive strength cylinder match curing equipment, that maintains the same concrete conditions that the corresponding PBU is exposed to, may be utilized in lieu of Stripping (80% f’c) field cured cylinders, with the use of thermocouples, controllers, and heaters.

**Table 1: Quality Control Sampling and Testing**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Quality Characteristic | Test Method | Sample Size | Specification Limit | Lot Size (c) | Sublot Size (d) | Frequency | Point of Sampling |
| Slump (in.) (a) | AASHTO T 119  | Per AASHTO | ≤ 8 in. or as approved by the Engineer | Total Quantity of PBUs fabricated on a Contract, per Bid Item, per Mix Design | One (1) PBU | One (1) per Sublot or fraction thereof | Point of Discharge |
| Air Content (%) | AASHTO T 152 | Per AASHTO | 5% ≤ % ≤ 8% |
| Temperature (°F) | AASHTO T 309 | Per AASHTO | 50°F ≤ °F ≤ 90°F |
| Compressive Strength (psi) | AASHTO T 22AASHTO T 23 | Stripping Cylinders: One (1) set of Three (3)4 x 8 in. | ≥ 80% f’ c at Stripping |
| 7-day Cylinders: One (1) set of Three (3)4 x 8 in. | For Information at 7 days |
| 28-day Cylinders: One (1) set of Three (3)4 x 8 in. | ≥ 100% f’ c at 28 days |
| 56-day Cylinders: One (1) set of Three (3)4 x 8 in.  | ≥ 100% f’ c at 56 days (b) |

**Notes:**

1. Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
2. 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f’ c).
3. Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
4. Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

#### Certificate of Compliance.

The Fabricator shall provide a Certificate of Compliance in accordance with Standard Specifications, Division I, Section 6.01, stating that QC test cylinders have achieved the design strength, f’c. A Certificate of Compliance shall accompany each shipment and shall be presented to the MassDOT Resident Engineer or designee upon delivery to the site.

#### Documentation.

At a minimum, the Fabricator shall maintain a filing system for the following QC records and documentation. All QC records and documentation shall be made available to MassDOT upon the request of the Department.

1. Current MassDOT Approved Mix Design Sheet(s) and Approval Letter(s)
2. PCI or NPCA Certification
3. Current Qualifications and Certifications for QC Manager(s) and QC Technician(s)
4. Most current set of Approved Shop Drawings
5. Approved Placement, Finishing and Curing Plan
6. Approved Dunnage Plan
7. Fabricator Certificate of Compliance for each fabricated PBU
8. Admixture Manufacturer’s Certification of Compliance for each approved Admixture
9. Completed QC Inspection Report for each fabricated PBU
10. Identification Number for each fabricated PBU
11. Time and date of casting of each fabricated PBU
12. Date of stripping of each fabricated PBU
13. Batch Ticket Printout reporting the quantity of concrete produced for each batch of concrete produced
14. Concrete temperature records for each fabricated PBU
15. QC Test Report Forms for each sublot of concrete produced
16. Non-Conformance Reports (NCRs)
17. Documentation of Repairs (if applicable)

### Acceptance.

MassDOT will perform Acceptance inspection, sampling, and testing during fabrication and installation, to evaluate the quality and degree of compliance of the fabricated PBU to MassDOT specifications. Additionally, MassDOT Inspectors will monitor the Fabricator’s Quality Control activities to ensure the Fabricator is properly administering Quality Control in conformance with the Fabricator’s NPCA or PCI Certification. Acceptance inspection and test results not meeting MassDOT specifications will result in Non-conformance Reports (NCR) being issued by MassDOT to the Fabricator or Contractor for corrective action. Final Acceptance for the fabricated PBUs shall be determined by MassDOT.

#### Inspection.

A MassDOT MassDOT Inspector will be assigned to perform Acceptance activities during fabrication, which includes the inspection of the materials, work procedures, and PBUs. At least seven (7) days prior to the scheduled start of fabrication, the Fabricator shall contact the MassDOT Research and Materials Section (RMS) to provide notice of the scheduled fabrication start date. The Fabricator shall complete the following activites prior to notifying MassDOT RMS of the scheduled start date:

1. Receive approval for all submitted Fabricator cement concrete mix designs from the MassDOT Research and Materials Section for the current year, as specified under the *Mix Design* section and *Table 3: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete shall meet the requirements of M4.02.17.
2. Receive approval for the submitted Fabricator Placement, Finishing, and Curing Plan from the MassDOT Research and Materials Section, as specified under the *Placement, Finishing, and Curing Plan* section.
3. Receive Engineer of Record approved shop drawings from the MassDOT Research and Materials Section as specified under the *Shop Drawings* section.
4. Participate in the pre-production meeting, as described under the *Pre-Production Meeting* section (if required).

Prior to the start of fabrication, the Fabricator shall review the fabrication schedule with the MassDOT Inspector. Fabrication shall only proceed when:

1. The QC Inspector and MassDOT Inspector are present to inspect the PBU(s) being fabricated.
2. The QC Manager is present at the Fabricator’s plant.

The Fabricator shall grant access to all required areas of the Fabricator’s plant to the MassDOT Inspector, during the hours of fabrication. Fabrication without MassDOT Inspector access to required areas is prohibited, and will result in the rejection of the PBU(s).

Additionally, the MassDOT Inspector will monitor the adequacy of the Fabricator’s Quality Control activities. MassDOT Inspector Acceptance activities performed at the Fabricator’s plant shall remain independent from the Fabricator, and does not replace the Fabricator’s required Quality Control activities.

#### Sampling and Testing.

At a minimum, the MassDOT Inspector will perform random Acceptance sampling and testing for each Sublot of concrete produced as specified in *Table 2: Acceptance Sampling and Testing.* The MassDOT Inspector will also perform Acceptance sampling and testing on concrete that has been retempered with admixtures or hold-back water during production. Test Specimens will conform to the requirements of Section M4.02.13 of the MassDOT Standard and Supplemental Specifications and AASHTO R 60.

**Table 2: Acceptance Sampling and Testing**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Quality Characteristic | Test Method | Sample Size | Specification Limit | Lot Size (c) | Sublot Size (d) | Frequency | Point of Sampling |
| Slump (in.) (a) | AASHTO T 119  | Per AASHTO | ≤ 8 in. or as approved by the Engineer | Total Quantity of PBUs fabricated on a Contract, per Bid Item, per Mix Design | One (1) PBU | One (1) per Sublot or fraction thereof | Point of Discharge |
| Air Content (%) | AASHTO T 152 | Per AASHTO | 5% ≤ % ≤ 8% |
| Temperature (°F) | AASHTO T 309 | Per AASHTO | 50°F ≤ °F ≤ 90°F |
| Compressive Strength (psi) | AASHTO T 22AASHTO T 23 | 7-day Cylinders: One (1) set of Three (3)4 x 8 in. | For Information at 7 days |
| 28-day Cylinders: One (1) set of Three (3)4 x 8 in. | ≥ 100% f’ c at 28 days |
| 56-day Cylinders: One (1) set of Three (3)4 x 8 in.  | ≥ 100% f’ c at 56 days (b) |

**Notes:**

1. Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
2. 56-day Compressive Strength test specimens shall require testing only when 28-day Compressive Strength test specimens have failed to meet Design Strength (f’ c).
3. Lot shall be defined as a specific quantity of material from a single source, produced or placed by the same controlled process.
4. Sublot shall be defined as an equal division or part of a Lot from which a sample of material is obtained in order to assess the Quality Characteristics of the Lot.

## MATERIALS

### Materials.

Materials shall meet the following specifications (if applicable):

General M4.00.00

Portland Cement M4.01.0

Blended Hydraulic Cements M4.01.1

Fly Ash M4.01.2

Cement Concrete M4.02.00

Cement M4.02.01

Cement Mortar M4.02.15

Aggregates M4.02.02

Lightweight Aggregates M4.02.03

Water M4.02.04

Cement Concrete Additives M4.02.05

Proportioning M4.02.06

Mixing and Delivery M4.02.10

Test Specimens M4.02.13

Mortar for Filling Keyways M4.04.0

Slag AASHTO M 302

High Performance Cement Concrete M4.06.1

Self-Consolidating Concrete (SCC) M4.02.17

Reinforcing Bars M8.01.0

Epoxy Coated Reinforcing Bars M8.01.7

Galvanized Reinforcing Bars M8.01.8

Mechanical Reinforcing Bar Splicer M8.01.9

Lifting Devices PCI MNL-116

Stud Shear Connectors M8.04.1

High Strength Bolts. M8.04.3

Structural Steel M8.05.0

#### Cement Concrete Mix Design.

The cement concrete shall be comprised of specified proportions of water and MassDOT approved aggregates, cement, supplementary cementitious materials (SCMs), and admixtures to form a homogenous composition. Cement concrete for PBUs shall be 4000 psi, ¾” inch, 585 HP Cement Concrete and meet the requirements of M4.06.1 High Performance Cement Concrete, with the exception that the “Total Cementitious Content” specified shall be considered the “Maximum Allowable Cementitious Content”, as specified in *Table 3: Cement Concrete for PBUs*). When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

**Table 3: Cement Concrete for PBUs**

|  |  |  |
| --- | --- | --- |
| 28 Day Compressive Strength  | Maximum Coarse Aggregate Size  | Maximum Allowable Cementitious Content  |
| 4000 psi  | ¾ inches  | 585 lb/cy  |

Prior to production of cement concrete, the Fabricator shall report and submit all proposed mix design formulations and its constituent materials onto the MassDOT Cement Concrete Mix Design Sheet to the MassDOT Research and Materials Section for review and approval. All mix design yields shall be designed for 1.0 cubic yards of concrete, with an allowable tolerance of +/- 1.0 %. All liquids incorporated into the proposed mix design(s) shall include both water and admixtures in the liquid mass calculation.

During production of cement concrete, the Fabricator shall not alter the previously approved mix design formulation or its constituent materials. Proposed alterations in source, type, batch quantity, or gradation to any of the constituent materials of the previously approved mix design formulation shall require a new MassDOT Mix Design Sheet submission to the MassDOT Research and materials Section for review and approval. Fabrication shall not occur without prior MassDOT mix design approval.

The Fabricator shall notify MassDOT RMS to schedule trial batch testing for the new mix design(s). Trial batch testing shall meet the following requirements:

1. Performed by a qualified laboratory and/or AASHTO accredited laboratory.
2. Performed and/or sampled in the presence of a MassDOT Inspector.
3. Meet the requirements as specified in *Table 4: Trial Batch Sampling Testing for New Mix Designs*. Self-consolidating concrete (SCC) shall meet M4.02.17.

Failure to perform all of the required trial batch testing or provide MassDOT RMS trial batch test results within the Specification Limits (as specified in Table 4) will result in the disqualification of the Fabricator’s proposed mix design(s).

**Table 4: Trial Batch Sampling and Testing for New Mix Designs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quality Characteristic | Test Method | Sample Size | Specification Limit | Performed By |
| Slump (a) | AASHTO T 119 | Per AASHTO | Max. 8 inches or as approved by the Engineer | Quality Control |
| Air Content (AC) | AASHTO T 152 | Per AASHTO | 5% ≤ AC ≤ 8% | Quality Control |
| Temperature (°F) | AASHTO T 309 | Per AASHTO | 50°F ≤ °F ≤ 90°F | Quality Control |
| Compressive Strength (b) | AASHTO T 22 AASHTO T 23 | 28-day Cylinders: One (1) set of Three (3) 4 x 8 in. | Lab Mixed f’cr = 1.3 f’c at 28 days | MassDOT |
| Batch Mixed f’cr = 1.2 f’c at 28 days |
| Alkali-Silica Reaction (ASR) (d) | ASTM C 1567 | Per ASTM | M4.02.00 | Quality Control |
| Resistance to Chloride Ion Penetration Chloride Ion Penetration (e) | AASHTO T 358 (f) | 28-day Cylinders: One (1) set of Three (3) 4 x 8 in. | Resistivity ≥ 21 kΩ-cm at 28 days | MassDOT |
| Freeze/Thaw Durability (c) | AASHTO T 161 (Procedure A) | Per AASHTO | Relative Dynamic Modulus of Elasticity after 300 cycles ≥ 80%  | Quality Control |

 **Notes:**

* 1. Self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.
	2. Trial batch compressive strength testing shall be performed by MassDOT. Acceptance will be based on compressive strength testing performed by MassDOT.
	3. If an AASHTO accredited laboratory is preparing the trial batch test specimens, MassDOT Acceptance presence is not required. If the Fabricator is preparing the trial batch test specimens, MassDOT Acceptance presence is required during trial batch test specimen preparation.
	4. Alkali Silica Reaction (ASR) testing shall meet the requirements of M4.02.00. Independent laboratories performing ASR testing shall be listed on the MassDOT Quality Construction Materials List (QCML).
	5. Calcium nitrite shall be removed from mix designs containing the admixture and replaced by an equivalent quantity of water when preparing Chloride Ion Penetration resistance trial batch test specimens.
	6. The Wenner probe tip spacing “a” shall be 1.5.

#### Reinforcement.

All deck reinforcing steel shall be of the size and spacing as indicated on the plans and shall be epoxy coated Grade 60 unless otherwise noted on the plans.

#### Stud Shear Connectors.

Stud shear connectors applied to flanges of the beams may be installed at either the steel fabrication shop or the precast plant. If the installation is performed at the precast plans, the work shall be done by steel fabrication shop personnel.

#### Threaded Inserts

Threaded inserts are permissible on the underside of the PBUs to facilitate forming of the closure pours. Threaded inserts shall be hot dip galvanized or made of stainless steel. The number of threaded inserts shall be minimized and the inserts shall not come in contact with the reinforcing steel.

## CONSTRUCTION METHODS – PLANT FABRICATION OF STRUCTURAL STEEL

### Shop Drawings.

Shop drawings shall conform to the following requirements:

1. General Requirements of Section 5.00
2. Section 960.60
3. The drawings shall account for the geometry of the complete bridge structure and individual PBU components.

### Fabrication.

All structural steel components shall be fabricated in accordance with Section 960.61.

### Coatings.

The corrosion protection for the fabricted steel members shall be as specified on the Plans. *Provide Special Provison for the type of coating to be used: Thermal Sprayed Coating (aka Metalizing) or Galvanized.*

### Tolerances.

Tolerances for the fabrication of the steel beams shall be in accordance with 960.61.

### Repairs and Replacement.

In the event defects are identified, a non-conformance report (NCR) shall be filed if required. The NCR shall be submitted to MassDOT for review. Any repairs shall be at the discretion of MassDOT and shall require the prior approval of MassDOT.

# CONSTRUCTION METHODS – PLANT FABRICATION OF PRECAST CONCRETE

### Shop Drawings

Prior to performing any work under this Section, the Contractor shall receive approval for all shop drawings for the PBU being worked on and any special Contract requirements, provided that a complete shop drawing package is provided. The Contractor shall not order materials or begin work before receiving approved shop drawings. MassDOT will reject any precast concrete bridge decks that deviate from the approved drawings or are fabricated prior to receiving written approval of the shop drawings. The Contractor shall bear full responsibility and costs for all materials ordered or work performed prior to the approval of the shop drawings or written authorization from MassDOT.

The Contractor shall submit scaled shop drawings to the Engineer of Record for review and approval. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24x36”) paper copies of the Approved (or Approved As Noted) shop drawings to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. An approval stamp shall appear on every shop drawing sheet. Wet-stamping or wet-signing is not required, provided that the stamp and reviewer name are legible. The Fabricator’s name and address shall appear on each sheet.

Resubmittal of “Approved as Noted” shop drawings is not necessary for minor revisions, provided that the correction can be clearly understood and is unambiguous without possibility of misinterpretation. Shop drawings with questions or comments that require a response and/or additional information from the Fabricator must be resubmitted.

Detailed shop drawings shall be prepared in accordance with the relevant provisions of Subsection 5.02 and shall, at a minimum, contain the following:

1. Number and type of PBUs including overall length, width and height.
2. Skew angle.
3. Location, size and geometry of all steel reinforcement, including mechanical reinforcing bar splicers to be used for connecting Prefabricated Bridge Units together in the field.
4. Location and details of all inserts, anchors, and any other items required to be cast into the Prefabricated Bridge Units (whether detailed on the plans by the Engineer of Record or provided for the Contractor's convenience). Prefabricated Bridge Units shall not be fired or drilled into for attachment purposes. All hardware shall be galvanized except as noted.
5. 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 Chapter 8 of the PCI Design Handbook (7th edition).
6. The minimum compressive strength required prior to handling the Prefabricated Bridge Unit.

The shop drawings shall not include procedures for placement, finishing, and curing of concrete. These details shall be included in the Placement, Finishing and Curing Plan that is to be submitted to MassDOT Research and Materials Section as described under *Placement, Finishing, and Curing Plan*.

### Fabrication.

All precast concrete deckslabs shall be fabricated in accordance with the latest edition of PCI MNL-116 as modified herein.

### PBU Assembly Plan Drawings.

PBU Assembly Plan Drawings shall identify the Fabricator’s proposed plan for supporting the steel beams of a PBU unit in a manner that will provide for the proper fit and relative elevations of PBUs consistent with the final relative bridge geometry (elevations, horizontal locations and skew) and that will ensure the beams deflect as assumed in the calculation of the beam camber and Top-of-Form elevations. The PBU Assembly Plan shall also show the design and plan of the foundation that shall support the PBU units during assembly, the method for forming the deck, and the procedure for the placement and finishing of the deck concrete. The PBU Assembly Plan Drawings shall be submitted by the Contractor to the Engineer of Record for approval.

To ensure proper fit in the field and conformance with the roadway profile and deck cross slope, the Fabricator shall cast the deck with the beams set to the relative proposed bridge seat geometry (elevations, horizontal locations, and skew) and the deck forms to the relative blocking distances as defined by the Top-of-Form elevations. The temporary supports shall be installed in accordance with the approved PBU Assembly Plan Drawings. The Contractor shall independently verify the Fabricator’s temporary support geometry and the foundation and temporary supports during all operations for settlement. The Contractor shall submit the following documentation to the Engineer of Record for review and approval:

1. The method the Contractor shall employ to independently verify the Fabricator’s temporary support geometry as installed to ensure that it is consistent with the final relative bridge geometry
2. The method the Contractor shall employ to independently monitor the foundation and temporary support during all assembly and casting operations for settlement
3. Method of forming deck slabs

### Placement, Finishing and Curing Plan.

At least 30 days prior to start of fabrication, the Contractor shall submit the Fabricator’s proposed Placement, Finishing and Curing Plan to the Engineer for approval by MassDOT Research and Materials Section. This shall be an independent submittal, separate from the fabrication shop drawings. The Placement, Finishing and Curing Plan shall include the following:

1. Method of Mixing
2. Method of Placement
3. Method of Consolidation
4. Method of Finishing
5. Method of Initial Curing
6. Method of Intermediate Curing
7. Method of Final Curing
8. Moisture Retention Materials and Equipment (water spray equipment, saturated covers, sheet materials, liquid membrane-forming compounds, accelerated curing equipment, etc.)
9. Cylinder Curing Methods, Location, and Environmental Control (temperature, humidity, etc.)
10. Temperature Monitoring, Recording, and Reporting

### Dunnage Plan Shop Drawings.

At least 30 days prior to the start of fabrication, the Contractor shall submit proposed Dunnage Plan Shop Drawings to the Engineer of Record for review and approval. This shall be an independent submittal, separate from the fabrication shop drawings. Upon approval, the Engineer of Record will forward two (2) sets of scaled, full size (minimum 24”x36”) paper copies of the Approved (or Approved As Noted) Dunnage Plan Shop Drawings to the MassDOT Director of Research and Materials. Calculations are not to be included in any submittal to the Research and Materials Section. The Dunnage Plan Shop Drawings shall include the following:

1. Proposed layout of the PBUs for storage in yard and during shipping
2. Support and blocking point locations
3. Support and blocking materials

### Pre-Production Meeting.

The Contractor shall notify the MassDOT Research and Materials Section to determine if a pre-production meeting will be required to review the specification, shop drawings, curing plan, schedule, and discuss any specific requirements. The meeting shall be held prior to scheduling a MassDOT Inspector (refer to Section *Quality Assurance – Precast Concrete, C. Acceptance, A. Inspection*), and at least seven (7) days prior to the scheduled casting of any PBU or control section. The Contractor shall schedule the meeting, which shall include representatives of the Fabricator and MassDOT.

### Reinforcement.

The reinforcing bars shall be installed in accordance with Section 901.62 of the Supplemental Specifications, including tolerances for cover and horizontal spacing of bars. Components of mechanical reinforcing bar splicers shall be set with the tolerances shown on the plans. The reinforcing bars and mechanical reinforcing bar splicers shall be assembled into a rigid cage that will maintain its shape in the form and which will not allow individual reinforcing bars to move during the placement of concrete. This cage shall be secured in the form so that the clearances to all faces of the concrete, as shown on the plans, shall be maintained.

### Tolerances.

Fabrication shall comply with tolerances specified on the plans. Tolerances for steel reinforcement placement shall be in accordance with 901.62. Tolerances for the deck finish shall be in accordance with 901.66E Section 5.

### Forms.

Concrete shall be cast in rigidly constructed forms, which will maintain the PBUs within specified tolerances to the shapes, lines and dimensions shown on the approved fabrication drawings. Forms shall be constructed from flat, smooth, non-absorbent material and shall be sufficiently tight to prevent the leakage of the plastic concrete. When wood forms are used, all faces in contact with the concrete shall be laminated or coated with a non-absorbent material. All worn or damaged forms, which cause irregularities on the concrete surface or damage to the concrete during form removal, shall be repaired or replaced before being reused. Any defects or damage of more than “Category 2, Minor Defects” made to the concrete, due to form work, stripping or handling, shall be subject to repair or rejection, as defined in the *Repairs and Replacement* section. If threaded inserts are cast into the elements for support of formwork, the inserts shall be recessed a minimum of 1 inch and shall be plugged after use with a grout of the same color as that of the precast cement concrete.

### Mixing of Concrete.

The concrete shall be proportioned and mixed in conformance with the Fabricator’s MassDOT approved mix design and M4.02.10 Mixing and Delivery. Fabrication shall not occur without prior MassDOT mix design approval. The Fabricator shall provide copies of batch tickets to the MassDOT Plant Inspector. The MassDOT Plant Inspector will verify if the batch ticket quantities are within the tolerances of the Fabricator’s MassDOT approved mix design.

### Limitations on Placement

When placing concrete, the evaporation rate of the exposed concrete surface shall be equal to or less than 0.15 lb/ft2/hr as specified in 901.66.B “Placement, Finishing and Curing of Concrete Bridge Decks” of the MassDOT Supplemental Specifications.

### Placement of Concrete.

Prior to the placement of concrete, the temperature of the forms shall be greater than or equal to 50°F. Quality Control inspection shall be performed by the Fabricator as specified in the *Fabricator Quality Control* section. Placement of the concrete shall not proceed until the MassDOT Plant Inspector is present to perform inspection and begin monitoring Fabricator Quality Control inspection activities, and is in compliance with specifications. The MassDOT Plant Inspector shall inspect and accept the placement of the reinforcing steel prior to the placement of concrete into the forms. The Fabricator shall verify all materials and equipment required for protecting and curing the concrete are readily available and meet the requirements of the *Final Curing Methods* section below. All items encased in the concrete shall be accurately placed in the position shown on the Plans and firmly held during the placing and setting of the concrete. Clearance from the forms shall be maintained by supports, spacers, or hangers and shall be of approved shape and dimension.

During placement, the concrete shall maintain a concrete temperature range between 50°F and 90°F. The Fabricator shall minimize the time to concrete placement (measured from start of mixing to completion of placement). In no event shall time to placement exceed 90 minutes. The Fabricator shall perform additional Quality Control sampling and testing on concrete that has been retempered with admixtures or hold-back water during the placement of the concrete as specified in the *Fabricator Quality Control* section above. Delays or shutdowns of over 30 minutes shall not be allowed during the continuous filling of individual forms.

### Consolidation of Concrete.

Suitable means shall be used for placing concrete to prevent segregation or displacement of reinforcing steel or forms. The concrete shall be thoroughly consolidated by external or internal vibrators or a combination of both. Vibrators shall not be used to move concrete within the forms. Vibrators shall be used as specified in 901.63C and as directed by the Engineer. Concrete shall be placed and consolidated in a way that minimizes the presence of surface voids or bug holes on the formed surfaces. When used, self-consolidating concrete (SCC) shall meet the requirements of M4.02.17.

### Finishing of Concrete.

The finished deck surface shall be smooth without any projections that could puncture the spray applied waterproofing membrane or depressions that could retain water. Deck panels that will receive a cast-in-place safety curb, barrier, or sidewalk shall have a raked finish with a ¼ inch amplitude applied longitudinally along the length of the PBU. If used, finishing machines shall follow the requirements of Specification Section 901.66E, Sections 1-3.

The Fabricator shall permanently mark each PBU with its type and/or piece mark, date of casting, and supplier identification either by stamp markings in fresh concrete, waterproof paint, or other approved means on a surface that will not be exposed after assembly.

### Exposed Surfaces of PBUs.

As soon as conditions permit, before the concrete has fully hardened, all dirt, laitance, and loose aggregate shall be removed from the exposed concrete surfaces. Contractor shall not allow foot traffic on the uncured concrete until it has reached sufficient strength to prevent damage.

### Exposed Surfaces of Closure Pour Shear Keys.

The closure pour shear key cast in the sides of the beam flanges shall have an exposed aggregate finish. The closure pour reinforcing steel and its coating shall not be damaged by the process for creating the exposed aggregate surface. Fabricator may utilize a surface retarder with water blast, abrasive blast, or a combination of both to achieve the desired shear key ﬁnish. The abrasive blast shall use oil free compressed air. The profile of the shear key surfaces shall be similar to that of 60 grit sand paper.

### Initial Curing Methods.

After the placement of concrete and prior to concrete finishing, the Fabricator shall initiate initial curing methods when the concrete surface begins to dry, to reduce moisture loss from the surface. Application of one or more of the following initial curing methods shall occur immediately after the bleed water sheen has disappeared.

#### Fogging.

Fogging nozzles shall atomize water into a fog-like mist. The fog spray shall be directed and remain visibly suspended above the concrete surface, to increase the humidity of the air and reduce the rate of evaporation. Water from fogging shall not be worked into the surface during finishing operations and shall be removed or allowed to evaporate prior to finishing.

#### Liquid-applied Evaporation Reducers

Evaporation reducers shall be sprayed onto the freshly placed concrete surface to produce an effective monomolecular film that reduces the risk of plastic-shrinkage cracking and rate of evaporation of the bleed water from the concrete surface. Evaporation reducers shall be applied in accordance with manufacturer’s recommendations.

### Intermediate Curing Methods.

The Fabricator shall initiate intermediate curing methods if concrete finishing has taken place prior to the concrete reaching final set. The freshly finished concrete surface shall be protected from moisture loss, by the continuation of initial curing methods (fogging and evaporation reducers) until final curing methods are applied or by the use of liquid membrane-forming curing compounds (see *Liquid Membrane-Forming Compounds for Curing* section).

### Final Curing Methods.

The Fabricator shall initiate and apply final curing methods to the concrete immediately after the following conditions are met:

1. Completion of concrete finishing
2. Final set of concrete
3. Concrete has hardened sufficiently enough to prevent surface damage

During fabrication of PBUs, the Fabricator shall maintain the required concrete temperature ranges throughout the entire duration of the final curing method cycle as specified herein. Controlled and gradual termination of the final curing method shall occur after all specified conditions are met. The concrete temperature shall be reduced at a rate not to exceed 30°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the final curing method enclosure. The Fabricator shall maintain a minimum concrete temperature of 40°F until 100% f’c is attained (see *Handling and Storage* section below).

#### Saturated Covers for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of saturated covers throughout the entire duration of the final curing method cycle (see *Table 5: Final Curing Method Cycle for Saturated Covers*). Saturated covers shall be allowed to dry thoroughly before removal to provide uniform, slow drying of the concrete surface.

**Table 5: Final Curing Method Cycle for Saturated Covers**

|  |  |  |
| --- | --- | --- |
| Sustained Concrete Temperature  | Final Curing Method Cycle Duration | Compressive Strength |
| 50°F ≤ °F ≤ 90°F | ≥ 10 days(a) | ≥ 80% f’c |

**Notes:**

1. Concrete that is elected to receive Spray-Applied Waterproofing Membrane, controlled and gradual termination of the final curing method cycle may occur after 5 days and 80% f’­c is attained.

Saturated covers, such as burlap, cotton mats, and other coverings of absorbent materials shall meet the requirements of 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 concrete. Saturated covers shall be dried to prevent mildew when storing. Prior to application, saturated covers shall be thoroughly rinsed in water and free of harmful substances that are deleterious or cause discoloration to the concrete. Saturated covers shall have sufficient thickness and proper positioning onto the concrete surface to maximize moisture retention.

Saturated covers shall contain a sufficient amount of moisture to prevent moisture loss from the surface of the concrete. Saturated covers shall be kept continuously moist so that a film of water remains on the concrete surface throughout the entire duration of the final curing method cycle. The Fabricator shall not permit the saturated covers to dry and absorb water from the concrete. Use of polyethylene film (see *Polyethylene Film* section) may be applied over the saturated cover to potentially decrease the need for continuous watering.

#### Sheet Materials for Curing.

All exposed concrete surfaces shall remain moist with a continuous application of curing sheet materials throughout the entire duration of the final curing method cycle (see *Table 6: Final Curing Method Cycle for Curing Sheet Materials*).

**Table 6: Final Curing Method Cycle for Sheet Materials**

|  |  |  |
| --- | --- | --- |
| Sustained Concrete Temperature  | Final Curing Method Cycle Duration | Compressive Strength |
| 50°F ≤ °F ≤ 90°F | ≥ 10 days(a) | ≥ 80% f’c |

**Notes:**

1. Concrete that is elected to receive Spray-Applied Waterproofing Membrane, controlled and gradual termination of the final curing method cycle may occur after 5 days and 80% f’­c is attained.

Sheet materials used for curing, such as polyethylene film, white burlap-polyethylene sheeting, and reinforced paper shall meet the requirements of ASTM C171 and the specifications herein. Sheet materials shall inhibit moisture loss and reduce temperature rise in concrete exposed to radiation from the sun during the final curing method cycle. Adjoining covers shall overlap not less than 12 inches. All edges of the covers shall be secured to maintain a moist environment.

##### Polyethylene Film.

Polyethylene film shall meet the requirements of ASTM C171, consist of a single sheet manufactured from polyethylene resins, be free of visible defects, and have a uniform appearance. Careful considerations shall be taken by the Fabricator to prevent the film from tearing during storage and application, so as to not disrupt the continuity of the film (polyethylene film reinforced with glass or other fibers is more durable and less likely to be torn). The Fabricator shall monitor the application of the film to prevent uneven spots from appearing (mottling) on the concrete surface, due to variations in temperature, moisture content, or both. The Fabricator shall prevent mottling from occurring on the concrete surface by applying additional water under the film or applying a combination of polyethylene film bonded to absorbent fabric to the concrete surface to retain and evenly distribute the moisture.

Immediately following final finishing, polyethylene film shall be placed over the surface of the fresh concrete surface, so as to not damage the surface of the concrete and shall be placed and weighted so that it remains in contact with the concrete throughout the entire duration of the final curing method cycle. The film shall extend beyond the edges of the concrete surface. The film shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling. 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 throughout the entire duration of the final curing method cycle.

##### White Burlap-Polyethylene Sheeting.

White burlap-polyethylene sheeting shall meet the requirements of ASTM C171, be securely bonded to the burlap so to avoid separation of the materials during handling and curing of the concrete, and be applied in the same manner as the polyethylene film.

##### Reinforced Impervious Paper.

Reinforced impervious paper shall meet the requirements of ASTM C171, 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, and be white in color. Reinforced impervious paper shall be treated to prevent tearing when wetted and dried.

Reinforced impervious paper can be reused so long as it is effective in retaining moisture on the concrete surface. The Fabricator shall visually inspect the reinforced impervious paper for all holes, tears, and pin holes from deterioration of the paper through repeated use by holding the paper up to the light. The paper shall be discarded and prohibited from use when the moisture is no longer retained.

After the concrete has hardened sufficiently to prevent surface damage, the concrete surface shall be thoroughly wetted prior to the application of the reinforced impervious paper, and be applied in the same manner as the polyethylene film.

#### Accelerated Curing.

Accelerated curing shall use live steam or radiant heat with moisture in accordance with PCI MNL-116 as modified herein. The concrete temperature shall meet the maximum heat increase and cool down rates as specified herein. Concrete temperature monitoring shall meet the requirements of the *Temperature Monitoring* section. Excessive and fluctuating rates of heating and cooling shall be prohibited. The concrete temperature shall not exceed 158°F at any time. The Fabricator shall meet the following accelerated curing sequencing and requirements.

##### Initial Delay Period.

The initial delay period shall be defined as the duration immediately following the placement of the concrete and the attainment of initial set of the concrete. The Fabricator shall determine the time of initial set in accordance with AASHTO T 197 specifications. Throughout the entire duration of the preset period, initial curing shall be implemented. The temperature increase period (see *Temperature Increase Period* section) shall not occur until initial set of the concrete is attained. During the initial delay period, the concrete temperature shall meet the following requirements:

1. Concrete temperature rate of increase shall not exceed 10°F per hour.
2. Total concrete temperature increase shall not exceed 40°F higher than the placement concrete temperature or 100°F, whichever is less

##### Temperature Increase Period.

The temperature increase period shall be defined as the duration immediately following the completion of the initial delay period (after initial set) and immediately prior to the start of the constant maximum temperature period. Application of steam to the enclosure shall not occur until the initial delay period is complete. After the initial delay period is complete, all exposed concrete surfaces shall be cured in a moist environment where the concrete temperature increases at a rate not to exceed 30°F per hour.

##### Constant Maximum Temperature Period.

The constant maximum temperature period shall be defined as the duration immediately following the completion of the temperature increase period and immediately prior to the start of the temperature decrease period. After the temperature increase period is complete, all exposed concrete surfaces shall be cured in a moist environment at a controlled and constant elevated temperature throughout the entire duration of the constant maximum temperature period. Termination of the constant maximum temperature period and the start of the termination decrease period shall occur after all specified conditions are met (see *Table 7: Constant Maximum Temperature Period*).

**Table 7: Constant Maximum Temperature Period**

|  |  |  |
| --- | --- | --- |
| Sustained Concrete Temperature  | Constant Maximum Temperature Period | Compressive Strength |
| 120°F ≤ °F ≤ 158°F | 6 hrs ≤ Time ≤ 48 hrs | ≥ 80% f’c |

##### Temperature Decrease Period.

After the constant maximum temperature period is complete, the concrete temperature shall be cured in a moist environment at a controlled and reduced rate not to exceed 30°F per hour until the concrete temperature is within 20°F of the ambient temperature outside of the curing enclosure.

### Stripping.

The Fabricator shall not strip forms or handle the precast concrete until Quality Control compressive strength cylinders attain a minimum compressive strength of 80% Design Strength (f’c) or the value indicated on the approved drawings has been achieved. After removal from the form, all exposed concrete surfaces shall continue to be cured in conformance with the *Final Curing Methods* sections until completion.

### Handling and Storage of PBUs.

PBUs may be exposed to temperatures below freezing (32°F) when the chosen curing cycle has been completed, provided that the following conditions are met:

1. PBUs are protected from precipitation with polyethylene curing covers until 100% f’c is attained
2. PBUs maintain a minimum concrete temperature of 40°F until 100% f’c is attained

PBUs damaged during handling and storage will be repaired or replaced at MassDOT’s direction at no cost to MassDOT. PBUs 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. PBUs shall be supported on the ground by means of continuous blocking, in accordance with the approved dunnage plan.

PBUs shall be loaded on a trailer with blocking as described above, in accordance with the approved dunnage plan. Shock-absorbing cushioning material shall be used at all bearing points during transportation of the PBUs. Blocking shall be provided at all locations of tie-down straps. PBUs stored prior to shipment shall be inspected by the Contractor prior to being delivered to the site to identify damage that would be cause for repair or rejection.

### Repairs and Replacement.

In the event defects are identified, they shall be classified in the following categories and a non-conformance report (NCR) shall be filed if required. The NCR shall be submitted to MassDOT for review. Defects in all categories shall be documented by plant Quality Control personnel and made available to MassDOT upon request. Any required repairs shall utilize materials listed on the MassDOT QCML.

Where noted, defects shall be repaired according to the PCI Northeast Region Guidelines for Resolution of Non-Conformances in Prefabricated Bridge Units, Report Number PCINE-18-RNPCBE. Please note that reference to PCINE-18-RNPCBE is made for repair details only. In the case of conflicts with this Special Provision, this Special Provision shall govern.

#### Category 1, Surface Defects.

Category 1 defects do not need to be repaired, and an NCR does not need to be filed. Surface defects are defined as the following:

1. Surface voids or bug holes that are less than 5/8-inch in diameter and less than ¼-inch deep, except when classified as Category 4
2. Cracks less than or equal to 0.006 inches wide
3. Cracks less than or equal to 0.125 inches wide on surfaces that will receive a concrete overlay or spray-applied membrane waterproofing

#### Category 2, Minor Defects.

Category 2 defects shall be repaired, but an NCR does not need to be filed. Minor defects are defined as the following:

1. Spalls, honeycombing, surface voids that are less than 2 inches deep and have no dimension greater than 12 inches
2. Cracks less than or equal to 0.016 inches that will not receive a concrete overlay or spray-applied membrane waterproofing
3. Broken or spalled corners that will be covered by field-cast concrete

Minor defects shall be repaired according to PCINE-18-RNPCBE. Cracks shall be sealed according to the PCI Repair Procedure #14 in PCINE-18-RNPCBE.

#### Category 3, Major Defects.

For Category 3 defects, the Fabricator shall prepare an NCR that documents the defect and describes the proposed repair procedure. The NCR shall be submitted to MassDOT for approval prior to performing the repair. Major defects are defined as the following:

1. 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
2. Concentrated area of defects consisting of four or more Category 2 Defects within a 4-square foot area
3. Exposed reinforcing steel
4. Cracks greater than 0.016 inches and less than or equal to 0.060 inches in width that will not receive a concrete overlay or spray-applied membrane waterproofing
5. Bearing area spalls with dimensions not exceeding 3 inches
6. Cracks, spalls and honeycombing that will be encased in cast in place concrete need not be repaired, but the limits and location of the defects shall be documented with an NCR

Upon MassDOT approval, defects and cracks shall be repaired according to PCINE-18-RNPCBE and this specification. All repairs shall be completed at the expense of the Contractor.

#### Category 4, Rejectable Defects.

Rejectable defects as determined by the MassDOT Inspector, RMS, and Engineer may be cause for rejection. Fabricator may submit an NCR with a proposed repair procedure, requesting approval. Some rejectable defects are defined as the following:

1. Surface defects on more than 5% of the surface area which will be exposed to view after installation
2. Minor defects that in total make up more than 5% of the surface area of the unit
3. Cracks greater than 0.060 inches in width except as noted in Category 1
4. Elements fabricated outside of the specified tolerances
5. MassDOT compressive strength testing that does not meet the specified Design Strength, f’c

### Loading.

Prior to the Fabricator loading the PBU on to the truck for shipping, the Fabricator shall provide the MassDOT Plant Inspector and RMS a minimum seven (7) days’ notice of the Fabricator’s intent to load the PBU. Inspection by the MassDOT Plant Inspector shall take place while the PBU is still on dunnage in the yard. The PBU shall not be loaded onto the truck until the MassDOT Plant Inspector has performed the inspection.

### Shipping.

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

1. PBUs shall remain at the Fabricator’s plant for a minimum of 7 days after cast date.
2. QC Inspection Reports shall be signed by the Quality Control Manager and provided to the MassDOT Plant Inspector.
3. QC Compressive Strength Test Report Forms attaining Design Strength, f’c for the PBU’s representative sublot shall be generated by the Fabricator and provided to the MassDOT Plant Inspector.
4. Certificate of Compliance shall be generated by the Fabricator as described under the Fabricator Quality Control section and provided to the MassDOT Plant Inspector.
5. All MassDOT RMS 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.
6. All NCRs shall be signed off by the Quality Control Manager, MassDOT Inspector and MassDOT RMS.

### Delivery.

Upon Delivery, the following documentation shall be provided to the MassDOT Resident Engineer or designee:

1. QC Compressive Strength Test Report Forms attaining Design Strength, f’c for the Prefabricated Bridge Unit’s representative sublot.
2. Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
3. QC Inspection Reports signed by the Quality Control Manager.

The Contractor shall inspect the PBUs upon receipt at the site. PBUs damaged during delivery shall be repaired or replaced at MassDOT’s direction at no cost to MassDOT.

## CONSTRUCTION METHODS – FIELD CONSTRUCTION

### General.

All of the Contractor’s field personnel involved in the erection and assembly of the Prefabricated Bridge Units shall have knowledge of and follow the approved Erection Procedure and Quality Control Plan for Prefabricated Bridge Unit Assembly.

Prior to installation, the following documentation shall be reviewed and confirmed by the MassDOT Resident Engineer or designee:

1. QC Compressive Strength Test Report Forms attaining Design Strength, f’c for the Prefabricated Bridge Unit’s representative sublot.
2. Certificate of Compliance generated by the Fabricator as described under the Fabricator Quality Control section.
3. QC Inspection Reports signed by the Quality Control Manager.

Field construction staff shall verify that the Resident Engineer has accepted all Prefabricated Bridge Units prior to installation.

### Erection Procedure and Quality Control Plan for Prefabricated Bridge Unit Assembly.

Prior to the erection, the Contractor shall submit an Erection Procedure and a Quality Control Plan for PBU Assembly for approval by the Engineer. This submittal shall include computations and drawings for the transport, hoisting, erection and handling of the PBUs. The Erection Procedure and Quality Control Plan for PBU Assembly shall be prepared and stamped by a Professional Engineer registered in the Commonwealth of Massachusetts with working knowledge of the Contractor’s equipment, approved shop drawings, and materials to build the bridge. The Erection Procedure and Quality Control Plan for PBU Assembly shall, at a minimum, include the following:

#### Erection Procedure

The Erection Procedure shall be prepared to conform to the requirements of 960.61, Erection and the applicable sections in Chapter 8 of the PCI Design Handbook (seventh edition) for handling, erection, and bracing requirements. At a minimum, the Erection Procedure shall provide:

1. Steel reinforcing details, concrete deck details, location, and details of lifting devices
2. Minimum concrete compressive strength for handling the PBUs.
3. Concrete stresses and steel member stresses during handling, transport, and erection.
4. Crane capacities, pick radii, sling geometry, and lifting hardware.
5. Verification that the equipment can handle all pick loads and weights with the required factor of safety.
6. Evaluation of construction sequence and evaluation of any geometric conflicts in the lifting of the PBUs and setting them on the abutments and piers.
7. Design of crane supports including verification of subgrade for support.
8. Location and design of all temporary bracing that will be required during erection.

#### Quality Control Plan for PBU Assembly

The Quality Control Plan for PBU Assembly is a document prepared and submitted by the Contractor prior to the start of work which requires the Contractor to identify and detail the sequence of construction in accordance with the project schedule and which clearly identifies all stages of field construction. The assembly procedures for the PBUs shall be submitted on full size 24”x36” sheets. This document will be treated as a Construction Procedure and will be reviewed by both the Designer and the District Construction Office.

At a minimum, the Quality Control Plan for PBU Assembly shall include the following:

1. Listing of the equipment, materials, and personnel including their assigned responsibilities that will be used to erect and assemble the PBUs on site.
2. Documentation of all preparatory work necessary for moving personnel, equipment, supplies, and incidentals to the project site before beginning work.
3. Detailed schedule showing the sequence of operations that the Contractor will follow to complete the field construction from setting working points and working lines to the casting of closure pours and the curing of the closure pour concrete, as described below and as called for on the plans.
4. Contractor’s means for ensuring that the PBU shall align to the roadway profile and cross slope and means for adjusting the final deck slab elevation.
5. Timeline and descriptions of Quality Control activities to be followed throughout the field construction operations including methods and procedures for controlling tolerance limits both horizontally and vertically.

### Survey and Layout.

Working points, working lines, and benchmark elevations shall be established prior to placement of all elements. The Contractor is responsible for field survey as necessary to complete the work. MassDOT reserves the right to perform additional independent survey. If discrepancies are found, the Contractor may be required to verify previous survey data.

### Preparation of Closure Pour Shear Keys.

Immediately prior to erecting the PBUs, the closure pour shear keys shall be cleaned at the job site of all dust, dirt, carbonation, laitance, and other potentially detrimental materials which may interfere with the bonding of the closure pour concrete and precast concrete bridge deck using a high-pressure water blast. The exposed reinforcing steel in the precast concrete bridge deck shall be protected from damage during the cleaning of the shear keys. Damaged epoxy coating of steel reinforcement shall be repaired, and the reinforcing steel shall be cleaned as directed by the Engineer. The surfaces of the shear keys shall be wetted so that the surfaces shall have a Saturated Surface Dry (SSD) condition no more than 24 hours prior to the placement of the closure pour concrete. If UHPC is used as the closure pour concrete, the shear keys shall be prepared as called for in the UHPC Special Provision.

### Erection.

The PBUs shall be placed in the sequence and according to the methods outlined in the Erection Procedure and Quality Control Plan for Prefabricated Bridge Unit Assembly to the line and grade shown on the plans. The height of each PBU shall be adjusted to within acceptable tolerances by approved means as specified in the Assembly Plan. The Contractor shall ensure that the PBU is in the proper horizontal and vertical location prior to releasing it from the crane and setting the next unit.

As the PBUs are being erected, the Contractor shall monitor the width of the closure pours and the out-to-out width of the precast concrete bridge deck elements so that, after all PBUs are erected, the actual overall width of the bridge deck shall not deviate from the dimension shown on the plans beyond a tolerance of +0 inches and -1 inches. In order to achieve this, the Contractor may vary the width of the closure pours within the tolerances specified on the plans.

After the layout of PBUs has been accepted by the Engineer, the Contractor shall cut all lifting devices off below the surface of the precast concrete bridge deck.

### Filling of Blockouts for Lifting Devices and Closure Pours.

Concrete for closure pours shall be as called for on the plans and shall be placed and cured in accordance with the Assembly Plan. If called for on the plans, the concrete end diaphragms, pier diaphragms, and link slabs shall be filled with the closure pour concrete in accordance with the Assembly Plan.

Blockouts in the precast concrete bridge deck that were provided for the lifting devices shall be filled with same concrete as that used for filling the closure pours.

After the formwork has been removed, all threaded inserts that have been cast into the precast concrete bridge deck for support of the formwork shall be plugged with a grout of the same color as that of the precast concrete.

## COMPENSATION

### **Basis** of Payment.

The furnishing, fabricating, and erecting of all Prefabricated Bridge Units for the structure shall be paid for at the contract unit price EACH, complete in place.

### Payment Items.

Prefabricated Bridge Units EA