DS-23029
(New)

DEVELOPMENTAL SPECIFICATIONS
FOR
ULTRA HIGH PERFORMANCE CONCRETE CONNECTIONS

Effective Date
October 17, 2023

THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

23029.01 DESCRIPTION.

A. Furnish all materials, tools, and labor necessary for the performance of all work to form, prepare bonding surfaces, cast, finish, and cure Ultra High Performance Concrete (UHPC) where required per plan for Ultra High Performance Concrete Connections.

B. Submittals.

1. General.
- **a.** Provide submittals to the Engineer in electronic format, in accordance with Article 1105.03 of the Standard Specifications.
- **b.** The submittals requiring written approval from the Engineer are as follows:

2. UHPC Placement Plan.
- **a.** Submit the UHPC Placement Plan for approval 30 days before casting concrete that includes a joint surface abutting UHPC for the superstructure to substructure connection (e.g. abutment footing concrete).
- **b.** The UHPC Placement Plan shall include, but not necessarily be limited to, the following:
  - Proposed method(s) of joint surface preparation to achieve the required concrete surface profile texture, as required in the design plans.
  - Proposed forming method(s).
  - Proposed batching sequence. The batching sequence shall include the order and time of introduction of the materials and the mixing time.
  - Proposed sequence and schedule for UHPC placement operations.
  - Details of all equipment to be used to batch and place UHPC materials, including mixers, pumps, concrete buggies, etc.
  - Curing procedures, including minimum cure time and minimum strength requirements prior to loading.
  - Include a plan that describes the process for curing and transporting the test specimens to assure that field curing conditions are being replicated.
  - Details of the UHPC mix's average anticipated strength by age for the following time increments shall be indicated in table form: 12 hours, 24 hours, 36 hours, 48 hours,

60 hours, 72 hours, for each day from 4 days through 14 days, 21 days, 28 days.
- Testing procedures.
- Quality control / quality assurance procedures for verification of mix uniformity.

3. UHPC Mix Design.

a. Submit UHPC mix design to the Engineer 60 days prior to first placement of UHPC. Results of all compressive and pullout tests, conducted by an AASHTO accredited testing lab, shall be submitted to the Engineer for review and approval with the mix design. The Engineer may waive the tests of the UHPC mix if these tests have been previously performed for material supplied by the manufacturer.

b. A minimum of eight cylinders 3 inches by 6 inches for compressive strength testing and three additional 12-inch diameter by 7 1/2 inch deep cylinders for pullout testing shall be cast for mix design testing.

c. All compressive test cylinders shall be cured using the same method of curing proposed to be used in the field. The temperature during curing shall be within 18°F of the low end of the proposed temperature range for curing in the field. Compressive testing times are at 4 days, 7 days, 21 days and 28 days and two cylinders shall be tested for each testing day. The compressive strength shall be measured by ASTM C39 and shall meet 12 ksi minimum at 4 days and 21 ksi minimum at 28 days. Only a UHPC mix design that passes these tests may be used to form the joints.

d. The additional three 12 inch diameter by 7 1/2 inch cylinders shall each have one 32 inch long epoxy-coated reinforcing bar cast in the center of the circular face for pullout testing. The axis of the bar shall be perpendicular to the formed surface. The bars shall be No. 4 bars embedded 3 inches deep. These cylinders shall be kept wet for four days prior to delivery to the testing lab. Pullout testing shall be in accordance with ASTM E488 – Unconfined Test Method. The test shall be performed as soon as practical after corresponding compressive test samples reach 12 ksi compressive strength. Pullout test samples pass if the bars yield without the UHPC failing and without the bars pulling out of the UHPC.

4. List of Similar Bridge Projects.

Sixty days prior to first placement of UHPC, provide to the Engineer a list of bridge projects in which the proposed UHPC material has been used as joint fill between cast-in-place and/or precast concrete elements (within or outside the USA). The Engineer reserves the right to reject proposed UHPC material which lacks a proven track record for precast concrete joint filling in bridge applications.

23029.02 MATERIALS.

A. UHPC Material.

UHPC material shall meet the following requirements at 28 days, unless noted otherwise.

Table 23029.02-1: UHPC Material

Property	Test Method	Value
Compressive Strength (min.) Heat-Treated * Non Heat-Treated ** Non Heat-Treated, 4 Day **	ASTM C 39	 ≥ 25 ksi ≥ 21 ksi ≥ 12 ksi
Flexural Performance of Fiber-Reinforced Concrete (First- Peak Strength)	ASTM C 1609 (using modifications described in ASTM C 1856)	≥ 1200 psi at 28 days
Long-Term Shrinkage, initial reading after set	ASTM C 157	≤ 766 microstrain
Chloride Ion Penetrability	ASTM C 1202	≤ 250 coulombs

Chloride Ion Penetrability, 1/2 inch depth	AASHTO T259	≤ 0.07 oz/ft^3
Scaling Resistance	ASTM C 672	Y < 3
Abrasion Resistance, 2x weight, ground surf.	ASTM C 944	< 0.025 oz. lost
Freeze-Thaw Resistance, 600 cycles	ASTM C 666A	RDM > 96%
Alkali-Silica Reaction, tested for 28 days	ASTM C 1260	Innocuous

* Heat treated according to Manufacturer's recommendation; Temperature not to exceed 250°F.
** Not heat-treated-cured at a temperature of 60°F ± 3°F

B. Water.

1. Free from foreign materials in amounts harmful to concrete and embedded steel and meeting the following requirements:

Table 23029.02-2: Water for UHPC

Property	Test Method	Value
Presence of Oil		None
pH	AASHTO T 26	5.0 to 8.5
Organic Solids, max PPM	AASHTO T 26	200
Total Inorganic Solids, max PPM	AASHTO T 26	2000
Chloride Ion Content, PPM		500
Sulphate Ion Content, PPM		1000

2. Potable water obtained from a municipal supply, suitable for drinking, may be accepted without testing.

C. Fiber Reinforcement.
Steel fibers are required for the UHPC.

23029.03 CONSTRUCTION.

A. Quality Assurance.
Determine flow of freshly mixed UHPC according to ASTM C 1856. The measured diameter of the concrete shall be within the following limits: minimum 8 inches; maximum 10 inches. The test shall be performed on every UHPC concrete batch. Record the flow for each batch in the QA/QC log. Provide a copy of the log to the Engineer.

B. Pre-Pour Meeting.
Prior to the initial placement of UHPC, arrange for an onsite meeting with the UHPC representative and the Engineer. The Contractor's staff and the Contracting Authority's inspectors shall attend the site meeting. The objective of the meeting will be to clearly outline the procedures for mixing, transporting, finishing, and curing of the UHPC material. Arrange for a representative of the UHPC supplier to be on site during the placement of all UHPC connections. The UHPC representative shall be knowledgeable in the supply, mixing, delivery, placement, and curing of the UHPC material.

C. Storage.
Assure the proper storage of UHPC premix fibers and additives as required by the UHPC supplier's specifications to protect materials against loss of physical and mechanical properties.

D. Forming, Batching, Placement, and Curing.

1. Work together with the UHPC Manufacturer to ensure appropriate initial strength gains to meet the desired project schedule.

2. The 7 day minimum age for subjecting concrete to loads shall not apply to the UHPC. Cure duration shall be based on early strength breaks using cube tests and UHPC Manufacturer's recommendation.

3. For UHPC joint applications connecting bridge superstructure to bridge substructure, abutment backfilling operations can proceed when abutment UHPC closure pour strength of 6 ksi has been achieved, unless otherwise recommended by the UHPC Manufacturer.

4. For all UHPC joint applications the bridge can be opened to traffic, including construction equipment, when strength of 14 ksi has been achieved, unless otherwise recommended by the UHPC Manufacturer.

5. Forming, batching, placing, and curing shall be in accordance with the procedures as submitted to and accepted by the Engineer.

6. The design and fabrication of forms shall follow approved installation drawings and shall follow the recommendations of the UHPC Manufacturer. All the forms for UHPC shall be constructed from a transparent plexiglass type material. The forms shall not absorb water.

7. Follow the batching sequence as specified by the UHPC Manufacturer and as approved by the Engineer.

8. The UHPC joint shall be cast using one continuous placement. No cold joints shall be permitted.

9. The concrete in the form shall be cured according to Manufacturer's recommendations at minimum temperature of 60°F to attain the design strength.

E. Material Testing.

1. Destructive Testing.

a. Due to the special nature and equipment required to test the UHPC, the UHPC supplier shall be responsible for providing Material Testing Services and Results. The Results shall be signed and sealed by the UHPC Supplier's Engineer, licensed and registered in the State of Iowa. The results shall be provided as arranged with the Engineer, to meet the construction schedule and requirements for opening the bridge.

b. For each day of UHPC placement, cast four sets of compressive test cubes and two sets of compressive test cylinders. Each cubic set shall consist of three, 2 inch by 2 inch cubes. Each cylindrical set shall consist of three, 3 inch by 6 inch cylinders. All sets shall be cured in an environment like the material they represent.

c. Early strength test breaks shall use cube sets to validate achievement of the required compressive strength. Cubic compressive tests shall be performed in accordance with ASTM C109. Three cube specimens shall be tested for each of the following early strength milestones: 6 ksi prior to abutment backfilling operations, 10 ksi prior to grinding UHPC overfill, and 14 ksi prior to opening the bridge to traffic. The remaining three cubic specimens shall be treated as reserves.

d. Final strength test breaks shall use cylinder tests to validate achievement of the required compressive strength. Cylindrical compressive tests shall be performed in accordance with ASTM C39. Three cylinder specimens shall be tested at 28 days to validate the required 21 ksi final strength. The remaining three cylindrical specimens shall be treated as reserves.

e. When test data shows specified strength milestones are not achieved, notify the Engineer. Wait until the next scheduled test or test the reserve specimens at a time that has been approved by the Engineer.

2. Maturity Method testing.

a. The Contractor has the option to use the Maturity Method for estimating the in-place UHPC strength in lieu of destructive testing. Use of this method requires the development of the strength-maturity relationship according to Materials I.M. 383.

b. If using the Maturity Method, cast one set of cubic specimens, as described above, for each day of UHPC placement. These shall be treated as reserves.

23029.04 METHOD OF MEASUREMENT.

Measurement of Ultra High Performance Concrete (UHPC) will be the quantity shown in the contract documents in cubic yards.

23029.05 BASIS OF PAYMENT.

Payment will be for the contract unit price of Ultra High Performance Concrete (UHPC). Payment is full compensation for furnishing all submittals, materials, labor, testing, results, formwork and incidental work for completion of the UHPC joint as indicated in this developmental specification and the contract documents.