DS-12050
(Replaces DS-12033)

Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATION
FOR
HIGH PERFORMANCE CONCRETE FOR STRUCTURES

Effective Date
April 15, 2014

THE STANDARD SPECIFICATIONS, SERIES 2012, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

12050.01 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 providing the following:
- Desired workability.
- ~~Minimum average 28 day compressive strength of 5000 pounds per square inch (34.5 MPa), unless specified otherwise in the contract documents.~~
- Maximum 28 day permeability of 2000 coulombs for the substructure (or greater than 20 K ohm-cm surface resistivity by Wenner probe) and 1500 coulombs for the deck (or greater than 30 K ohm-cm surface resistivity by Wenner probe).

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

12050.02 MATERIALS.

Contractor may use other mixes than those described below provided they meet the requirements of this specification and are approved by the District Materials Engineer.

A. Substructure:

1. Apply the following conditions for substructure HPC mixes:
- 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.

2. HPC mix for substructure may be a HPC-S or CV-HPC-S. Apply the following conditions:
- **a.** Use one of the following cement combinations:
  - Type IS.
  - Type I/II with a minimum of 30% weight (mass) substitution with GGBFS.
  - Type IP, except with an absolute volume of 0.126 for HPC-S mix.
- **b.** Fly ash substitution not to exceed 20% by weight (mass) of the cement.
- **c.** Maximum total substitution of 50%
- **d.** A high range water reducer may be used with a maximum allowable slump of 8 inches (200 mm) and target air content of 7.5% ± 2.0%.

B. Deck.

1. Apply the following conditions for deck HPC mixes:
- Use coarse aggregate meeting Class 3i durability.
- Basic w/c ratio of 0.40, with a maximum w/c ratio of 0.42.

2. The HPC mix for the deck may be a HPC-D or a CV-HPC-D. Apply the following conditions:
- **a.** Use one of the following cement combinations:
  - Type IS.
  - Type I/II with a minimum of 30% weight (mass) substitution with GGBFS.
  - Type IP, except use an absolute volume of 0.126 for the HPC-D mix.
- **b.** Fly ash substitution not to exceed 20% by weight (mass) of the cement.
- **c.** Maximum total substitution of 50%.
- **d.** 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.

C. Contractor Designed HPC.

Other mixes meeting the above requirements may be approved by the District Materials Engineer.

~~Apply the following conditions for Contractor designed HPC:~~
- ~~Type IP or IS cement.~~
- ~~Type I/II cement with a minimum of 25% weight (mass) substitution with GGBFS.~~
- ~~Minimum cementitious content of 624 pounds per cubic yard (370 kg/m^3).~~
- ~~Maximum fly ash substitution not to exceed 20% by weight (mass) of the cement.~~
- ~~Maximum total substitution of 50% by weight (mass) of the cement.~~
- ~~Maximum water to cementitious ratio of 0.45 for substructure and 0.42 for deck.~~
- ~~Coarse aggregate meeting Class 3I durability.~~
- ~~For deck concrete, provide a 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.~~
- ~~For substructure, a high range water reducer may be used with a maximum allowable slump of 8 inches (200 mm) and a target air content of 7.5% ± 2.0%.~~

12050.03 CONSTRUCTION.

~~**A. Trial Batch Concrete.**~~

~~**1.** Trial batch is required only when Contractor proposes HPC mixes other than mixes described in Article DS-12033.02, A and B. When a trial batch is required, make one or more trial batches. An Iowa DOT PCC Level III Certified Technician shall develop HPC mix design.~~

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

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

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

~~**5.** Use concrete for testing purposes representative of entire batch 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
- **Substructure:** Evaluate mix workability for intended application and method of placement.
- **Deck:** Cast at least one test slab 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 concrete by hand and evaluate mix workability and finishability for intended application and method of placement.

6. Submit trial batch report to 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. District Materials Engineer will cast samples and transport them to 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. One permeability and six strength samples will be cast in 4 inch by 8 inch (100 mm by 200 mm) cylinder molds.

8. One cylinder will be sent to Central Materials Laboratory for rapid chloride permeability testing in accordance with Iowa Materials Test Method 412-A. Samples for permeability will be delivered within seven days of casting, left in molds, and sealed in a plastic bag or placed in container with water. Two samples will be obtained from the cylinder. Target value of permeability is 2000 coulombs for substructure and 1500 coulombs for deck, or less based on 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 28, and 56 days. For a mix design without previous experience, average 28 day compressive strength shall be equal to or greater than 5000 plus 1400 pounds per square inch (34.5 + 9.5 MPa).

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

B A. Production Concrete.

1. Notify District Materials the Engineer at least 48 hours prior to placement of production concrete. Use only approved HPC mixes for production concrete. If a mix other than mix

described in Article DS-12050.02, A or B is to be used, ensure it has same materials, proportions, and properties (including slump, air content, and w/c ratio) as ~~established in trial batch~~ approved by the District Materials Engineer.

~~**2.** Test production concrete for strength. These test results will be used for acceptance. An Iowa DOT certified PCC Level I Concrete Field Testing Technician shall cast, cure, and handle strength samples according to Materials I.M. 315. Properly cure cylinders at the site with wet burlap and plastic. Do not move cylinders for 16 hours and leave them at the site for a maximum of one calendar day before transporting to a certified laboratory for final curing and testing. Cast six strength samples in 4 inch by 8 inch (100 mm by 200 mm) cylinder molds for each day of placement greater than 100 cubic yards (75 m^3). Document slump, air content, and w/c ratio (adjusted for all water) of the concrete for the cylinders cast.~~

~~**3.** Strength samples shall be tested by a certified lab according to AASHTO T 22. Test three cylinders for strength at each age of 28 and 56 days. After 15 or more sets of samples have been tested, testing of the cylinder at 56 days may be waived by the Engineer, if average 28 day strength exceeds required strength.~~

~~**4.** Submit test results to Engineer and District Materials Engineer no later than one working day after testing is completed. Clearly indicate in the submittal (as 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**~~ **2.** District Materials Engineer will obtain random verification strength samples on a minimum of ~~one substructure placement and~~ one deck placement. Strength samples will be tested at District 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. One cylinder will be tested for permeability on a random basis by Central Materials Laboratory or Wenner probe resistivity testing by the District Materials Engineer. Permeability testing will not be evaluated on footings or drilled shafts.

~~**C. Non Complying Strength.**~~

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

~~D~~ B. Placing Concrete.

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

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

3. For the deck, placing of concrete floors shall not begin if the theoretical rate of evaporation exceeds 0.1 pounds per square foot per hour (0.5 kg/m^2 per hour). Monitor theoretical evaporation rate at a maximum interval of every three hours during 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 next location acceptable to Engineer.

~~E~~ C. 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 in 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 floor.
   - **d.** Prewet burlap with sufficient water, prior to placement, to prevent absorption of moisture from concrete surface. Place two layers of pre-wetted burlap on floor immediately after artificial turf drag or broom finish with a maximum time limit of 10 minutes after final finishing. Apply water to burlap covering for entire curing period by means of a continuous wet sprinkling system that is effective in keeping burlap wet during moist curing period.
   - **e.** Use evaporation retardant only in situations where equipment and/or labor delays, or environmental conditions, prevent adequate protection of 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 evaporation retardant into concrete surface or use as a finishing aid.

~~F~~ D. Cold Weather Protection.

1. Monitor surface temperature of concrete continuously during curing period using electronic recording type thermometers capable of recording a minimum of one reading per hour. Furnish results to 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 heat source. Verify maximum temperature at monitor point closest to heat source does not exceed 150ºF (65ºC).

3. After required curing period, gradually reduce temperature of air surrounding 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 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).

12050.04 METHOD OF MEASUREMENT.

Measurement for High Performance Concrete will be ~~as follows:~~ the

~~A. High Performance Concrete.~~

Cubic yards (cubic meters) shown in the contract documents.

~~B. Trial Batch Concrete.~~

~~None.~~

12050.05 BASIS OF PAYMENT.
Payment for High Performance Concrete will be at the contract unit price ~~as follows:~~

~~**A. High Performance Concrete.**~~

~~**1.** P~~per cubic yard (cubic meter).

~~**2.**~~ Payment ~~i~~includes cost for testing production concrete ~~in the contract unit price for High Performance Concrete~~.

~~**B. Trial Batch Concrete.**~~

~~**1. Lump sum.**~~

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