ITEM 557.4301XX09 - LIGHTWEIGHT, HIGH-PERFORMANCE PRECAST SUPERSTRUCTURE SLABS WITH ULTRA-HIGH PERFORMANCE CONCRETE JOINTS

DESCRIPTION
This work shall consist of furnishing and placing Lightweight, High-Performance Precast Superstructure Slabs with Ultra-High Performance Concrete Joints and integral precast concrete barrier with ultra-high performance concrete (UHPC) joints. The maturity method shall be used to estimate the in-place UHPC strength. The time required before removal of the forms and loading of the structure will be determined based on the estimated in-place UHPC strength.

MATERIALS

| Lightweight Precast Superstructure Slab Panels | See Lightweight Concrete Below |
| Concrete Reinforcing | §709 |
| Stud Shear Connectors | §709-05 |
| Vertical Adjustment Devices | ASTM A307 |
| Ultra-High Performance Concrete | See Table, Joint Material UHPC |

Lightweight Concrete.
Manufacture lightweight, high-performance concrete according to §501, and the following modifications:

A. **Design** Design a lightweight high-performance concrete mixture, proportioned according to the American Concrete Institute Manual of Concrete Practice, ACI 211.2, Standard Practice for Selecting Proportions for Structural Lightweight Concrete.

1. Produce a homogeneous mixture of cement, pozzolan (fly ash or GGBFS), microsilica, fine aggregate, lightweight coarse aggregate, air entraining agent, normal range set-retarding water reducing admixture, and water as designed.
2. Use Type I, Type I/II, II, IT or Type IP (8) cements conforming to §701-01, or §701-03. Use a minimum cementitious content of 675 lb/cy. Use 15-20% pozzolan (§711-10, Fly ash or §711-12, GGBFS), and 6-10% microsilica (§711-11). When blended cements (Type IT, Type SF (also known as Type IP(8)) are used, a separate addition of microsilica is not required.
3. Use lightweight coarse aggregate conforming to §703-10, with a gradation in the 1 inch to 3/16 inch size designation in Table 1, ASTM C330.
4. Determine the cement content for each trial batch by means of a yield test according to ASTM C138.
   a. At least 10 working days prior to concrete placement, provide the DCES with a copy of the trial mix design with the following data:
      - Fine and coarse aggregate (saturated, surface dry condition) content in lb/cy.
      - Cementitious content in lb/cy.
      - Water content in lb/cy.
      - Unit weight of freshly mixed concrete in accordance with ASTM C138.
      - Dry unit weight in accordance with ASTM C567.
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- 28-day compressive strengths.
- Batch weights.
  b. The DCES, or their representative, will approve the batch weights prior to use. Use these values to manufacture all lightweight concrete for this project, and periodically correct the batch masses to account for changes in the fine aggregate fineness modulus and aggregate moisture contents in accordance with Materials Method 9.1, or current Department directives.

B. **Batching** After the materials have been accepted for this work, determine the proportions for concrete and equivalent batch weights based on trials made with materials to be used in the work.

C. **Stockpile Handling** Construct and periodically re-agitate lightweight coarse aggregate stockpile(s) at the production facility so as to maintain uniform moisture throughout the pile. Continuously and uniformly sprinkle the stockpile(s) with clean, potable water meeting the requirements of §712-01, using a sprinkler system approved by the DCES. Soak for a minimum of 48 hours, or until the stockpile has achieved a minimum internal moisture content of 15% by weight. If a steady rain of comparable intensity occurs, turn off the sprinkler system. If the rain ceases prior to the end of the wetting period, restart the sprinkling system. At the end of the wetting period, or when a rainfall ceases beyond the end of the wetting period, allow stockpiles to drain for 12 to 15 hours immediately prior to use, unless otherwise directed by the DCES.

The DCES, or his representative, will take a 1 quart microsilica sample in accordance with Materials Method 9.1 for each day’s placement, for testing by the Department.

Panels shall receive an interim sealing in accordance with §717-03 prior to leaving the production facility.

D. **Compressive Strength Determination** Achieve an average 28-day compressive strength of 5000 psi, or greater, with no individual cylinder compressive strength less than 4500 psi.

E. **Density Determination** Produce concrete with an average dry unit mass ranging from 110 to 115 lb/ft³ when tested in accordance with ASTM C567.
Joint Material UHPC.
The material shall be Ultra High Performance Concrete, all components supplied by one manufacturer.

UHPC material shall meet the following, 28 days unless otherwise noted:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Compressive Strength</td>
<td>ASTM C39</td>
<td>≥ 25 ksi</td>
</tr>
<tr>
<td>High Heat-Treated*</td>
<td></td>
<td>≥ 12 ksi</td>
</tr>
<tr>
<td>Medium Heat-Treated 12 hours**</td>
<td></td>
<td>≥ 21 ksi</td>
</tr>
<tr>
<td>Not Heat-Treated 14 days***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prism Flexural Tensile toughness</td>
<td>ASTM C1018; 12 in. span</td>
<td>I30 ≥ 48</td>
</tr>
<tr>
<td>Long-Term Shrinkage</td>
<td>ASTM C157; initial reading after set</td>
<td>≤ 766 microstrain</td>
</tr>
<tr>
<td>Chloride Ion Penetrability</td>
<td>ASTM C1202</td>
<td>≤ 250 coulombs</td>
</tr>
<tr>
<td>Chloride Ion Penetrability</td>
<td>AASHTO T259; ½ in. depth</td>
<td>&lt; 0.07 oz/ft³</td>
</tr>
<tr>
<td>Sealing Resistance</td>
<td>ASTM C672</td>
<td>y &lt; 3</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>ASTM C944 2x weight; ground surface</td>
<td>&lt; 0.025 oz. lost</td>
</tr>
<tr>
<td>Freeze-Thaw Resistance</td>
<td>ASTM C666A; 600 cycles</td>
<td>RDM &gt; 96%</td>
</tr>
<tr>
<td>Alkali-Silica Reaction</td>
<td>ASTM C1260</td>
<td>Innocuous</td>
</tr>
</tbody>
</table>

*High Heat-Treated - According to manufacturer’s recommendation, temperature not to exceed 250°F.
**Medium Heat Treated temperatures not to exceed 120°F
***Not Heat Treated temperature not to exceed 70°F

Results of all the tests above, conducted by an AASHTO accredited testing lab shall be submitted to the DCES along with the installation drawings. Provide to the DCES a list of bridge projects in which the proposed UHPC material has been used as joint fill between precast concrete elements (within or outside the USA). The DCES reserves the right to reject a proposed UHPC material which lacks a proven track record in precast concrete joint filling in bridge applications.

Storage: The contractor shall assure the proper storage of premix, fibers and additives as required by the supplier's specifications in order to protect materials against loss of physical and mechanical properties.

Acceptance Testing: Note: acceptance testing will be waived if the same material from the same supplier has already been tested according to this standard. The Contractor shall complete the testing of the UHPC a minimum of one month before placement of the joint. The testing
sequence will include the submission of a plan for casting and testing procedures to the DCES for review and approval followed by casting and testing according to the approved plan.

Casting and testing must include the following:

A minimum of 12 cylinders 3in. x 6 in. shall be cast.

The temperature during curing shall be as per heat treatment temperature limits established in this specification. 2 cylinders shall be tested each testing interval. Testing intervals are at 10 hours, 12 hours, 14 hours, and 24 hours.

**Pullout Test:** Cast 6 additional cylinders 12 in. diameter and 7.5 in. deep. Each cylinder shall have one 32 in. long epoxy-coated reinforcing bar cast in the center of the circular face. The axis of the bar shall be perpendicular to the formed surface. 3 of the bars shall be #6 bars embedded 5 in. deep and 3 of the bars shall be #4 bars embedded 3 in. deep. These cylinders will be kept wet for four days then delivered to the Materials Bureau for testing according to Test Method No. NY 701-14 E. Contact the Materials Bureau prior to casting for specific instructions on preparing the test specimens. The test will be performed as soon as practical after the corresponding compressive strength samples reach 12 ksi. Acceptance criteria for pullout testing shall be when there is complete tensile failure of the reinforcing bar, prior to pullout from the concrete or failure of the concrete.

**Equipment For Maturity Testing:**
Use a Maturity Meter and thermocouples that can:

- Provide a maturity value based on the Equivalent Age or Temperature Time Method as detailed in ASTM C 1074-11.
- Continuously log and store maturity data.
- Accurate to within +/- 1°F when the meter is calibrated as per the manufacturer’s instructions.
- Take readings every half hour for the first 48 hours and every hour after that at a minimum.
- Print data and/or download it into a spreadsheet.

**Methodology For Maturity Testing:** The procedure for utilizing the maturity method to determine in-place UHPC strengths includes three steps: development of the strength-maturity relationship, monitoring the maturity of the placement, and regular validation of the strength maturity relationship. Any changes in the mix design, its components, or proportions will require that a new strength-maturity relationship be developed. The strength-maturity relationship shall be developed one month prior to construction. Continue data collection for the strength-maturity relationship after acceptance of the maturity value until the strength reaches 21 ksi.
A procedure to develop the strength-maturity relationship shall be submitted to the DCES for review and approval along with the shop drawings. The submitted procedure shall include all necessary information for the development of the strength maturity relationship. All necessary testing included in the procedure shall be conducted by an AAHSTO accredited testing lab.

CONSTRUCTION DETAILS
Bar lists for the superstructure slab panels barrier are not provided in the contract documents. Submit bar list and placement drawings in accordance with §557-3.17. The submitted drawings shall include details of lifting and handling of concrete units in the production facility and their storage, transportation, handling and storage at the construction site. Lifting holes will not be permitted in panels. The proposed handling and lifting shall be such that the maximum tensile stress in concrete due to handling and erection loads shall not exceed 4.5 (f'ci)1/2, where f'ci is the concrete compressive strength at the time being considered in psi. Calculations showing actual concrete stresses based upon the proposed support locations and expected dynamic loading of the panels during handling, storage and transportation of the panels shall be prepared by a Professional Engineer licensed in the State of New York and shall be submitted along with the drawings. These drawings and calculations shall be stamped and signed by a Professional Engineer licensed in the State of New York.

The following shall apply (in addition to the provisions in the PCCM):

1. **Section 5.8** - Second sentence, change to: If no strength is indicated, the required minimum strength shall be 5000 psi at 28 days or at the time of shipping, if earlier.
2. **Section 5.10.2** - Delete this subsection, replace with: The tops of all units shall be finished in an identical manner. The finished surface shall be that approved on the Shop Drawings and in accordance with §557-3.07.
3. **Section 6.1** – Add the following: Lifting shall be done in the manner approved on the Shop Drawings.
4. **Section 6.4.2** - Add the following: Honeycombing of concrete to such an extent that chipping away the honeycombed concrete exposes:
   a. Any reinforcement comprising the top reinforcing mat.
   b. Reinforcement comprising the bottom reinforcing mat which is 24 diameters or longer, or two or more reinforcing bars regardless of length.
   c. Any unit exhibiting a crack in any part of the concrete that is greater than ½ inch in depth and 0.002 inches in width.
5. **Section 7** - The following tolerances shall apply:

Precasting Tolerances - The units shall comply with the applicable tolerances listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Panel Width</td>
<td>±1/4 inch</td>
</tr>
<tr>
<td>Overall Depth of Structural Slab</td>
<td>+3/8 inch, -1/8 inch</td>
</tr>
<tr>
<td>Slope (Top of Unit)</td>
<td>+½%, -0%</td>
</tr>
<tr>
<td>Reinforcing Cover - Both Mats</td>
<td>±1/4 inch</td>
</tr>
<tr>
<td>Reinforcing Placement – Horizontal</td>
<td>±2 inches</td>
</tr>
<tr>
<td>Inserts</td>
<td>±3/8 inch</td>
</tr>
<tr>
<td>Deviation from square, or designated skew</td>
<td>±1/4 inch (vertical)</td>
</tr>
<tr>
<td>Deviation from theoretical diagonal length</td>
<td>±3/4 inch</td>
</tr>
</tbody>
</table>

Any movement of the forms during casting beyond the tolerances listed above is cause for rejection of the unit. The Inspector will document all form movements to the DCES. A determination will be made by the DCES regarding the unit’s acceptability.

Post Lifting - All units shall be inspected for compliance with the tolerances listed below within 24 hours after lifting. All units failing to meet any one tolerance limit will be rejected with the concurrence of the DCES:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Alignment</td>
<td>3/8 inch</td>
</tr>
<tr>
<td>(Deviation from straight line parallel to centerline of unit)</td>
<td></td>
</tr>
<tr>
<td>Deviation between adjacent steel stringer flanges</td>
<td>±1/4 inch (within units)</td>
</tr>
<tr>
<td>Camber deviation from design camber (upright position)</td>
<td>±1/4 inch</td>
</tr>
<tr>
<td>Overall length of Unit</td>
<td>±3/4 inch,</td>
</tr>
<tr>
<td>Adjacent units shall not vary by more than</td>
<td>3/4 inch.</td>
</tr>
</tbody>
</table>

**Concrete Panels**

**Loading of Panels.** Equipment weighing more than 2500 pounds shall not be permitted on the precast units between the initial set of the UHPC and the time the UHPC has reached a minimum strength of 10 ksi.

**Mixing and Placing UHPC Joints and Haunches.** Thoroughly and continuously wet the concrete contact area for 24 hours prior the placing of UHPC, keep wet and remove all surface water just prior to UHPC placement.
Installation Requirements for Deck Slabs
Installation shall meet the requirements of the PCCM and the following:

1. Prior to installing panels, the supporting steel surfaces in contact with the panels or field placed concrete shall be cleaned, including removal of free water, to the satisfaction of the engineer.
2. Installation tolerances shall be as per the approved installation drawings. It is the responsibility of the contractor to develop appropriate controls during the fabrication and installation of the panels so that proper cross slopes and grades are achieved after the diamond grinding operation. Installation drawing shall show the details of the proposed controls.

Installation Requirements for UHPC
The contractor shall arrange for a representative of the UHPC supplier to be on site during the placement of the joints until the Contractor’s own staff has become well-trained in the use of the material. The representative shall be knowledgeable in the supply, mixing, delivery, placement, and curing of the UHPC material.

Pre-Installation Meeting
Convene a preplacement meeting 7 to 14 calendar days before the planned start of slab installation. The contractor shall arrange for an on site meeting with representatives from the UHPC and the precast system suppliers. The contractor's staff and the NYSDOT Engineer and Inspectors shall attend the site meeting. The objective of the meeting will be to clearly outline the procedures for placing and leveling the precast concrete panels and for mixing, transporting, finishing and curing of the UHPC material.

Form Work, Batching and Curing. The design and fabrication of forms shall follow approved installation drawings and shall follow the recommendations of the manufacturer. All the forms for UHPC shall be constructed from plywood or approved equal. The forms shall be coated to prevent absorption of water using a form release agent from the Department’s Approved List of Materials.

The contractor shall follow the batching sequence as specified by the supplier and approved by the DCES. The surface of the UHPC field joints shall be filled as shown on the approved drawings.

The UHPC in the form shall be cured according to Manufacturer’s recommendations to attain the required strength shown on the contract documents.
Quality Control
The contractor shall measure the slump flow on each batch of UHPC. The slump flow will be conducted using a mini-slump cone. The flow for each batch shall be between 7 in. and 10 in. The slump flow for each batch shall be recorded in the QA/QC log. A copy of the log shall be given to the Engineer.

Estimation of In-Place Strength
1. Two thermocouples per each UHPC joints, one at each end, shall be installed. The locations of these installations shall be shown on the installation drawings. These locations shall be revised if directed by the DCES. The thermocouple wiring may be connected to reinforcing steel, but probe endings may not be in direct contact with the steel. Consider structural or exposure conditions when placing thermocouples.
2. Listed actions are allowed when the maturity value of all the thermocouples reaches the corresponding strength values listed below.

<table>
<thead>
<tr>
<th>Action</th>
<th>Strength Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removal of Top Forms</td>
<td>10 ksi</td>
</tr>
<tr>
<td>Open Bridge deck to Traffic</td>
<td>12 ksi</td>
</tr>
</tbody>
</table>

3. Record and save the maturity data from the meter until the strength reaches 21 ksi. Disconnect the meter and clip all wires flush with the concrete surface.

A continuous read thermocouple or thermistor with a data logger can be used to estimate in place strength. The methodology outlined in ASTM C 1074-11 will be used. The maturity function used to estimate strength will be calculated with the same formula that is used by the maturity meter that established the initial strength maturity relationship. Copies of the calculations will be provided to the engineer.

Validation of the Strength-Maturity Relationship:
For each day of placement, perform validation tests by casting 7 cylinders. Equip one of the cylinders with a thermocouple. Test the cylinders as close as possible to the maturity value corresponding to 21 ksi. Record the maturity value immediately prior to testing. All testing shall be conducted by an AASHTO accredited testing lab. Report the results to the DCES. If the average value of compressive strength of each pair of cylinders is within 10% of the estimated value, the strength-maturity relationship will be validated. If the average cylinder value is more than 10% below the estimated value, the strength maturity relationship will need to be reestablished. If the first four cylinders produce acceptable results, the remainder need not be tested.

The Department may perform additional testing for research purposes. Casting and testing in addition to that required in this spec will be performed by NYSDOT personnel. In case of loss of
required data, or non-verification of the strength-maturity relationship, use the cylinders cast above, one pair at a time, to verify the strength.

**METHOD OF MEASUREMENT**
This work will be measured as the number of square yards of precast slabs satisfactorily installed, including closure pours, measured to the nearest 0.1 square yards.

**BASIS OF PAYMENT**
The unit price bid per Square Yard of Lightweight, High-Performance Precast Superstructure Slabs With Ultra-High Performance Concrete Joints, shall include the cost of all labor, materials, and equipment necessary to satisfactorily complete the work.

X = Type Friction

**Pay Items**

557.43010109 - Lightweight, High-Performance Precast Superstructure Slabs With Ultra-High Performance Concrete Joints, Type 1 Friction

557.43010209 - Lightweight, High-Performance Precast Superstructure Slabs With Ultra-High Performance Concrete Joints, Type 2 Friction

557.43010309 - Lightweight, High-Performance Precast Superstructure Slabs With Ultra-High Performance Concrete Joints, Type 3 Friction

557.43010909 - Lightweight, High-Performance Precast Superstructure Slabs With Ultra-High Performance Concrete Joints, Type 9 Friction