

## **SECTION 515 – UHPC OVERLAY**

### **515.01 DESCRIPTION**

This specification consists of supplying, mixing, transporting, placing, finishing, curing, and diamond grinding of Ultra-High Performance Concrete (UHPC) for use as an overlay and riding surface in accordance with the Contract Documents and as directed by the RE. It also includes the construction of stage line construction joints including placing galvanized reinforcement for these joints.

UHPC is a cementitious composite material composed of an optimized gradation of granular constituents, a water-to-cementitious materials ratio less than 0.25 and a high percentage of discontinuous internal fiber reinforcement.

### **515.02 MATERIALS**

#### **515.02.01 Materials**

Ultra-High Performance Concrete for Overlay.....	903.11
Curing Materials.....	903.10
Reinforcement Steel .....	905.01

#### **515.02.02 Equipment**

Provide equipment as specified:

Spreading and Finishing Machine .....	1005.02
Spreading and Finishing Machine for Concrete Bridge Decks .....	1005.03
Slip-Form (Extrusion) Machine .....	1005.06
Vibrator .....	1005.04
Straightedge .....	1008.02
Concrete Trucks .....	1010.02

If the Contractor elects to use a Spreading and Finishing Machine for Concrete Bridge Decks (1005.03) or a Slip-Form (Extrusion) Machine (1005.06), the machines must be specifically designed or modified for use with UHPC overlays.

Provide a minimum of two portable units for mixing the UHPC. Mixing equipment that is not supplied by the UHPC manufacturer must be reviewed and approved by the UHPC manufacturer for adequacy. During mixing keep the temperature of the UHPC below 85°F or the recommendation of the UHPC manufacturer; ice may be added to the mix as recommended by the UHPC manufacturer’s representative.

### **515.03 CONSTRUCTION**

#### **515.03.01 Storage**

Assure proper storage of all materials including but not limited to cement, aggregate, fibers and additives, as required by the supplier’s recommendation in order to protect the integrity of the materials against the loss of physical and mechanical properties.

#### **515.03.02 Placement Plan**

Submit a Placement Plan with a detailed construction work schedule to the RE for review and approval at least 30 days prior to the scheduled UHPC placement. No UHPC placement will be permitted until the Placement Plan has been submitted by the Contractor and approved by the RE.

The following list is intended as a guide to what should be included in the Placement Plan and may not address all of the means and methods the contractor may elect to use. The Contractor is expected to assemble a comprehensive list of all necessary items for executing the placement of UHPC.

1. Responsible personnel and hierarchy.

2. Equipment – including but not limited to pumps, hoses, mixers, holding tanks, generators, wheelbarrows, scales, meters, thermometers, floats, screeds, plastic sheeting, heaters, blankets, etc.
3. Quality Control of batch proportions - including dry ingredients, fibers, water and admixtures.
4. Quality Control of mixing time and batch times.
5. Batch procedure sequence.
6. Form work – including materials and removal.
7. Placement procedure – including but not limited to surface preparation of existing concrete surfaces and pre-wetting of the existing concrete interface to a saturated-surface- dry (SSD) condition before the placement of UHPC, spreading, finishing, and curing protection. Include provisions for acceptable ambient conditions and batch temperatures and corrective measures as appropriate.
8. Threshold limits for ambient temperature, ambient relative humidity, batch consistency, batch temperature, batch times and related corrective actions.
9. Cold weather placement procedures if appropriate.

Pumping of UHPC will not be allowed unless it is successfully demonstrated for approval at least 30 days prior to the scheduled UHPC placement. The demonstration must take place under ambient temperature conditions that are similar to those anticipated for the scheduled UHPC placement. If ambient temperatures during the scheduled UHPC placement exceed those during the pumping demonstration by more than 7°F, pumping will not be permitted without another demonstration at the higher temperature.

Construction loads applied to the bridge during UHPC placement and curing are the responsibility of the Contractor. Submit the weight and placement of concrete buggies, grinding equipment and other significant construction loads for review as part of the proposed Placement Plan.

#### **515.03.03 Survey**

Perform surveys of the bridge surface according to Section 157 – Construction Layout. Submit the surveys to the RE for approval prior to undertaking any further work on the deck or roadway surface. The Department will not make payment of UHPC overlay until all surveys are complete and approved by the RE. The Department will pay for survey separately.

#### **515.03.04 Surface Preparation**

Roughen **the** concrete deck surface during the hydro-demolition operation. Repair any remaining delaminations or spalls on the deck surface in accordance with the Plans and these Special Provisions so that the new overlay is placed on sound concrete.

After performing any concrete deck repairs and prior to placing UHPC, pre-wet the deck surface to a saturated surface dry (SSD) condition.

#### **515.03.05 Forming, Mixing, Transporting, Placing, and Curing**

Arrange for an on-site meeting with the UHPC manufacturer's representative one day before the start of the UHPC placement. The Contractor's staff and representatives from the Department will attend the meeting. The objective of the meeting will be to review the approved Placement Plan and clearly outline the procedures for mixing, transporting, finishing and curing of the UHPC.

Design and fabricate formwork, if required, to adhere to these specifications and the recommendations of the UHPC manufacturer. Construct forms from nonabsorbent material that are properly sealed and capable of resisting the hydrostatic pressures from UHPC in the unhardened state.

Ensure that a representative of the UHPC manufacturer knowledgeable in supplying, mixing, transporting, placing, finishing and curing of the UHPC material is present during mixing, transporting and placing of the UHPC to ensure the UHPC operations conform to the manufacturer's recommendations. Do not start mixing or placing UHPC until the manufacturer's representative is on-site. Place UHPC in accordance with the approved Placement Plan using one continuous pour per each stage of construction. The Department will not permit use of bulkheads. Keep UHPC from freezing until it has achieved a minimum compressive strength of 11.0 ksi.

If the ambient temperature and/or the deck temperature is less than 50°F during the day of placement or is expected to drop below 50°F during the two days following placement, then ensure that the cold weather placement procedures are in place to maintain the temperature of the UHPC and of the deck above 50°F until the UHPC has reached a minimum compressive strength of 11.0 ksi.

Ensure that forming, mixing, placing, and curing are in accordance with the UHPC manufacturer’s recommendations and as submitted to and accepted by the RE.

Progressively apply wet burlap or a curing compound to the UHPC overlay surface as the UHPC is being placed and screeded and then cover the overlay with waterproof sheeting as soon as practical afterwards. Ensure that the UHPC overlay surface is continuously covered by the waterproof sheeting until the UHPC has achieved a minimum compressive strength of 11.0 ksi.

Provide construction joints in the overlay at the stage line in accordance with the details shown on the Plans, including the installation of galvanized reinforcement steel. The RE will allow joints only at stage lines to facilitate construction, but will not allow additional joints in the overlay without prior approval. Any additional joints installed for the Contractor’s convenience or means and methods will not be the basis for additional payment or an extension of time.

**515.03.06 Material Acceptance Testing**

The Department Division of Construction and Materials will be on site during the placement of UHPC. To schedule a representative, contact the Division of Construction and Materials a minimum of 48 hours prior to the anticipated UHPC placement.

28-day compressive strength will be the basis for final material acceptance . The Department will not allow field coring of UHPC to determine compressive strength for dispute resolution.

Ensure that the entire UHPC overlay is fully bonded to the substrate concrete. Any evidence of lack of bond between the UHPC and the substrate concrete will require remedial action as directed by the RE.

The Contractor is responsible for providing an adequate location to place acceptance specimens for initial curing prior to transport to the lab. Cure specimens in accordance with ASTM C1856 in the same environment as the field-placed material they represent. Perform testing and obtain approval from the RE. Ensure that all testing are carried out on a set consisting of a minimum of three samples. Testing is summarized in Table 516.03.05-1. The numbers of each test listed in the table are a minimum value. The RE may require more tests are performed than described in the table at his/her discretion.

Table 515.03.06-1: UHPC Acceptance Testing			
Description	Test Method	Acceptance Criteria	Number
Compressive Strength	ASTM C1856	≥14 ksi at 28 days	7 sets of three samples for each day of placement.
Rapid Chloride Ion Penetrability	AASHTO T 277 / ASTM C1202	≤ 250 coulombs	2 per job (during field placement)
Slump Flow and Visual Stability	ASTM C1856/C1437	Acceptable range per Manufacturer’s recommendation; No bleed water; Consistent fiber distribution	1 per batch

If the UHPC overlay does not meet the requirements as described herein, remove and replace or remediate the UHPC overlay to the satisfaction of the RE at no additional cost.

**515.03.07 Surface Profile and Finish**

UHPC OVERLAY RESEARCH PROJECT  
 CONTRACT A (NORTH), CONTRACT NO. SW1183790  
 TOWNSHIPS OF MANSFIELD, MONTVILLE, AND KEARNY,  
 COUNTIES OF WARREN, MORRIS, AND HUDSON

Match the finished surface of the UHPC overlay with the proposed UHPC overlay surface profile to within  $\pm 1/4$  inch. Meet existing grades with the finish performed and conform to the deck finish tolerances and rideability requirements as specified in Section 507.03.

If asphalt is to be placed on top of the UHPC overlay, then no further surface preparation is required unless the condition of the UHPC overlay will inhibit the ability to properly install the asphalt to the minimum thickness shown. If surface remediation is pursued by the Contractor to facilitate asphalt placement on top of UHPC, it will be performed at no additional cost to the Department.

Where the UHPC overlay is the final riding surface, diamond grind the entire top surface of the UHPC overlay in accordance with Section 454. Perform the grinding of the UHPC surface after the UHPC overlay has achieved a minimum compressive strength of 11.0 ksi. Install a temporary surface above the final grade to facilitate the diamond grinding procedure to ensure the profile is met while the entire surface is ground. Determine the thickness of the temporary surface/overpour. The Department will not make additional payment for the temporary surface/overpour of UHPC.

Traffic or other loading will not be permitted directly on the UHPC overlay until the UHPC achieves a minimum compressive strength of 11.0 ksi, unless otherwise approved by the RE. Shifting traffic will not be permitted until the surface has been finished with UHPC (and diamond grinding) and/or asphalt pavement in accordance with these specifications.

#### **515.04 MEASUREMENT AND PAYMENT**

The Department will measure and make payment for Items as follows:

<i>Item</i>	<i>Pay Unit</i>
CONCRETE OVERLAY, UHPC	SQUARE YARD

The unit price bid for this work shall include surface preparation, supplying, mixing, transporting, placing, finishing, curing, grinding, grooving, and for furnishing all equipment, tools, labor, and incidentals required to complete the work as shown on the Plans. Include all costs to install the overlay in the square yard bid price for the pay item Concrete Overlay, UHPC. Any deviation for material placed within 20 percent of the estimated average thickness for each bridge as shown on the Plans will not be considered for additional payment. Extra material placed for temporary surface/overpours and/or any over-milling beyond the minimum deck hydro-demolition limits shown on the Plans will not count towards this 20 percent value. Additional material needed for stage construction joints must be added to the anticipated overlay material and included in the square yard bid price for the overlay.

Additional quantity of material used in the determination of material properties and for acceptance testing as described herein will be furnished at no additional cost to the Department. No additional payment will be made for surface preparation or for grinding procedures.

# DIVISION 900 – MATERIALS

## SECTION 903 – CONCRETE

### 903.11 ULTRA-HIGH PERFORMANCE CONCRETE FOR OVERLAY

Provide materials as follows. All materials in items (1) & (2) below must be preblended and proportioned in bags or supersacks and come from the same batch or lot.

1. Fine Aggregate
2. Cementitious Material
3. Fibers – Supplied by or as recommended by the UHPC manufacturer. Minimum fiber content will be 3.25% of the mix’s dry volume.
4. Water – per Section 919.08 and as specified by the manufacturer for use in the UHPC mix.
5. Admixtures - Only as specified by the UHPC Manufacturer.

The mix must be capable of being placed on an 8% grade while maintaining the required profile.

The UHPC mixture shall meet the material properties listed in Table 515.02.01-1 after 28 days, unless otherwise noted in the contract documents or as directed by the Engineer. Material properties listed below will be verified by the manufacturer and submitted for approval in the Placement Plan.

Table 903.11-1: UHPC Material Properties		
Description	Test Method	Acceptance Criteria
Compressive Strength	ASTM C1856	≥ 14 ksi at 28 days
Direct Tension Cracking Strength	FHWA-HRT-17-053	≥ 1,100 psi
Direct Tension Sustained Post-Cracking Tensile Strength	FHWA-HRT-17-053	≥ 1,250 psi
Direct Tension Bond Strength	ASTM C1583, bonded to an exposed aggregate concrete surface	100% failure in substrate concrete with concrete compressive strength ≥ 4 ksi.
Modulus of Elasticity	ASTM C1856	≥ 6,500 ksi
Long-Term Shrinkage	ASTM C1856	≤ 800 micro-strain
Rapid Chloride Ion Penetrability	AASHTO T277 / ASTM C1202	≤ 250 coulombs
Scaling Resistance	ASTM C672	Y < 3
Freeze-Thaw Resistance	ASTM C1856	Relative Dynamic Modulus of Elasticity > 95%
Alkali-Silica Reaction	ASTM C1260	Innocuous

At least 60 days before the proposed placement, place a rectangular test slab of UHPC that is 4 feet by 12 feet, with a grade of 8% in the longitudinal direction, with a thickness of 3 inches. After the UHPC has achieved final set, take six cores at locations chosen by the RE, such that two cores are taken in each third of the slab, as measured longitudinally. The depth of all cores must be within ½ inch of 3 inches.

If the Contractor does not achieve the required tolerance, procedures must be changed to assure the material can meet the tolerance, and the test slab repeated. Subsequent failures must be followed by placement of a new test slab, until the Contractor is successful.

Submit the results of all the tests above, conducted by an AASHTO accredited testing lab to the Department for review and approval a minimum of 30 days prior to the use of UHPC in the field. Should the tests not meet the specified criteria, additional testing will be required prior to placement of UHPC to demonstrate compliance with these specifications.

#### **903.11.01 Storage**

Ensure 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.

#### **903.11.02 Qualification Testing**

Complete the testing of the UHPC a minimum of one month before production placement of UHPC. The testing sequence will include the submission of a plan for casting and testing procedures to the RE for review and approval followed by casting and testing according to the approved plan.

Casting and testing must include the following:

Cure all cylinders using the same method of curing proposed to be used in the field. The temperature during the curing to be within 18° Fahrenheit of the low end of the proposed temperature range for curing in the field.

Compression Test: Prepare a minimum of 12 cylinders 3 inches in diameter and 6 inches deep. Test three (3) cylinders at each time interval. The time intervals and minimum strength requirements are given above. Measure the compressive strength by ASTM C39. Use only a UHPC mix design that passes these tests.

Submit results of all the tests above, conducted by an AASHTO accredited testing lab, to the ME for approval at least 30 days prior to the start of field placement. Provide to the ME a list of bridge projects in which the proposed UHPC material has been used for bridge overlays (within or outside the USA). The ME reserves the right to reject a proposed UHPC material which lacks a proven track record for use in bridge overlays.

#### **903.11.03 Quality Control**

Measure the dynamic flow on each batch of UHPC. Conduct the dynamic flow using a mini-slump cone according to ASTM C230 and ASTM C1437 with 20 drops or a number recommended by the UHPC supplier over a period of 10 seconds, subject to the Department's approval. Ensure that the flow for each batch is between 7 inches and 10 inches, or according to the manufacturer. The specified spread is to be confirmed during the mock-up trials. Record the flow for each batch in the QA/QC log. Provide a copy of the log to the RE.

Take a minimum of 4 sets of compressive strength test samples for each day of placement. Ensure each set consists of at least 3 cylinders 3 inches x 6 inches. Provide molds as required. Cure all sets in an environment similar to the material they represent. After removal from the molds, grind the ends of the cylinders per ASTM C1856 so that the ends are ground parallel and planer before testing.

Perform compressive strength testing according to ASTM C39 as modified by C1856. Ensure the timing of the testing is as required to demonstrate design strength before loading; test multiple sets of cylinders if different loading periods will be proposed based on the magnitude of loading. Perform the testing of the second set at 28 days. Submit the third set to the Materials Bureau between the 4th day and the 14th day. Treat the 4th set as a reserve set.

All requirements and procedures of Section 903.03.05F apply.