DS-09014
(New)

Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATION
FOR
HIGH PERFORMANCE CONCRETE FOR STRUCTURES
(COUNCIL BLUFFS INTERSTATE SYSTEM)

Effective Date
October 20, 2009

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

09014.01 DESCRIPTION.

A. Develop and provide high performance concrete (HPC) for bridge substructures and decks when called for in the contract documents. HPC is defined as a concrete mix that provides the following:
- Desired workability.
- Minimum average 28 day compressive strength for deck of 4500 psi (35 MPa).
- Minimum average 28 day compressive strength for substructure of 5000 psi (35 MPa).
- Target permeability of 2500 coulombs for the substructure and 1500 coulombs for the deck.

B. A CV-HPC-S mix design is an HPC mix design used in the substructure. A CV-HPC-D mix design is an HPC mix design used in the deck.

C. Apply Sections 2403, 2412, and Division 41 of the Standard Specifications with the following modifications.

09014.02 MATERIALS.
At the option of the Contractor, other mixes than those described below may be used, provided they meet the requirements of this specification and are approved by the District Materials Engineer.

A. Substructure.

1. For all substructure HPC mixes, apply the following conditions:
- Use coarse aggregate meeting Class 3i durability
- Basic water to cementitious material (w/c) ratio of 0.42, with a maximum w/c ratio of 0.45
- Use a mid-range water reducing admixture meeting the requirements of Materials I.M. 403, Appendix C. Other admixtures may be approved by the Engineer.
- Maximum allowable slump of 4 inches (100 mm).
- Air content according to Article 2403.03, C, 3, of the Standard Specifications, except with a target of 6.5% and a maximum variation of plus 2.0% and minus 1.0%

2. The HPC mix for the substructure may be a CV-HPC-S with a mid range water reducer admixture and a w/c ratio of 0.42, with a maximum w/c ratio of 0.45.

3. Use a CV-HPC-S mix design with the characteristics and absolute volumes per unit volume shown in Table 09014.02-1:

Table 09014.02-1: CV-HPC-S Characteristics and Absolute Volumes.

Type IP Cement	0.126
Fly Ash	20% Maximum replacement by weight (mass)
Water	0.156 (w/c ratio of 0.42)
Coarse Aggregate	0.296
Class V Aggregate	0.362
Air	0.060

4. For the substructure HPC mixes other than a CV-HPC-S apply the following conditions:

- Use one of the following cements:
  - **a.** Type IP.
  - **b.** Type I/II with 35% weight (mass) replacement with Ground Granulated Blast Furnace Slag (GGBFS) and a maximum fly ash replacement of 15% by weight (mass).
- Minimum cementitious content of 624 pounds per cubic yard (370 kg/m^3).
- Use mid range water reducer with a maximum allowable slump of 4 inches (200 mm) and a target air content of 6.5% plus 2.0% and minus 1%.

B. Deck.

1. For all deck HPC mixes, apply the following conditions:

- Use coarse and intermediate aggregates meeting Class 3i durability.
- Basic w/c ratio of 0.40, with a maximum w/c ratio of 0.42.
- Retarding admixture may be required by contract documents or by the Engineer. Use a water reducing/retarding admixture meeting the requirements of Materials I.M. 403, Appendix B, according to Section 2403. When placements require extended working times, increase the dosage rate for the appropriate working time and temperature. Other admixtures may be approved by the Engineer.
- To aid in minimizing water cement ratio, use a mid range water reducer in conjunction with the retarding admixture as recommended by the manufacturer. Use a mid range water reducer compatible with retarding admixture.
- Air content according to Article 2403.03, C, 3, of the Standard Specifications, with a target of 6.5% and a maximum variation of plus 2.0% and minus 1.0%.

2. The CV-HPC-D mix may have the characteristics and absolute volumes per unit volume shown in Table 09014.02-2:

Table 09014.02-2: HPC Mix Characteristics and Absolute Volumes

Cement	0.126
Fly Ash	20% Maximum replacement by weight (mass)
Water	0.148 (w/c ratio of 0.40)
Coarse Aggregate	0.300
Class V Aggregate	0.366
Air	0.060

3. For deck HPC mixes other than the mix described in Table 09014.02-2, apply the following conditions:

- Use one of the following cements:
  - **a.** Type IP.

b. Type I/II with 35% weight (mass) replacement with GGBFS, and a maximum fly ash replacement of 15% by weight (mass).

- Minimum cementitious content of 624 pounds per cubic yard (370 kg/m^3).
- Use a mid range water reducer with a maximum allowable slump of 4 inches (100 mm) and a target air content of 6.5% plus 2.0% and minus 1.0%.
- Combined aggregate gradation optimized according to Materials I.M. 532 and meeting the limits in Article 2513.03, A, 2, b, 3, of the Standard Specifications.

09014.03 CONSTRUCTION.

A. Trial Batch Concrete.

1. A trial batch is required only when the Contractor proposes HPC mixes other than the CV-HPC-S mix described in Article 09014.02, A, or the mix described in Table 09014.02-2. When a trial batch is required, make one or more trial batches of concrete. An Iowa DOT PCC Level III Certified Technician is to develop the HPC mix design.

2. Allow the District Materials Engineer ample opportunity to witness the trial batching. Provide the District Materials Engineer notice and mix proportions seven calendar days prior to this event.

3. Mix the trial batch (a minimum of 3 cubic yards (3 m^3) in size) at least 30 calendar days prior to planned placement. Establish the batching sequence of the materials during the trial batch.

4. Transport the concrete a distance comparable to the distance from the ready mix plant to the placement site.

5. Use concrete for testing purposes that is representative of the entire batch while having a slump within 1 inch (25 mm) of the maximum slump allowed, an intended in place air content of 6% ± 1%, and a w/c ratio that will be typical in substructure and deck placement. Perform the following tests for each trial batch:

Specific Gravity of Each Individual Aggregate	Materials I.M. 307
Gradation of Each Individual Aggregate	Materials I.M. 302
Unit Weight of Plastic Concrete	Materials I.M. 340
Slump of Plastic Concrete	Materials I.M. 317
Air Content of Plastic Concrete	Materials I.M. 318

a. Substructure.
Evaluate the mix workability for the intended application and method of placement.

b. Deck.
Cast one or more test slabs 8 feet by 4 feet (2.4 m by 1.2 m) in area and 4 inches (100 mm) thick. Place and consolidate using methods typical for bridge deck pours. Finish the concrete by hand and evaluate the mix workability and finishability for the intended application and method of placement.

6. Submit a trial batch report to the District Materials Engineer no later than seven calendar days after trial batching. Include the following in the report:

Cover Page	Contractor and Producer Name Project Number Date and Location of HPC Trial Batch Date Submitted Signature of Contractor/Producer Representative

Material Source Information	Brand, Type, and Source
Material Proportion Information	Specific Gravity Relative % of Each Individual Aggregate Target Combined Gradation % Passing (Materials I.M. 531) Target Combined Gradation Charts (Materials I.M. 532) Design and As Mixed Batch Weights (Mass) (SSD) Design and As Mixed w/c Ratios
Mix Properties	Unit Weight (Mass) of Plastic Concrete Air Content of Plastic Concrete Slump

7. The District Materials Engineer will cast samples and transport them to the Central Materials Laboratory for testing. Trial batch concrete will be tested for permeability and strength. All samples will be cast, cured, and handled according to Materials I.M. 315. Two permeability and nine strength samples will be cast in 4 inch by 8 inch (100 mm by 200 mm) cylinder molds.

8. Permeability samples will be stripped of their molds and wet cured to an age of seven calendar days in a moist room. After seven calendar days, the samples will be submerged in water heated to 100ºF (38ºC) until an age of 28 days. One sample will be obtained from each cylinder and tested according to AASHTO T 277 at 28 days. The target value of permeability is 2500 coulombs for the substructure and 1500 coulombs for the deck, or less based on the average of two tests.

9. Strength samples will be stripped of their molds and wet cured until their break age. Strength samples will be tested according to AASHTO T 22. Three cylinders will be tested for strength at each age of 7, 28, and 56 days. The average 28 day compressive strength must be equal to or greater than 6400 psi (45 MPa) for the substructure and 5000 psi (35 MPa) for the deck.

10. Approval will be based on trial batch mix properties and submittal of a trial batch report. The District Materials Engineer may waive the trial batch testing provided satisfactory mix properties have been achieved through testing of previous trial batches or production placements.

B. Production Concrete.

1. Notify the District Materials Engineer 48 hours prior to placement of production concrete. Use only approved HPC mixes for production concrete. If a mix other than the mix described in Article 09014.02 is to be used, ensure it has the same materials, proportions, and properties (including slump, air content, and w/c ratio) as established in the trial batch.

2. Test production concrete for strength. These test results will be used for acceptance. An Iowa DOT PCC Level I Concrete Field Testing Technician is to cast, cure, and handle strength samples according to Materials I.M. 315. At the site, properly cure the cylinders with wet burlap and plastic. Do not move the cylinders for 16 hours and leave at the site for a maximum of one calendar day before transporting to a certified laboratory for final curing and testing. Cast nine strength samples in 4 inch by 8 inch (100 mm by 200 mm) cylinder molds for each placement. Document the slump, air content, and w/c ratio (adjusted for all water) of the concrete for the cylinders cast.

3. Strength samples are to be tested by a certified lab according to AASHTO T 22. Test three cylinders for strength at each age of 28 and 56 days. For acceptance, the average 28 day strength must be equal to or greater than 5000 psi (35 MPa).

4. Submit test results to the Engineer and the District Materials Engineer no later than one working day after testing is completed. In the submittal clearly indicate (at a minimum) the project number, location, Contractor, producer, structural element constructed, slump, air content, w/c ratio (adjusted for all water), date sampled, date tested, break age, individual compressive strengths, and average compressive strengths. In addition, attach the plant report for the pour to the submittal.

5. The District Materials Engineer may obtain random verification strength samples. Strength samples will be tested at the Central Materials Laboratory according to AASHTO T 22. A set of four cylinders will be cast, cured, and handled according to Materials I.M. 315. Three cylinders will be tested for strength at 28 days. The remaining cylinder will be tested for permeability on a random basis by the Central Materials Laboratory. The testing will be conducted as described in Article 09014.03, A.

C. Non Complying Strength.

When the average 28 day compressive strength does not meet or exceed the specified strength, propose evaluation methods to determine the in place concrete strength. Submit the proposal to the Engineer. Notify the Engineer 48 hours in advance of sampling and testing. The Engineer will witness the sampling and testing of the in-place concrete. The Engineer will review the results and determine corrective action required. The Contractor is responsible for the cost of evaluation and all corrective action required.

D. Placing Concrete.

1. Fly ash and GGBFS will be allowed throughout the year provided concrete is protected according to Section 2403 of the Standard Specifications and Article 09014.02 of this specification.

2. If concrete is to be placed by pumping, use a pump line with a section reduction to reduce the exit velocity of the pumped concrete and minimize damage to epoxy coated reinforcement. Submit measures for reducing exit velocity of the concrete to the Engineer for approval prior to placement by pumping.

3. Protect epoxy coated reinforcement from damage caused by placing and handling equipment.

4. For the deck, placing of concrete floors will not be allowed to begin if the theoretical rate of evaporation exceeds 0.1 pounds per square foot per hour (0.5 kg/m^2 per hour). Monitor the theoretical evaporation rate at a maximum interval every three hours during the placement at a location as near the deck as possible. If the rate exceeds 0.15 pounds per square foot per hour (0.75 kg/m^2 per hour), cease placement at the next location acceptable to the Engineer.

E. Curing.

1. **Substructure.**
   - **a.** Leave forms in place for 96 hours of curing.
   - **b.** Leave wet burlap covering in place for 96 hours.

2. **Deck.**
   - **a.** Leave forms place for 168 hours of curing.
   - **b.** Apply water to the burlap covering for 168 hours of continuous wet sprinkling system curing.
   - **c.** Do not place curing compound on the floor.
   - **d.** Prewet burlap with sufficient water, prior to placement, to prevent absorption of moisture from the concrete surface. Place two layers of pre-wetted burlap on the floor immediately after artificial turf drag or broom finish with a maximum time limit of 10 minutes after final

finishing. Apply water to the burlap covering for the entire curing period by means of a continuous wet sprinkling system that is effective in keeping the burlap wet during the moist curing period.

e. Use evaporation retardant only in situations where equipment and/or labor delays, or environmental conditions, prevent adequate protection of the concrete until prewetted burlap is in place. Have an evaporation retardant, including Confilm, Conspec Acquafilm, Evapre, or Sure Film, readily available during placement for application as directed by the Engineer. Do not work the evaporation retardant into the concrete surface or use as a finishing aid.

F. Cold Weather Protection.

1. Monitor the surface temperature of the concrete continuously during the curing period using electronic recording type thermometers capable of recording a minimum of one reading per hour. Furnishing the information to the Engineer in electronic format as required.

2. If supplemental housing and heating is used, locate temperature monitors in the concrete at the furthest and closest point from the heat source. Verify maximum temperature at monitor point closest to heat source does not exceed 150ºF (65ºC).

3. After required curing period, gradually reduce the temperature of the air surrounding the concrete to outside air temperature according to Article 2403.03, I, of the Standard Specifications.

a. Substructure.
Ensure concrete and its surface temperature are maintained at a temperature of no less than 50ºF (10ºC) for the first 120 hours after placing. Curing time will not be counted if the concrete temperature falls below 50ºF (10ºC).

b. Deck.

1. Covering with plastic will not be allowed as a substitute for continuous wet sprinkling system curing.

2. Ensure concrete and its surface temperature are maintained at a temperature of no less than 50ºF (10ºC) for 168 hours of continuous wet sprinkling system curing. Curing time will not be counted if the concrete temperature falls below 50ºF (10ºC).

09014.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

A. High Performance Concrete.
Cubic yards (cubic meters) shown in the contract documents.

B. Trial Batch Concrete.
None.

09014.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. High Performance Concrete.

1. Per cubic yard (cubic meter).

2. The cost for testing the production concrete is included in the contract unit price for High Performance Concrete.

B. Trial Batch Concrete.

1. Lump sum.

2. Payment is full compensation for furnishing all materials, tools, and labor for the performance of all work necessary to design, cast, finish, and dispose of test slabs as indicated.