SP-230382
(New)

SPECIAL PROVISIONS
FOR
NON-PROPRIETARY ULTRA-HIGH PERFORMANCE CONCRETE FOR BRIDGE DECK OVERLAYS

Crawford County
BRF-039-1(030)--38-24

Effective Date
December 16, 2025

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

230382.01 DESCRIPTION.

A. This work consists of substrate preparation, batching, placing and finishing of non-proprietary ultra-high performance concrete (UHPC) for bridge deck overlay(s) at the location(s) specified in the contract documents.

B. Furnish materials, equipment and labor as specified and as necessary to perform the work in accordance with these special provisions. The fresh and hardened material properties of UHPC differ from conventional concrete. To accomplish the work in accordance with these special provisions, use of specialized procedures, equipment, and techniques should be expected.

230382.02 MATERIALS.

A. Mix Design.

1. The non-proprietary UHPC mixture shall be made in accordance with the following ratios and proportions:

Table 230382.02-1: Mix Design Materials

Ingredients	Cement	Silica Fume	Fine Aggregate	Water
Volume Ratio (for 1.0 ft^3)	0.33	0.11	0.46	0.10
Proportion (lb/yd^3)	1,400	460	1,880	410

2. In addition to the listed ingredients, the mix design includes steel fibers. The steel fiber dosage is 2.0% by volume (264 lb/yd^3).

B. Mix Ingredients.

1. **Cement.**
   Use Type I/II or Type IL cement meeting the requirements of Section 4101 of the Standard Specifications.

2. **Silica Fume.**
   - **a.** Use high purity (silica content ≥ 94%) silica fume meeting the requirements of AASHTO M 307.
   - **b.** Pre-evaluated products/sources of silica fume are provided below. Alternate sources which comply with the specified material properties may be considered for approval.
     - R-E-D Industrial Products (e.g., R-E-D 102 DM)
     - Master Builders Solutions (e.g., MasterLife SF 100)
     - Norchem Silica Fume Products (e.g., Norchem Silica Fume)

3. **Fine Aggregate.**
   - **a.** Use fine aggregate consisting exclusively of crushed quartz sand. Crushed quartz sand must have a specific gravity of at least 2.65 It shall be sieved to ensure that 100% passes the No. 8 sieve, with no more than 3% passing the No. 200 sieve. The chemical composition must contain at least 96.5% SiO_2, with impurities conforming to ASTM C 40, ASTM C 142 / AASHTO T 112, and ASTM C 295 / AASHTO T 297. The soundness must meet the requirements of ASTM C 88 / AASHTO T 104 and ASTM C 289.
   - **b.** Crushed quartz sand shall be used in a fully dry state, with a maximum allowable moisture content of 1% at time of use. If material is supplied to the project at a higher moisture content, it must be dried to compliant moisture content, and maintained in that condition for at least 12 hours, prior to use. Fine aggregate shall not be accepted for use without a representative moisture content test. For fine aggregate sealed and stored in a weatherproof container until time of batching, the moisture content results may be obtained at the time the material is sealed and stored.
   - **c.** Pre-evaluated sources/products for crushed quartz sand are provided below. Material from these sources may require additional screening to achieve the specified gradation. Alternate sources which comply with the specified material properties may be considered for approval.
     - L. G. Everist, Inc.
     - Minnesota Paving and Materials

4. **Steel Fiber.**
   - **a.** Use straight 0.008-inch diameter by 0.5-inch long (nominal) steel fibers with a smooth surface meeting the requirements of ASTM A 820. The steel fibers shall have a minimum tensile strength of 285 ksi.
   - **b.** Pre-evaluated sources/products for steel fiber are provided below. Alternate sources which comply with the specified material properties may be considered for approval.
     - HiPer Fibers (e.g., HiPer Brass Coated Steel Fibers for UHPC)
     - Bekaert (e.g., Dramix short steel fibers for UHPC)

5. **Water.**
   Use water meeting the requirements of Article 4102.

6. **High-Range Water Reducer (HRWR).**
   - **a.** Use polycarboxylate ether-based HRWR with a minimum solid content of 30% by weight. HRWR shall be in accordance with Article 4103 and Materials I.M. 403.
   - **b.** HRWR dosage shall be determined based on the trial batch to reach the desired flow, i.e., with a spread diameter of 6 to 8 inches for the UHPC mixture with fibers. Per ASTM C 1856, the recommended procedure for flow measurement is the static flow table test, conducted without tapping. The weight ratio of HRWR to binder (i.e., cement and silica fume) shall remain between 1% (18.5 pounds per cubic yard) and 3% (56.0 pounds per cubic yard), as needed to obtain the desired flow spread. The 1% ratio can be used as a

starting point, and the maximum 3% ratio shall not be exceeded, unless otherwise directed.

c. Pre-evaluated sources/products for HRWR are provided below. Alternate sources which comply with the specified material properties may be considered for approval.

- Chryso, Inc. (e.g., Chryso Premia 390, Chryso Optima 100)
- Mapei (e.g., Dynamon SX)
- Master Builders Solutions (e.g., MasterGlenium 7920)

C. Mixing Equipment.

1. Use truck mixers capable of performing dry mix with no failure throughout the mixing process. Each truck mixer must be clean, with no leftover water, as the UHPC mix is sensitive to excess water. Portable drum mixers are not permitted.

2. Due to the high energy required to mix the fluid UHPC, limit each batch to less than half of the mixer's nominal rated capacity.

3. Provide sufficient quantity and size of mixers to maintain a steady production rate of UHPC in compliance with Article 230382.03, G, 1, e.

D. Material Storage.

Store materials in sealed packaging and/or weatherproof enclosures. Prevent contamination and/or moisture exposure. For materials with expiration dates, ensure delivery/receipt of materials is coordinated with the project schedule, such that the materials are used prior to their expiration date.

E. Mixing Protocol.

All mixing operations shall be conducted under the direction of the Engineer's Designated Technical Representative (DTR). Refer to Article 230382.03, B. The following mixing protocol shall be used, unless otherwise directed by the DTR.

1. Ensure the temperatures of constituent ingredients at the start of mixing are conducive to complaint batch temperatures at the end of mixing, taking expected heat gain into account. Heat gain during mixing will vary depending on incoming material temperature, ambient temperature, and mixing duration. For reference, the mix is expected to gain 10-15°F additional heat during the batching process, assuming incoming material temperature of 70°F, ambient temperature of 70°F, and batching duration of 40 minutes. Heat gain is expected to be higher for higher incoming material temperatures, higher ambient temperatures, or longer batching duration. The preferred method of cooling batch water during hot-weather concreting operations is by placing ice into the water storage tank, container, or totes to reduce the temperature of the mixing water. Ice used for this purpose shall be furnished at no additional cost to the Contracting Authority and shall be used solely as a means for temperature control (not water substitution). Refer to batch temperature requirements specified in Article 230382.03, G, 1, d.

2. Ensure the maximum moisture content of the fine aggregate does not exceed the limit specified in Article 230382.02, B, 3, b.

3. Dry mix the cement, silica fume and sand in accordance with the following, as applicable to the mixing equipment used. The truck mixer may arrive to the mixing site empty, or pre-loaded with the measured quantity of dry cement. Combine cement, silica fume and sand in the truck drum, and mix them at a high revolution per minute (RPM) rate (e.g., 18 to 22 RPM) for a minimum of 10 minutes.

4. Add the water, ice if applicable, and HRWR. Mix at a speed of 8 to 12 RPM until the mixture achieves a uniform, fluid consistency, expected after a minimum of 10 minutes.

5. Perform flow testing per ASTM C 1856. Ensure no bleed water is present. The flow, prior to introduction of steel fiber, shall be between 8 and 10 inches. If the target flow is not achieved, the DTR will direct adjustment to the HRWR dosage, within the provided allowable range. If adjustments to HRWR are directed, thoroughly remix the batch for a minimum 6 minutes after HRWR addition and repeat step Article 230382.02, E, 5.

6. When compliant flow criteria are achieved and confirmed by testing, add the steel fibers and mix for an additional 6 minutes. Immediately preceding introduction into the mixer, pass the fibers through a mesh screen with opening size not exceeding 1.0 inches. Disperse the fibers gradually using methods that prevent fiber clumping or balling.

7. Batch acceptance shall be in accordance with Article 230382.03, G, 8, a. Batches that fail to meet temperature requirements, uniformity requirements or flow requirements shall be subject to rejection and disposal. Rejection will be at the discretion of the DTR, after any directed attempts to mitigate the issue have been exhausted. Rejected batches shall be addressed in accordance with Article 230382.03, G, 9, and a new batch shall be mixed.

230382.03 CONSTRUCTION.

A. Submittals.

Provide the following to the Engineer for review and acceptance at least 30 calendar days prior to trial batch and test placement. Submittals and allotted review schedule shall be in accordance with Article 1105.03 of the Standard Specifications.

1. **Material Certifications.**
   a. **Non-Standard Materials.**
      For materials not governed under DOT Standard Specifications, furnish certification statements by supplier, accompanied by test results from an independent 3rd party testing agency, attesting that the material properties are compliant with specification requirements. Include any Technical Data Sheets (TDS) by the manufacturer. Pre-evaluated product suppliers herein are offered to assist the Contractor's identification of suitable products, but shall not relive the Contractor from furnishing material certification statements, TDS, and test results demonstrating compliance with these special provisions. Materials for this work that classify as non-standard include, but are not necessarily limited to:
      - Silica fume
      - Fine aggregate (crushed quartz sand)
      - Steel fiber

   b. **Standard Materials.**
      For materials governed under DOT Standard Specifications, select products from DOT approved product lists and furnish material certifications in accordance with DOT Standard Specifications. Include any TDS by the manufacturer. Materials for this work that classify as standard include, but are not necessarily limited to:
      - Cement
      - Water
      - HRWR
      - Curing compound

2. **Work Plan.**
   Provide a detailed, step-by-step plan identifying key personnel, equipment, procedures, sequence, governing specifications, and quality controls for the work. At a minimum, address the following steps in the work plan:

a. Trial batch and test placement.
b. Surface preparation and cleaning.
c. Material storage.
d. Mix batching, handling and transport.
e. Placement and finishing.
f. Curing.
g. Surface profile correction (grinding).
h. Surface texturing (grooving).

B. Engineer's Designated Technical Representative (DTR).

1. In consultation with the Construction & Materials Bureau (CMB), the Engineer shall assign a Designated Technical Representative (DTR) to direct all UHPC batching operations. The DTR shall be an employee of Iowa DOT versed in the batching protocol, quality control procedures, and applicable constraints associated with use of the non-proprietary UHPC mix. The name and contact information for the DTR shall be identified at the project pre-construction meeting.

2. In accordance with Article 1105.06, the DTR shall have the delegated authority to reject materials or suspend work associated with UHPC batching, if the fresh material properties of the UHPC are found to be non-compliant with these special provisions. The DTR shall have the authority to modify the batching procedure or batch acceptance process, subject to the limitations herein.

C. Research Coordination.

1. The development of the non-proprietary UHPC mix, and evaluation of field performance, is part of an ongoing research effort. The Contractor shall keep the DTR and research team apprised of the work schedule and operations. A representative of the research team shall be present in observational/advisory capacity for the pre-pour meeting, trial batch, test placement, surface texturing of existing bridge deck, production batching operations and placement, and post-placement inspection. The Contractor shall notify the research team a minimum of 5 calendar days for these forementioned events. The research team shall be afforded reasonable accommodation to access the work for the duration of the project, for purposes of testing and documentation. Research personnel may be installing instrumentation in the two-course deck.

2. Coordination with the research team shall be via the contact below. Unless otherwise agreed by the Engineer, include the Engineer and the DTR on all communications with the research team.

Dr. Behrouz Shafei
Iowa State University
Phone: (515) 294-4058; Email: shafei@iastate.edu

D. Pre-Pour Meeting.

1. Following review and acceptance of the work plan by the Engineer, and prior to any UHPC placement (inclusive of test placement), arrange for an on-site pre-pour meeting. Allow at least 7 calendar days prior to UHPC placement for coordination and agreement on the pre-pour meeting schedule. The objective of the meeting will be to review the details of the accepted work plan, logistics of the placement, quality control, and quality assurance.

2. At the discretion of the Engineer, and at no additional cost to the Contracting Authority, additional pre-pour meetings may be required prior to each day of production UHPC placement.

E. Trial Batch and Test Placement.

1. General.

a. Provide notice and allow at least 7 calendar days for coordination and agreement on the trial batch and test placement schedule and location. Do not proceed with trial batch and test placement without authorization of the Engineer.

b. Conduct trial batch and test placement at least 7 calendar days prior to planned placement of production UHPC.

c. To the extent practical, schedule the trial batch and test placement to occur during ambient weather conditions representative of the conditions anticipated for production work.

d. Ensure the materials used for the trial batch are consistent with those that will be used for production work, inclusive of manufacturer's lot number, storage temperature, storage conditions, etc.

e. Do not place production UHPC until the trial batch and test placement have been accepted by the Engineer. Trial batch(es) or test placement(s) that fail to meet acceptance criteria must be repeated, following appropriate material and/or procedure modifications. Repeat trial batches and test placements shall be addressed in accordance with Article 230382.03, G, 9.

2. Trial Batch.

a. Identify dedicated batching personnel for UHPC. Use the same personnel, procedures, and equipment for the trial batch as planned for the production UHPC.

b. Follow the batching protocol prescribed in Article 230382.02, E, under the observation and direction of the DTR. Demonstrate temperature control, proportioning, introduction, and mixing of the material in accordance with the specified requirements.

c. Sample and test the trial batch placement in accordance with the requirements provided in Article 230382.03, G, 8, a, under the observation of the DTR.

d. Obtain initial batch temperature within 2 minutes after introduction of wet ingredients to the mix, and obtain final batch temperature at completion of batching. Record heat gain, and ambient temperature conditions.

e. Trial batch volume shall be sized as necessary to accommodate all the following:

- Collection of all specified test samples.
- Completion of the test placement to the minimum specified dimensions.
- 2 CY minimum.

f. Acceptance of the trial batch shall be in accordance with the requirements provided in Article 230382.03, G, 8, a.

3. Test Placement.

a. After the required samples are collected from the trial batch, utilize the remaining trial batch concrete to conduct a test placement. Test placement shall be sized to use all remaining trial batch concrete but covering not less than 200 square feet. The least horizontal dimension of the test placement shall be a minimum of 12 feet. Nominal thickness of the test placement shall match as close as practical the nominal thickness of the production UHPC overlay.

b. Simulate the general placement conditions for production UHPC. Conduct the test placement in open air, during weather generally consistent with the anticipated conditions during production placement.

c. After completion of batching, postpone the test placement for time in minutes approximately equal to the anticipated delivery time for production UHPC. During this postponement, maintain the UHPC in a state of agitation generally representative of the anticipated delivery conditions for production UHPC. This requirement may be waived if production UHPC will be batched on site with minimal time lapse between end of batching and start of placement.

d. Test placement shall be made at a mutually agreeable location, on a rigid and uniform concrete subbase. The rigid concrete subbase may be a pre-existing concrete section or

may be a new concrete section constructed specifically for UHPC test placement. Preparation of the rigid concrete subbase shall be in accordance with the requirements for production work, as specified in Article 230382.03, F, 1. Contain UHPC placement on the prepared concrete subbase within side/edge forms or other approved means, representative of the production work. The cost of furnishing and preparing the rigid concrete subbase shall be incidental to the price bid for Trial Batch and Test Placement (UHPC).

e. Place, consolidate and finish the UHPC on the prepared test placement subbase, using methods representative of the production work. Evaluate workability, finishability, and general suitability of the mix for production use.

f. Acceptance of the test placement shall be on the basis of compliant placement, finishing and curing processes, representative of the proposed means and methods of construction for production work. Test placements that exhibit non-compliant properties, or that do not adequately demonstrate the proposed means and methods of construction, shall be repeated subject to the provisions of Article 230382.03, G, 9.

g. Unless otherwise agreed, the test placement(s) shall become the property of the Contractor. For test placement(s) within DOT right-of-way, remove the test placement and restore the area as directed by the Engineer. Cost of removal of the test placement and restoration of the test placement area shall be incidental to the price bid for Trial Batch and Test Placement (UHPC).

F. Preparation for Production UHPC.

1. Substrate Preparation.

a. The production UHPC shall be cast as overlay on the newly-constructed bridge deck specified in the contract documents. The bridge deck must attain/demonstrate all the following prior to UHPC overlay placement:

- Minimum wet cure duration in compliance with the contract documents, not less than the duration specified in Article 2412.03, E.
- Minimum tested strength in compliance with 28-day strength requirements specified in the contract documents.
- Minimum age of 28 days.

b. The bridge deck surface shall be prepared and textured by abrasive shotblasting. The travel speed, size of shot, flow of shot, and/or number of passes of the shotblasting unit shall be adjusted to achieve removal of all weak or loose surface mortar, exposure of aggregates within the concrete, open pores in the exposed concrete, and a visible change in concrete color. Produce surface relief within the range of Surface Preparation Level 5 to 7, as defined by the International Concrete Repair Institute (ICRI).

c. Utilize a vacuum unit during shot blasting to control debris accumulation and dust generation. All shot blasting media, removal debris, loose particles, dust and surface contaminants shall be promptly and completely cleaned from the deck surface.

d. Following shot blasting and vacuum cleaning, thoroughly clean the deck surface by pressure washing or blast cleaning with oil-free compressed air.

e. Maintain the bridge deck surface in clean and contaminant-free condition until the time of production UHPC placement. Except as may be necessary to set up the finishing equipment or place production UHPC, do not operate tire or track-mounted equipment on the cleaned and prepared deck surface. Contamination or appreciable dust accumulation on the prepared surface prior to UHPC placement shall necessitate re-cleaning at no additional cost to the Contracting Authority.

2. Prepared Substrate Bond Testing.

a. To validate proper roughness and cleanliness of the prepared surface, and to obtain baseline tensile capacity of the bridge deck, perform bond testing on the prepared substrate in accordance with ASTM C1583.

b. Bond testing shall be conducted by a qualified, independent 3rd party testing laboratory.

c. Bond tests shall be conducted at 3 test locations per stage selected by the Engineer with 3 tests per location .The tests should be spread equidistantly. Acceptance criteria for prepared substrate bond testing shall be as follows:
- Average bond strength for all tests shall not be less than 250 psi
- Average bond strength for any individual test shall not be less than 200 psi.

d. Failure to achieve the minimum bond requirements specified above shall require repreparation and recleaning of a portion or entirety of the deck surface. Following corrective actions, retest to confirm compliant bond. Repreparation, recleaning and retesting, if necessary, shall be at no additional cost to the Contracting Authority.

e. Patch the test locations after acceptance of the test results, using an approved product in accordance with Materials I.M. 491.08 Appendix A, or 491.20 Appendix B.

3. Finishing Machine Dry Run.

a. After final setup of the finishing equipment, prior to UHPC placement and under the observation of the Engineer, traverse the finishing screed over the entire length of placement area to verify intended overlay thickness will be achieved.

b. Measure and record the depth from the finishing surface of the screed to the top of the prepared substrate, at even station marks (ex. STA 1+00.00, STA 1+20.00), on a grid of 20 feet longitudinal and not less than 10 feet transverse.

c. The recorded dry run depth checks will be compared with depth checks at the time of overlay placement, to confirm compliance with contract thickness requirements, and establish maximum allowable depth of corrective grinding, should grinding be necessary.

4. Saturated Surface Dry.

Prior to UHPC placement, bring the prepared substrate in the placement area to saturated surface-dry (SSD) condition, and maintain the substrate in SSD condition until UHPC is placed. SSD is defined as the condition in which the concrete surface is fully saturated, without any visible evidence of excess or free water. Have equipment and procedures available to remove excess water as may be necessary, at the time of placement.

G. Production UHPC.

1. Batching.

a. Do not proceed with batching of UHPC if ambient temperature at the time of placement is forecast below 45°F or above 90°F.

b. Do not proceed with batching of UHPC if the theoretical evaporation rate, calculated in accordance with Article 2412.03, C, 4, exceeds 0.15 pounds per square foot per hour.

c. Follow the mixing protocol specified in Article 230382.02, E.

d. Ensure batch temperature at time of placement does not exceed 85°F. Pre-cooling of the mix ingredients and/or external cooling of the mixing equipment (water applied to mixing drum, etc.) shall be the responsibility of the Contractor and may be necessary to achieve compliant batch temperature at time of placement.

e. Utilize sufficient quantity of mixers, and size batch volume as necessary to ensure steady and uninterrupted production of UHPC in compliance with the placement and finishing timeframes specified in Article 230382.03, G, 1, f and Article 230382.03, G, 3, c. Minimize intervals between successive batches such that newly placed material and previously placed material can be successfully incorporated without cold joints, finishing disparities, undue exposure or plastic drying shrinkage, or other detrimental impacts.

f. Maximum time from adding water to the mix to completion of batch placement shall not exceed 75 minutes.

2. Transport and Handling.

a. Pumping of UHPC is prohibited. When discharging UHPC, use buggies or a truck mixer chute to prevent free-fall from heights greater than 3 feet.

b. When buggies, truck mixers, or other equipment are operated on the prepared bridge deck surface, take measures to ensure the equipment is maintained and operated in a

manner that does not contaminate the prepared surface. Any contamination to the prepared surface, including tire track-out or fluid leaks, shall be completely cleaned prior to UHPC placement.

c. Do not transport or hold UHPC in unagitated state for more than 6 minutes, from completion of batching to start of placement. If the transport and/or hold time is expected to exceed 6 minutes, provide means to maintain the UHPC in a continuous state of agitation (e.g., using low (in the range of 6-10) RPM on a truck mixer until discharge).

3. Placement and Finishing.

a. Unless otherwise accepted in the work plan and successfully demonstrated during test placement, use equipment and procedures in accordance with the following:

- Article 2413.03, A, 4.
- Article 2413.03, E, 2, a, through 2413.03, E, 2, e.

b. The following mix-specific equipment requirements need not apply to UHPC:

- Class O concrete equipment per Article 2413.03, A, 4, c, 1.
- Class HPC-O concrete equipment per Article 2413, A, 4, c, 2.

However, previous research trials have had success utilizing Class O concrete equipment as part of the finishing process for this UHPC mix.

c. UHPC can be vulnerable to rapid loss of workability when mixing/agitation is ceased and the material is placed. Depending on the age in minutes of UHPC after initial placement, UHPC can exhibit finishing “stickiness”, and/or “surface skin” formation. Uniformly deposit the mix as close as practical to final intended location. Place only enough material in front of the finishing machine as necessary to maintain steady and uninterrupted finishing progress. Do not allow placed material to be exposed for more than 15 minutes prior to finishing.

d. Using appropriate tools, rake and grade the mix manually ahead of the finishing machine. Maintain sufficient, but not excessive, material thickness in front of the finishing machine to ensure the screed template cuts and consolidates the material to intended profile, without low spots. Do not anticipate the ability to successfully incorporate new material on top of material which has been previously placed and consolidated. Previous research trials suggest repair of low spots in the UHPC, after passage of the finishing machine, is unlikely to be successful.

e. Utilize the finishing machine to achieve final finish. Do not anticipate the ability to successfully smooth or otherwise apply final finish to the UHPC surface with manual concrete finishing tools. Previous research trials suggest manual finishing with conventional concrete tools can result in surface fins, tears, or other irregularities.

f. Application of surface water or finishing aids to improve workability or facilitate finishing is not allowed.

g. Perform plastic depth checks of the finished overlay, at locations consistent with the recorded dry run checks. Utilize work bridges to access the depth check areas. Ensure the measuring tools and methods minimize disruption to the finished surface to the extent practical. Repair the disrupted surface by gently leveling and consolidating, without dragging, using an appropriate concrete trowel or rake.

h. The surface finish requirements of Article 2413.03, E, 2, e, 2, and the smoothness provisions of Article 2428, shall apply. It is recognized that UHPC is not considered conducive to manual final finishing processes, and past experience suggests likelihood the UHPC material may require corrective grinding to achieve compliant surface finish and/or smoothness. Place additional uniform thickness of overlay material as deemed appropriate to ensure final overlay thickness, after grinding, meets the depth requirements in the project plans. Additional overlay thickness placed for this purpose shall be incidental to the price bid and shall not be measured separately for payment. Refer to Article 230382.04, B, 2. Indicate the intended nominal thickness of additional material in the submitted work plan.

i. If non-compliant production conditions are identified by the Engineer, including but not limited to deficient production rate, deficient finishing rate or finishing quality, or deficient curing rate or curing quality, the Engineer may direct batching and production work to be

stopped. If so directed, terminate production in a manner and at a location acceptable to the Engineer. Do not resume batching or production until procedural corrections are implemented and demonstrated, to the satisfaction of the Engineer. All costs associated with work stoppage and delay for this reason shall be borne by the Contractor, at no additional cost to the Contracting Authority.

4. **Curing.**
   - **a.** As soon as practical, but not more than 5 minutes after passage of the finishing machine, thoroughly and uniformly apply white pigmented curing compound to the UHPC in accordance with Article 2403.03, E, 4, a. For coverage uniformity, it is recommended that the curing compound be applied in 2 coats, with the application direction of the second coat perpendicular to the application direction of the first coat.
   - **b.** As soon as practical, but not more than 5 minutes after application of the curing compound, cover the surface with impermeable plastic sheeting. Minimum thickness of the plastic sheeting shall be 3.4 mils, and sheets shall be overlapped a minimum of 1 foot at seams. When the UHPC surface attains sufficient strength to do so, use weights to secure the plastic sheeting from displacement by wind.
   - **c.** Maintain complete coverage and leave the curing protection undisturbed for a duration of 7 days, or until representative compressive strength test results indicate minimum strength of 10 ksi has been achieved, whichever comes first.

5. **Grinding and Grooving.**
   - **a.** Following deck smoothness evaluation in accordance with Article 2413.03, E, 2, k, perform corrective grinding to the extent necessary to achieve acceptable smoothness in accordance with Article 2428.
   - **b.** Do not initiate corrective grinding or grooving until the UHPC demonstrates minimum compressive strength of 12 ksi.
   - **c.** Coordinate the location and depth of grinding passes with the Engineer, with consideration to the documented plastic thickness of the overlay. Ensure the final ground surface does not result in deficient overlay thickness.
   - **d.** Depending on the magnitude of surface correction necessary, compliance with the provisions of Article 2428.03, E and Article 2428.03, G may require width of corrective grinding to extend beyond the lane lines, into the shoulders, and/or to the gutter lines. Vertical difference of more than 1/8 inch between adjacent grinding passes will not be permitted. If grinding appreciably lowers the profile of the lane surface, grinding shall be appropriately tapered into the shoulders to maintain positive drainage and acceptable crown profile. Final longitudinal profile at the gutterlines shall achieve positive drainage to the deck drains.
   - **e.** Perform grooving in accordance with Article 2413.03, E, 3, a.
   - **f.** Due to the inclusion of steel fibers and the comparatively high strength of UHPC, it should be anticipated that grinding and grooving operations will require more and/or different effort compared to conventional concrete.

6. **Overlay Bond Testing.**
   - **a.** Bond tests shall be conducted in accordance with ASTM C1583 at 3 test locations per stage selected by the Engineer with 3 tests per location. Acceptance criteria for prepared substrate bond testing shall be as follows:
     - Average bond strength for all tests shall not be less than 250 psi
     - Average bond strength for any individual test shall not be less than 200 psi.
   - **b.** Bond testing shall be conducted by a qualified, independent 3rd party testing laboratory.
   - **c.** Failure to achieve the minimum bond requirements specified above shall be addressed in accordance with Article 230382.03, G, 9.
   - **d.** Patch the test locations after acceptance of the test results using UHPC.

7. **Responsibility for the Work.**

a. These special provisions specify a prescriptive mix recipe and batching procedure. The Contracting Authority accepts responsibility for mix performance issues if, and only if, they can be specifically and exclusively attributed to the mix recipe and/or batching procedure.

b. The Contractor holds responsibility for all other aspects of the work, including but not limited to:

- Substrate preparation, substrate SSD establishment and maintenance, and pre- and post-placement bond achievement and testing.
- Trial batch and test placement.
- Sourcing, storage and handling of constituent mix ingredients.
- Pre-cooling of mix ingredients, or post-cooling of batching equipment, as may be necessary to satisfy batch temperature requirements.
- Following prescribed direction for mix ingredient introduction, blending, testing and adjustment. Furnishing, operating and maintaining mixing equipment.
- Transporting, placing and finishing mix. Furnishing, operating and maintaining finishing equipment.
- Achieving specified timelines for completion of finishing operations, and completion of curing application.
- Achieving specified final thickness, smoothness, crown and drainage profile.
- Achieving uniform, durable final product, free of quality flaws which result from deviation from prescribed procedure, or which are otherwise the result of actions or inactions which are, or should have been, within the Contractor's reasonable awareness and/or control.

8. Testing and Acceptance.

a. Batched Material Properties.

Batched UHPC will be evaluated and accepted for production use in accordance with the following:

- Compliant materials and proportions.
- Consistent, uniformly mixed material with no visual evidence of segregation and/or detrimental fiber clumping or fiber balling.
- Tested material properties in accordance with the following. Unless otherwise agreed by the Engineer, all testing shall be by the Contractor and witnessed by the Engineer or their designated representative.

Table 230382.03-1: UHPC Material Properties

Description	Test Method	Acceptance Criteria	Minimum Frequency
Aggregate Moisture Content	ASTM C 566	Aggregates shall be in dry condition with a moisture content not exceeding 1.0% by mass.	3 per stockpile. (*)
Flow (w/o fibers)	ASTM C 1856 (Static spread; no drops)	8 inches (Minimum) 10 inches (Maximum)	1 per batch. Sampled prior to fiber introduction.
Flow (w/ fibers)~	ASTM C 1856 (Static spread; no drops)	6 inches (Minimum) 8 inches (Maximum)	1 per batch. Sampled prior to mix discharge.

Description	Test Method	Acceptance Criteria	Minimum Frequency
Temperature	ASTM C 1064	≤ 85°F	1 per batch. Sampled at time of placement.
Visual Stability	ASTM C 1856 (The visual stability index (VSI) can be adopted from ASTM C 1611)	No segregation and/or bleed water; Consistent fiber dispersion	1 per batch. Conducted at time of discharge.
Unit Weight~	ASTM C 138 (fresh density)	≥ 145 pcf	1 per batch. Sampled at time of placement.
Compressive Strength*~	ASTM C 1856 (3×6 inch cylinders)	≥ 9 ksi (at 7 days) ≥ 11 ksi (at 14 days) ≥ 12.5 ksi (at 28 days) (150 psi/sec loading rate)	3 sets (2 samples each) per batch. Sampled at time of placement. 7 day, 14 day (**), and 28 day. (***)
Rapid Chloride Ion Penetrability***~	ASTM C 1856 (4×8 inch cylinders)	≤ 300 coulombs	1 per batch. Sampled prior to fiber introduction. 28 day.

* Additional aggregate moisture content testing may be required by the Engineer, at no additional cost to the Contracting Authority, any time there is reason to suspect change in aggregate moisture content, or exceedance of the acceptance criteria.

** 14 day compressive test shall be used for acceptance.

*** Each set shall contain at least three samples and all test sets shall be cured under conditions similar to the production work

~ Testing for record only.

b. Placement, Finishing and Smoothness.

Placed and finished UHPC will be evaluated and accepted in accordance with the following. Acceptance criteria for the finished overlay surface shall be evaluated after corrective grinding, if grinding is necessary.

- Compliant placement conditions, including substrate preparation, substrate bond testing, and environmental conditions.
- Compliant material production rate, finishing rate, and cure application rate.
- Compliant overlay geometry, including thickness, profile, crown, and drainage.
- Compliant bond testing for completed overlay.
- Surface free of fiber balling.
- Surface free of avoidable defects associated with timeliness and/or methods of finishing and/or curing application.

9. Corrective Actions.

a. General.

With exception to surface smoothness/profile correction in accordance with Article 2428, corrective actions are not expected to be necessary for work performed in compliance with these special provisions. For work not in compliance with these special provisions,

the Engineer will determine if the work shall be corrected, or removed and replaced, in accordance with Article 1105.04.H.

b. Owner Responsibility.
The Contracting Authority shall be responsible for the cost of corrective action if the non-compliant condition can be specifically and exclusively attributed to the mix recipe and/or batching procedure. If such conditions are identified by the Engineer, corrective action shall be performed by the Contractor, paid as extra work in accordance with Article 1109.03 and the following. Potential corrective actions that fall under the Contracting Authority's responsibility are expected to be limited to the following.

- **Batch Flow Characteristics and Visual Stability.**
  If, due to no fault of the Contractor, the fresh material properties of the UHPC do not meet the requirements of these special provisions, the DTR may direct adjustments to the batch, or may direct the batch to be discarded. Batch adjustments, if directed, are expected to be limited to addition of water, addition of HRWR, and/or extra mixing time. Batch adjustment additives and additional mixing time shall be provided by the Contractor at no additional cost. If the DTR directs the batch to be discarded, the volume of discarded material will be paid at the bid price for Special Deck Overlay (UHPC), Furnish, and a new batch shall be mixed by the Contractor. The Contractor shall not be held accountable for the delay in production rate for batch adjustments, or rebatching of discarded material. Discarded material shall become the property of the Contractor and shall be removed from the project site.
- **Hardened Material Properties.**
  If, due to no fault of the Contractor, the strength or durability properties of the hardened material do not meet requirements or expectations, the Engineer may direct repair or replacement of any affected portion of the hardened UHPC. Though not expected, possible circumstances which could prompt corrective action include surface cracking or scaling in excess of tolerable limits, deficient compressive strength, deficient chloride ion penetrability, or material-related bonding deficiency. Corrective action for conditions of this nature, if directed, shall be performed by the Contractor and paid by the Contracting Authority in accordance with Article 1109.03.B.

c. Contractor Responsibility.
For all other aspects of the work, including but not limited to those listed in Article 230382.03, G, 7, b, the Contractor shall be responsible for correction of non-compliant work, as directed by the Engineer, at no additional cost to the Contracting Authority.

230382.04 METHOD OF MEASUREMENT.

A. Special Deck Overlay (UHPC), Surface Preparation.
Measured as plan quantity, in square yards. Plan quantity shall be calculated as the nominal surface area to receive surface preparation.

B. Special Deck Overlay (UHPC), Furnish.

1. Measured as plan quantity, in cubic yards. Plan quantity shall be calculated as the nominal volume of material required to furnish the overlay to minimum plan thickness, plus 15% contingency. The 15% contingency does not cover placement of sacrificial or discretionary additional overlay thickness. Refer to Article 230382.03.G.3.h.

2. In accordance with the provisions of Article 230382.03, G, 3, h and Article 230382.03, G, 8, b, the Contractor shall furnish material in excess of plan quantity, as may be necessary to ensure compliant final overlay thickness after corrective grinding. Furnished material in excess of plan quantity, including materials that are not batched, or materials that are batched and/or placed in excess of plan quantity, will not be measured separately for payment.

3. Materials that are batched and discarded under the direction of the DTR, due to no fault of the Contractor and in accordance with Article 230382.02, E, 7, will be measured and paid separately, to the nearest increment of 1/10th cubic yard, at the bid price for Special Deck Overlay (UHPC), Furnish.

C. Special Deck Overlay (UHPC), Place.
Measured as plan quantity, in square yards. Plan quantity shall be calculated as the nominal surface area to receive overlay.

D. Trial Batch and Test Placement (UHPC).
Measured as a combined lump sum item.

E. Compressive Strength of Cylindrical Concrete Specimens (UHPC)
Measured as plan quantity of each. The plan quantity is estimated assuming a batch size of 4 cubic yards in a truck and the number of specimens required in accordance with Article 230382.03,G,**8,a.**

230382.05 BASIS OF PAYMENT.

A. Special Deck Overlay (UHPC), Surface Preparation
Payment will be at the contract unit price for Special Deck Overlay (UHPC), Surface Preparation. Payment includes full compensation for all materials, equipment and labor for shot blasting, vacuum cleaning, water/air blast cleaning, pre-placement bond testing, and establishment/maintenance of clean surface in SSD condition, for the lower course bridge deck surface.

B. Special Deck Overlay (UHPC), Furnish
Payment will be at the contract unit price for Special Deck Overlay (UHPC), Furnish. Payment includes full compensation for all materials, equipment and labor for:

- UHPC material ingredient storage.
- Furnishing, batching, transporting and testing UHPC.
- Disposing and re-batching non-compliant material, should non-compliant properties of batched material be identified by the DTR. If material disposal is directed by the DTR, due to no fault of the Contractor, the volume of the disposed material will be measured and paid separately at the unit bid price for Special Deck Overlay (UHPC), Furnish.

C. Special Deck Overlay (UHPC), Place
Payment will be at the contract unit price for Special Deck Overlay (UHPC), Place. Payment includes full compensation for all materials, equipment and labor for:

- Placing, consolidating, finishing and curing UHPC material.
- Smoothness evaluation and corrective grinding in accordance with Article 2428 and these special provisions.
- Overlay bond testing and repair of tested areas in accordance with Article 230382.03, G, 6,

D. Trial Batch and Test Placement (UHPC)
Payment will be at the lump sum contract unit price for Trial Batch and Test Placement (UHPC). Payment includes full compensation for all materials, equipment and labor for:

- Furnishing and preparing concrete test placement subbase.
- Furnishing, forming, placing, finishing and testing UHPC material.
- Removing and disposing the test placement and restoring the test placement area to the satisfaction of the Engineer.

E. Compressive Strength of Cylindrical Concrete Specimens (UHPC)
Payment will be at the contract unit price for each specimen tested in accordance with Article 230382.03,G, **8, a**.