

ULTRA-HIGH-PERFORMANCE CONCRETE (REV 4-20-23)

The following new Section is added:

SECTION 349 ULTRA HIGH PERFORMANCE CONCRETE

349-1 Description.

Use ultra-high-performance concrete (UHPC) composed of an optimized gradation of granular constituents, cementitious materials, and reinforcing fibers with a water-to-cementitious materials ratio of less than 0.25. Use only materials listed on the Department's Approved Product List (APL).

Prior to casting UHPC, construct a mockup of a typical UHPC element to demonstrate the casting process meets Contract Document requirements.

349-2 Materials.

349-2.1 General: Meet the following requirements:

Prepackaged Ultra High Performance Concrete (UHPC)*Section 927

Water**Section 923

*Use products listed on the Department's APL.

**Use potable water only.

349-3 Onsite Supervision of Ultra-High-Performance Concrete (UHPC) Production.

349-3.1 General: Ensure a qualified onsite supervisor and a technical field representative from the manufacturer is on-site during all UHPC production and work activities; including mockup, mixing, batching, placement, and curing.

349-3.2 On-Site Supervisor: On-site supervisors must complete the Department's online training course.

Ensure that the on-site supervisors have related work experience on at least one long bridge (bridges having a length greater than 100 feet) or two short bridges (bridges having a length less than or equal to 100 feet). Submit a list of projects where the work included UHPC production and work activities. For each bridge listed, provide a brief description of each, dates of completion of work, the project owner's name, and the name, title, and current contact information of a project owner representative.

349-3.3 Manufacturer's Technical Representative: Arrange for a technical field representative of the UHPC manufacturer to be onsite during mockup demonstration, and project construction, including mixing, batching, placement, and curing activities of UHPC for bridge construction.

When the UHPC placement is scheduled for more than one day, the manufacturer representative must be present at the jobsite on the first day of production. The Engineer may accept the non-participation of the manufacturer's for the rest of the onsite placements.

349-4 Construction Work Plan.

Submit a detailed work plan to the Engineer for review and approval prior to UHPC pre-pour meeting. As a minimum, include the following items in the work plan:

1. Quality Control Plan (QCP) in accordance with Section 105.
2. Submit the selected APL product at least 60 days prior to the first anticipated UHPC placement.
3. Project specific storage requirements of UHPC materials ingredients per manufacturer's recommendation.
4. Structural Plans with dimensions showing connection joints, suggested sequence of UHPC placement, and project schedule requirements.
5. Proposed forming materials and procedure for maintaining watertight joints.
6. Top forms when used for deck-level connections are prepared and adequate hold downs are available for the top forms.
7. Top form when used for deck -level connections are set at a minimum of 1/4 inch above the top of the deck to allow for all overfilling in accordance with the project Plans.
8. Details of all equipment to be used to batch and place UHPC materials.
9. Schedule and duration of traffic control measures required for completion of the work.
10. Method to attain 1/8 inch to 3/16-inch average amplitude of the exposed aggregate finish for all precast concrete surfaces in contact with UHPC. The use of paste retarders is required to provide the required aggregate finish of precast concrete surfaces in contact with UHPC surfaces.
11. Surface preparation plan of existing concrete surfaces and pre-wetting of the existing concrete interface to a saturated surface-dry (SSD) condition prior to placement of UHPC.
12. Detailed plan and procedure for UHPC joint mockup.
13. Include provisions for acceptable ambient temperature, batch temperatures, ambient relative humidity, batch consistency, and batch times.
14. The mixing, batching, delivery, placement, finishing, and curing procedure of UHPC.
15. The procedure for casting of a demonstration mockup to show the ability to properly cast UHPC components.
16. Proposed schedule and procedure for watertight integrity testing of completed UHPC bridge deck joints.
17. Pre-pour meeting agenda, including manufacturer's recommended topics.

349-5 UHPC Pre-Pour Meeting.

Conduct a pre-pour meeting prior to the UHPC mockup demonstration. Notify the District Materials Office (DMRO) and the State Materials Office (SMO) at least 48 hours prior to the scheduled meeting.

349-6 UHPC Mockup.

349-6.1 General: Construct a mockup in accordance with the design Plans, approved shop drawings, pre-pour meeting discussions, and as recommended by the UHPC manufacturer. Notify the DMRO and the SMO for witnessing, reviewing, and evaluating of the mockup construction operations, at least seven calendar days prior casting of the mockup.

Cast a mockup at least 30 calendar days prior to placement of UHPC, either at the jobsite or offsite, that is a full-scale representation of the proposed joint and replicates the form pressure created by the liquid. Ensure that the mockup replicates the interface between the UHPC and precast concrete panel, roughened to an exposed aggregate finish. The use of paste

retarders is required to provide the exposed aggregate finish of precast concrete surface in contact with UHPC surfaces. Following placement and sufficient curing of the UHPC, cut the hardened mockup transversely at two locations to allow for visual inspection of the joint interface and material bond.

Make the completed mockup cut sections available for review. Notify the DMRO and the SMO.

The Engineer with input from the SMO or their designated DMRO representative may approve the mockup.

The Engineer's approval of field casting of the UHPC is dependent on successful demonstration of the mockup.

349-7 Construction Methods and Requirements.

1. Notify the DMRO and the SMO for witnessing, reviewing, and evaluating of the construction operations, at least seven calendar days prior of the onsite placement.

2. Perform forming, batching, placing, and curing in accordance with approved construction work plan.

3. Do not remove formwork prior to 24 hours after UHPC placement or per manufacturer's recommendations.

4. Provide the required number of mixers in accordance with the manufacturer's recommendations.

5. Ensure that the fibers are evenly distributed to avoid clumping.

6. During batching, keep the temperature of the UHPC below 85°F. Add ice to the mix as recommended by the UHPC manufacturer's representative, but do not exceed the allowable specified water-to-cementitious materials ratio.

7. Ensure that the measured average amplitude of the exposed aggregate finish for all precast concrete surfaces in contact with UHPC is between 1/8 inch and 3/16 inch.

8. Keep connections free of any oil, dirt, and debris.

9. Prior to UHPC placement, prewet precast concrete surfaces that will be in contact with UHPC. Continuously wet the concrete contact area with fresh water for at least 24 hours prior to the UHPC placement.

10. Remove all standing surface water just prior to UHPC placement.

11. Follow the batching sequence as described in the approved UHPC construction work plan.

12. When specified, fill the surface of the UHPC field joints to 1/4-inch above the surface of the adjacent concrete surface.

13. Place UHPC in accordance with the approved construction work plan. Do not use internal vibration during UHPC placement. The use of rodding of UHPC is allowed at the locations where successive pours meet. Keep UHPC at the manufacturer's recommended temperature range during the placement.

14. On short bridges, place the UHPC in a continuous operation with no cold joints. For long bridges, submit for Engineer's approval, the UHPC placement sequence, including all planned joints. Cure and cover the UHPC in accordance with the manufacturer's recommendations.

15. Ensure that the connection joints remain free from differential movement and rotation until the UHPC achieves the required compressive strength shown in the Contract Documents.

16. Ensure that all lifting lug pockets and any other deck protrusions are water blast cleaned and filled with UHPC.

17. After the installation of the bridge deck joints, perform a water integrity test in accordance with 349-9.2.

18. Perform grinding of the UHPC surface after the UHPC achieves the required compressive strength shown in the Contract Documents. Suspend grinding if significant fiber pullout is observed during grinding operations. Take corrective actions to prevent the recurrence of the problem which require the Engineer's approval prior to implementation.

19. Ensure that the UHPC compressive strength has achieved the required strength shown in the Contract Documents.

349-8 Sampling and Testing.

349-8.1 UHPC Quality Control Sampling and Testing: During field demonstration of mockups and construction, perform sampling and testing of UHPC at the frequencies described in Tables 349-1 and 349-2, respectively. Perform the following quality control sampling and testing during casting of the mockup and field casting of UHPC placement:

1. Measure the flow of each batch of UHPC. The allowable flow range is between 8 to 10 inches.

2. Record UHPC flow, ambient air temperature, and mix temperature for each batch. Include the time and date, amounts of water and ice, and admixtures corresponding to the UHPC batch and LOT numbers for traceability. A LOT of UHPC is defined as 15 cubic yards or one day's production, whichever comes first.

3. As part of the as-built records, track and show the placement locations of UHPC LOTs. Submit a copy of the as-built records to the Engineer.

4. Compressive Strength Cylindrical Specimens: From every LOT, take four sets of three compressive strength test cylinders described in Table 349-2. Cure all sets in an environment like that of the placed UHPC. For traceability, track all sets to LOT numbers.

Table 349-1 Quality Control Sampling and Testing Frequencies During Field Demonstration of Mockup		
Material Characteristic Description	Test Method	Minimum Sampling and Testing Frequency
Flow of UHPC	ASTM C1437 (Using Modifications Described in ASTM C1856)	One test per batch
Temperature of freshly mixed hydraulic cement concrete	ASTM C1064	One test per batch
Compressive strength of cylindrical concrete specimens	Make test specimens in accordance with ASTM C31 and test them in accordance with ASTM C39 (Using Modifications Described in ASTM C1856)	Cast two sets of 3 cylinders for testing at 4 and 28 days. Include extra set when other ages are specified in the Contract Documents.
Tensile strength and relative toughness of cylinders	FM 5-626	Cast a specimen for 28 days testing. Include extra specimens when other ages are specified in the Contract Documents.

Table 349-2 Quality Control Sampling and Testing Frequencies During Construction		
Material Characteristic Description	Test Method	Minimum Sampling and Testing Frequency
Flow of UHPC	ASTM C1437(Using Modifications Described in ASTM C1856)	One test per batch
Temperature of freshly mixed hydraulic cement concrete	ASTM C1064	One test per batch
Compressive strength of cylindrical concrete specimens	Make test specimens in accordance with ASTM C31 and test them in accordance with ASTM C39 (Using Modifications Described in ASTM C1856)	Cast two sets of 3 cylinders for testing at 4 and 28 days, and two additional cylinders for resolution per LOT of 15 CY or one day's production, whichever comes first. Include extra sets when other ages are specified in the Contract Documents.
Tensile strength and relative toughness of cylinders	FM 5-626	Cast a specimen for 28 days testing. Include extra specimens when other ages are specified in the Contract Documents.
Chloride content	FM 5-516	One test per month of UHPC production
Water integrity test for bridge deck joints	349-10.2	One test per bridge deck

349-8.2 UHPC Quality Control Compressive Strength Testing: For each LOT, test the compressive strength cylinders at the times that are described below:

1. Test three cylinders at 4 days.
2. Test three cylinders at 28 days.
3. Hold the remaining two cylinders for resolution testing, if needed.

Cast additional sets of cylinders when other ages are specified in the Contract Documents, or for form removal, opening of the bridge to traffic and loading the structure.

Ensure that the tests are performed by a testing laboratory meeting the lab qualifications of 105-7. Cure the cylinders onsite in a similar environment as the UHPC joint material and ship them to the Department qualified testing laboratory for testing. Cure the 28-day test cylinders and resolution test cylinders initially in the field in accordance with ASTM C31 and ship them to the laboratory for final curing and testing.

Ensure that the Quality Control (QC) testing laboratory enters the compressive strength test results into the Department's Materials Acceptance and Certification (MAC) within 24 hours of their testing, as described in 346-9.1.

349-8.3 UHPC Chloride Content Limits for Concrete Construction: Perform the chloride content test at a frequency of one sample per month of UHPC production. The maximum allowable chloride content is 0.40 pounds per cubic yard.

349-9 Quality Assurance Program.

349-9.1 Verification Sampling and Testing: The Engineer will observe the UHPC placement and take verification samples for concrete temperature, flow, and compressive strength tests at a frequency of one sample per four LOTs.

For UHPC, the compressive strength verification samples consist of five cylinders; three cylinders for the 28-day tests and two cylinders for resolution testing, if needed.

Notify the Engineer at least 48 hours prior to the anticipated UHPC placement. Final acceptance will be based upon 28-day compressive strength. Field coring of UHPC for dispute resolution is not allowed.

The Engineer will compare UHPC QC and Verification test results in accordance with 346-9.5. The Department will proceed to the resolution procedure in accordance with 346-9.6 if the difference between the QC and Verification test results exceeds 14%.

Provide an adequate location to place acceptance specimens for initial curing prior to transport to the laboratory. Equip the curing boxes with supplemental heat or cooling as necessary to cure specimens in accordance with ASTM C31.

Remove the UHPC and replace or remediate to the satisfaction of the Engineer, if the UHPC does not meet the minimal material properties of this Section.

349-9.2 Water Integrity Test for Bridge Deck joints: After the bridge deck joints have been installed with UHPC and formwork has been removed, flood the entire deck with water for a minimum duration of 30 minutes. Inspect the concrete surfaces under the joint during this minimum of 30-minute period, and for a minimum of 45 minutes after the supply of water has stopped to ensure that there is no evidence of dripping water or moisture. The Engineer will verify the results of the inspections by performing an independent inspection of the concrete surfaces under the joints. The surfaces on the underside of the joint are considered watertight when they are free from any sign of moisture. If the joint system exhibits evidence of water leak at any location, take remedial measures necessary to stop further leakage. Subsequent water integrity tests may be required subject to the same conditions as the original test per the Engineer.

349-10 Method of Measurement.

The quantity of UHPC to be paid for will be the Plan Quantity, in cubic yards, in place, and accepted.

349-11 Basis of Payment.

349-11.1 General: Price and payment will constitute full compensation for all work including surface preparation, supplying, mixing, transporting, volume of UHPC joint mockup, placing, finishing, curing, grinding, water integrity testing for bridge deck joints, and for furnishing all equipment, tools, labor, and incidentals required to complete the work.

No payment will be made for material used in the determination of material properties or for acceptance testing.

349-11.2 Pay Items: Payment will be made under:

Item No. 918-349 – Ultra High-Performance Concrete – per cubic yard.

PREPACKAGED ULTRA-HIGH-PERFORMANCE CONCRETE

(REV 4-20-23)

The following new Section is added:

SECTION 927

PREPACKAGED ULTRA-HIGH-PERFORMANCE CONCRETE

927-1 Description.

This Section covers ultra-high-performance concrete (UHPC) products.

927-2 Product Certification.

UHPC Manufacturers must submit product data sheets and certified test reports from an independent laboratory showing that the product meets the requirements of this Section.

Manufacturers seeking evaluation of products for inclusion on the Department's Approved Products List (APL) shall submit an application to the Department and include the documentation identified in 927-3.2. The Department may require material samples for verification testing.

Any change of materials or material sources requires new testing and certification of the conformance of the UHPC with this Specification.

927-3 Materials.

927-3.1 Packaging, Marking and Storage: Deliver product in original, unopened moisture-proof bags with the manufacturer's name, date of manufacture, and clearly marked with the information described below. Store the material in a dry and weather protected enclosure in full compliance with the manufacturer's recommendations. Material must be used within the manufacturer's recommended shelf life.

All containers must be marked with the following information:

1. Packaging date and material expiration date.
2. Weight of each bag and number of bags in each pallet.
3. Storage temperature.
4. Mix components, proportions, yield, and mixing procedure, including

the following:

a. Description of the premixed dry materials in each bag.
b. Fibers – the type, diameter, length, and tensile strength of fiber, including the percentage of the mix's dry volume. All fibers reinforcement must comply with the source of supply requirements of Section 6.

c. Admixtures – Indicate if admixtures are part of the premixed component or if they will be delivered in separate bags or containers. Do not use admixtures or additives containing calcium chloride, either in the raw materials or introduced during the manufacturing process.

927-3.2 Product Data Sheet: Provide a product data sheet with the following information:

1. Storage of product components at project site.
2. Mix proportions and yield in cubic yards. For each product, provide a mix design with a maximum allowable water-to-cementitious materials ratio of less than 0.25
3. Ambient and mixture temperatures during mixing, batching, and placement.

4. Batching, mixing, transportation, placement, finishing, and curing.
5. Product properties listed in Tables 927-1 and 927-2
6. The typical fresh properties of UHPC product, including density, flow, working time, and set time of the mix.

Table 927-1: Prepackaged UHPC Properties		
Material Characteristic Description	Test Method	Acceptance Criteria (*)
Temperature of freshly mixed hydraulic cement concrete	ASTM C1064	Specified by the Manufacturer
Flow of UHPC	ASTM C1437(Using Modifications Described in ASTM C1856)	Specified by the Manufacturer
Time of setting of UHPC	ASTM C191 (Using Modifications Described in ASTM C1856)	Specified by the Manufacturer
Concrete Compressive Strength of Cylindrical Concrete Specimens (Non-Heat Treated)	ASTM C39 (using modifications described in ASTM C1856)	≥17,400 psi at 28 days
Tensile strength and relative toughness of cylinders	FM 5-626	For Information Only
Split Cylinder First Cracking Strength	ASTM C496 (Mount LVDTs to the ends of the test cylinder for measuring the first cracking strength.)	≥1,000 psi at 28 days
Flexural Performance of Fiber - Reinforced Concrete (First- Peak Strength)	ASTM C1609 (using modifications described in ASTM C1856)	≥1,200 psi at 28 days
Static Modulus of Elasticity of Concrete in Compression	ASTM C469 (using modifications described in ASTM C1856)	≥6,500,000 psi at 28 days
Length Change of Hardened Concrete	ASTM C157 (using modifications described in ASTM C1856)	≤800 micro-strain at 28 days
(*) For APL approval, the Department may accept values outside of the specified acceptance criteria.		

Table 927-2: UHPC Durability Properties		
Material Characteristic Description	Test Method	Acceptance Criteria (*)
Chloride content	FM 5-516	≤ 0.40 lb/yd ³
Chloride ion permeability	AASHTO T 259 (0.5-inch depth)	< 0.1 lb/yd ³
Scaling Resistance	ASTM C672	Y < 3
Freeze-Thaw Resistance	AASHTO T 161/ASTM C666A (600 cycles)	Relative Dynamic Modulus of Elasticity ≥ 95%
Alkali-Silica Reaction	ASTM C1567	Innocuous (at 28-day Test)
(*) For IPL approval, the Department may accept values outside of the specified acceptance criteria.		