

**NJDOT HIGH PERFORMANCE INTERNAL CURING (HPIC) GUIDE
SPECIFICATIONS – DRAFT PROJECT SPECIFIC SPECIAL PROVISIONS**

DIVISION 500 – BRIDGES AND STRUCTURES

SECTION 507 – CONCRETE BRIDGE DECK, BRIDGE PARAPET, AND APPROACHES

507.01 DESCRIPTION

THE FOLLOWING IS ADDED:

HPIC concrete bridge decks are to adhere to all construction requirements as specified in 507.03.02.

507.02 MATERIALS

507.02.01 Materials

THE FOLLOWING MATERIAL IS ADDED TO THE LIST:

High Performance Internal Curing (HPIC) Concrete..... 903.11

THE FOLLOWING IS ADDED:

Construct all bridge decks using HPIC concrete. Bridge parapet and sidewalk concrete may be constructed using HPC.

507.03 CONSTRUCTION

507.03.02 Concrete Bridge Deck

H. Placing Deck Concrete

THE THIRD PARAGRAPH IS DELETED AND REPLACED BY THE FOLLOWING:

Do not place a deck section until the previously placed concrete within the unit has attained 70% of the design compressive strength or has cured for a minimum of 72-hours, whichever duration is greater.

THE FOLLOWING SUBPART IS ADDED:

507.03.09 Concrete Test Slab, HPIC

Produce two (2) HPIC mix designs and perform verification batching and testing as specified in 903.11.

After approval of the HPIC mix designs, and at least 90 days prior to constructing the Bridge Deck, produce two (2) HPIC trial batches and construct two (2) test slabs. Submit an HPIC Test Slab Plan to the RE for approval at least 15 days before the planned test slab placement. The HPIC Test Slab Plan shall include, at minimum:

1. Batching procedure for the trial batches.
2. Proposed locations of the HPIC test slabs, including subgrade preparation.
3. A step-by-step description of the delivery, placing, finishing, and curing procedures.
4. Cutsheets for all handling, placing, and finishing equipment.

The lightweight fine aggregate (LWFA) treatment and trial batching shall adhere to the requirements for production as specified in 901.06.04 and 903.11.03. Do not trial batch if the LWFA does not meet 24-hr design absorption values. A representative of the LWFA supplier shall be present during the trial batching to aid the Contractor.

The HPIC trial batches are to be batched, produced, delivered, and placed under the same conditions and using the same procedure and equipment expected during production. This includes but is not limited to travel-time and the supply method of LWFA, whether it is delivered to the concrete plant in a pre-soaked condition or stored and soaked at the concrete plant. The HPIC trial batch shall be produced at the same plant and supplied using the same delivery and placement methods proposed for the production bridge deck placement. Produce batch sizes for each trial batch to ensure load size is sufficient for use with automated batch plant methods, as proposed for production. Manual batching will not be permitted.

Construct 10-ft. x 10-ft. test slabs utilizing the approved HPIC concrete mix. The slab thickness shall be identical to the design thickness for the bridge deck being cast. The test slab shall be reinforced with two mats of uncoated #16 reinforcement, extending the full width and length of the slab in both directions. The reinforcement shall be spaced at a distance identical to the actual spacing utilized in the bridge deck. The slab shall be placed on a non-absorbent vapor barrier and competent sub-grade capable of supporting the weight of the slab without settlement. The test slab shall be placed with a minimum, constant slope of 4% or the actual slope of the production bridge deck, whichever is greater. The test slab location shall be directed by the RE, ideally near the bridge if site conditions allow. If proximity is impractical, the Contractor may propose alternative locations that meet project requirements, subject to RE approval.

Construct and cure the test slabs as specified in 507.03.02, with the following exceptions:

1. Test slab finishing may be completed using a vibratory or power roller screed.
2. Apply deck slab surface texture finish as specified in 507.03.02.I.
3. Sawcut grooving of the test slab is not required.
4. Concrete Deck Surface Requirements as specified in 507.03.02.N shall not be applicable to the test slab.

The test slab shall have control and acceptance testing conducted as specified in 903.11.04.

In addition to acceptance testing requirements, the test slab shall be considered defective if any of the following defects are present:

1. The test slab is not constructed within 10% of the specified dimension or slope requirements.
2. Extensive hairline cracking is present. Extensive hairline cracking is defined as cracking greater than .003 inches in width and greater than 20% of the test slab area.
3. Any cracks with width greater than .03 inch.
4. Surface defects such as honeycombing or exposed aggregate over areas greater than 10% of the slab surface.

If the test slab does not pass acceptance testing or is otherwise considered defective as defined above, remove and recast the test slab at no additional cost to the Department. Modify the HPIC mix as necessary and resubmit the mix design for approval if it is determined that the HPIC mix requires adjustment.

If the test slab of either or both HPIC mixes pass acceptance testing, the Department will direct the Contractor on which HPIC mix design is to be utilized for production.

Remove and dispose of the test slabs and related materials as specified in 201.03.01.H.

507.04 MEASUREMENT AND PAYMENT

THE FOLLOWING PAY ITEMS ARE ADDED:

<i>Item</i>	<i>Pay Unit</i>
CONCRETE TEST SLAB, HPIC	LUMP SUM
CONCRETE BRIDGE DECK, HPIC	CUBIC YARD

THE FOLLOWING IS ADDED:

The Department will make payment for CONCRETE TEST SLAB, HPIC at fifty percent of the bid price (or \$100,000, whichever is less) after completion of verification batching and testing and Department acceptance of the HPIC mix designs. The Department will make the remaining payment upon completion of the test slabs and acceptance of one or both test slabs.

The Department shall not be responsible for claims related to the Contractor's inability to produce an HPIC mix that conforms to the requirements of these specifications.

The Department will not make additional payment for revisions to the Contractor's HPIC mix, additional verification batching and testing, or the need to recast additional test slab(s) due to nonconformance with the requirements of the specifications.

If the Contractor is unable to successfully produce an HPIC mix meeting the requirements of the specifications, the Department reserves the right to substitute the production HPIC concrete with HPC at the bid price of the item CONCRETE BRIDGE DECK, HPIC. This substitution will be made at the Department's discretion and only after verification by the Department that the Contractor is not able to produce the HPIC mix meeting the specification requirements.

DIVISION 900 – MATERIALS

SECTION 901 – AGGREGATES

901.06 AGGREGATES FOR CONCRETE, MORTAR, AND GROUT

THE FOLLOWING SUBPART IS ADDED:

901.06.04 – Lightweight Fine Aggregate for Internal Curing

Lightweight fine aggregate (LWFA) for internal curing shall conform to ASTM C1761 *Standard Specification for Lightweight Aggregate for Internal Curing of Concrete*. LWFA shall have a minimum 72-hr absorption of 10%.

Submit LWFA data with the HPIC Concrete Mix Design submittal. The LWFA data shall substantiate the aggregate physical properties and assumed design properties used in the HPIC mix design. All lab testing shall be performed by AASHTO accredited testing laboratories, as applicable. The LWFA data shall include:

1. Test results and certifications for the aggregates classification to ASTM C1761.
2. Test results substantiating the aggregate physical properties to be used for the mix design, including aggregate gradation, absorption, desorption, and relative density (specific gravity). (Refer to ASTM C 1761)
3. ASTM C1761 Modifications: Aggregate laboratory absorption shall be determined for 24-hr and 72-hr soaking periods. Aggregate design absorption and substitution calculations shall be determined using 24-hr instead of 72-hr soaking periods. Confirm the absorption at 72-hours increases by no more than 30 percent higher than at the 24-hour absorption in the lab.

LWFA shall be sourced as specified in 901.01. Use only sources of aggregate that are listed on the QPL and classified as lightweight aggregate for internal curing of HPC. LWFA for internal curing that is not listed on the QPL may be permitted if it meets the requirements as specified in this subpart and is approved by the ME.

LWFA shall be stockpiled and handled as specified in 901.02 and in accordance with the LWFA supplier recommendations. LWFA shall be prevented from freezing, frozen LWFA shall not be batched. LWFA shall be stockpiled and soaked at the concrete production facility or can be shipped in a pre-wetted condition from the material supplier.

If the LWFA stockpile is soaked at the concrete production facility, it shall be pre-soaked for a minimum of 48 hours before batching by sprinkling or soaking with equipment approved by the ME. During steady rain of comparable intensity, the sprinkler system may be turned off with the approval of the ME until the rain ceases. After pre-soaking, allow the LWFA stockpile to drain for 12-16 hours immediately prior to batching. After draining, mix the stockpile before batching and moisture testing to maintain uniform moisture distribution throughout the stockpile.

If pre-wetted LWFA is shipped, the material supplier shall provide test data substantiating the shipped LWFA absorption. Submit a certificate of compliance, as specified in 106.07. Shipped pre-wetted LWFA shall provide a minimum absorption of the 24-hour design absorption value. Ensure uniform moisture distribution is maintained throughout the shipped pre-wetted LWFA. If shipped pre-wetted LWFA is not utilized within 24 hours of arrival, the pre-wetted LWFA shall be re-tested in accordance with NJDOT Test Method A-8 to verify the minimum absorption is maintained. If shipped pre-wetted LWFA does not meet the minimum absorption requirements, the material will be rejected, or stockpile pre-soaking shall be conducted.

Immediately prior to batching, the absorbed moisture and surface (free) moisture content of the LWFA stockpile or shipped, pre-wetted LWFA shall be determined in accordance with the NJDOT Test Method A-8. Achieve a minimum aggregate absorption of the 24-hour design absorption value. If the measured absorption is below the minimum value, then continue soaking. The minimum absorption must be confirmed by the ME prior to batching.

SECTION 903 – CONCRETE

903.05 HIGH PERFORMANCE CONCRETE (HPC)

903.05.02 Mix Design and Verification

THE FOLLOWING PARAGRAPH IS ADDED:

Design at least two (2) HPIC mixes to equal or exceed the design and verification requirements as specified in Table 903.05.02-2. At least one (1) HPIC mix design shall be based on an existing, NJDOT approved HPC mix that has been modified to provide a sufficient volume of internally stored water to provide internal curing in accordance with ASTM C1761, Appendix X1. At least one (1) mix design shall be developed with a maximum cementitious material content of 600 lbs./cy and have a sufficient volume of internally stored water to provide internal curing in accordance with ASTM C1761, Appendix X1. All approved mix designs shall be evaluated with a trial batch and test slab as specified in 507.03.09.

THE FOLLOWING TABLE IS ADDED:

Table 903.05.02-2 Design and Verification Requirements for HPIC		
Performance Characteristic	Test Method	Requirement
Scaling Resistance ¹ @ 50 cycles (visual rating of the surface, maximum)	ASTM C 672	3
Freeze-Thaw Durability (relative dynamic modulus of elasticity after 300 cycles, minimum)	ASTM C 666 Proc. A	80%
Surface Resistivity ² @ 56 days (k Ω -cm, minimum)	AASHTO T 358	36
Unit Weight (pounds per cubic foot, minimum)	AASHTO T 121	135
Compressive Strength ³ @ 3, 7, 28, 56 days (pounds per square inch, minimum)	ASTM T 22	5,400
Flexural Strength @ 28, 56 days (pounds per square inch, minimum)	ASTM C 78	500
Free Shrinkage @ 56 days ($\mu\epsilon$, maximum)	AASHTO T 160	450

1. For the scaling resistance testing, moist cure specimens for 14 days and then air cure for 14 days.
2. If the surface resistivity requirement has been achieved in 28 days, consider the surface resistivity acceptable. If the required surface resistivity is not achieved in 28 days, test the HPIC sample at 56 days.
3. If the compressive strength requirement has been achieved in 28 days, consider the strength acceptable. If the required compressive strength is not achieved in 28 days, test the HPC sample at 56 days.

903.05.04 Control and Acceptance Testing Requirements

THE FOLLOWING TABLE IS ADDED:

Table 903.05.04-2 Acceptance Requirements for HPIC

Performance Characteristic	Test Method	Requirement
Percent Air Entrainment ¹	AASHTO T 152	6.0 ± 1.5 (No. 57/67 Aggregate) 7.0 ± 1.5 (No. 8 Aggregate)
Slump (inches) ^{1,2}	AASHTO T 119	3±1
Surface Resistivity @ 56 days ^{3,4,5} (kΩ-cm, minimum)	AASHTO T 358	19
Unit Weight ⁶ (pounds per cubic foot, minimum)	AASHTO T 121	135
Compressive Strength ^{6,7} @ 3, 7, 28, 56 days (pounds per square inch, minimum)	ASTM T 22	4,400
<ol style="list-style-type: none"> If using a Type F or G admixture, change the Slump and Air Content values for the HPC as follows: <ol style="list-style-type: none"> Slump: 6 ± 2 inches. Air Content: increase both the target value and tolerance percentages by 0.5. For slip-formed parapet, design and produce a mix with a slump of 1 ± 1/2 inch. The ME will not test for the surface resistivity requirements for HPC used for Items other than bridge decks. For surface resistivity, the ME will mold 4 additional cylinders, taking 2 cylinders each from 2 randomly selected delivery trucks for testing at 56 days. If the surface resistivity requirement has been achieved in 28 days, consider the surface resistivity acceptable. If the required surface resistivity is not achieved in 28 days, test the HPIC sample at 56 days. For compressive strength testing, the initial rate for the HPIC is 6 per lot. The retest limit is 4,400 pounds per square inch. If the compressive strength requirement has been achieved in 28 days, consider the strength acceptable. If the required compressive strength is not achieved in 28 days, test the HPIC sample at 56 days. 		

THE FOLLOWING SUBSECTION IS ADDED:

903.11 HIGH PERFORMANCE INTERNAL CURING (HPIC) CONCRETE

903.11.01 Composition

Produce HPIC as specified in 903.05.01, except for the following:

The HPIC mix design shall have total normal-weight fine aggregate volume substituted with pre-wetted lightweight fine aggregate (LWFA) that conforms to the requirements as specified in 901.06.04. The quantity of LWFA substitution shall be calculated to provide a sufficient volume of internal curing water in accordance with ASTM C1761, Appendix X1. Aggregate design absorption and substitution calculations shall be determined using 24-hr instead of 72-hr soaking periods. Aggregate desorption need not be considered in the substitution calculations. The maximum quantity of LWFA substitution for the mix design shall not exceed the calculated quantity required to provide internal curing water in accordance with ASTM C1761, Appendix X1.

HPIC mixes utilizing light-weight coarse aggregate, superabsorbent polymer, or colloidal silica will not be accepted by the Department.

903.11.02 Mix Design and Verification

At least six (6) months before constructing the bridge deck, submit Project specific HPIC concrete mix design and verification testing to be approved by the ME.

Perform the mix design and verification testing as specified in 903.03.02 and 903.05.02.

Design an HPIC mix that conforms to the requirements as specified in 903.05.02 and Table 903.05.02-2 requirements, except for the following:

1. Do not include the absorbed water in the prewetted LWFA as part of the water-to-cement ratio calculations.
2. The design unit weight of the HPIC concrete mix design shall not be less than 135 pounds per cubic foot. The HPIC Concrete Mix Design submittal shall include the following:
 1. Fine and coarse aggregate content (lb/yd³) based on saturated surface dry (SSD) condition.
 2. LWFA properties including absorption, desorption, and relative density to be used for the mix design. The mix design shall be based upon LWFA 24-hr absorption values, wetted surface dry (WSD) conditions as defined in ASTM C 1761. Desorption need not be considered in the substitution calculations. Mix design for normal-weight aggregates shall be based upon saturated surface dry (SSD) or oven dry conditions.
 3. Cementitious and supplementary cementitious materials content (lb/yd³)
 4. Water content (lb/yd³).
 5. All proposed admixtures and design air content.
 6. Determination of LWFA substitution quantity, including calculations substantiating the internal curing water provided.
 7. Batching plan including the methods of adjusting batch volumes based upon absorbed and surface (free) water of the LWFA after pre-soaking.
 8. Lab performance testing, performed by AASHTO accredited testing agency, substantiating the HPIC mix meets requirements as specified in 903.05.02 and Table 903.05.02-2.

The Contractor shall be responsible for ensuring the HPIC mix meets workability requirements.

HPIC mix designs that have been approved by other agencies that do not meet the specification requirements will not be approved by the Department. NJDOT approved HPC mixes modified to provide internal curing that do not meet the specification requirements will not be approved by the Department.

903.11.03 Mixing

Adjust the batch weights of the pre-soaked lightweight fine aggregate (LWFA) to account for the actual absorbed moisture content and maintain the design internal curing water quantity. After adjusting LWFA batch weights, additional adjustments must be made to the fine aggregates and water quantities to account for the surface (free) moisture content of all aggregates. Ensure the mix design water-cementitious materials ratio and the total fine aggregate volume are maintained in accordance with the mix design. Do not batch if LWFA absorbed moisture content is less than the 24-hour design absorption value.

Mix HPIC concrete as specified in 903.05.03 and in accordance with the LWFA supplier recommendations. Use mixing procedures that will ensure LWFA absorbed water is maintained during batching. To produce HPIC, pre-soaked LWFA shall not be mixed or added with the other dry components of the mix. The other components of the mix shall be combined prior to adding the LWFA to avoid releasing internally stored water. Admixtures to improve workability shall be added after the LWFA is added and mixed for at least 3 minutes.

Adhere to LWFA stockpile and batching related requirements as specified in 901.06.04.

Batch water weight shall not be adjusted for the absorbed moisture within the prewetted LWFA.

903.11.04 Control and Acceptance Testing Requirements

Produce HPIC that conforms to the requirements as specified in 903.05.04 and Table 903.05.04-2.

NJDOT TEST METHOD A-8 – DETERMINING MOISTURE CONTENT OF LIGHTWEIGHT FINE AGGREGATE

- A. Scope.** This test method is used to determine the total, absorbed, and surface (free) moisture content of lightweight fine aggregate to be used for internal curing of Portland cement concrete. The moisture content determination is to be used to verify minimum absorbed water content is provided and for batch adjustments accounting for the surface (free) moisture. The method is commonly referred to as the “paper towel method” per ASTM C1761/C1761M.
- B. Apparatus.**
- I. Balance: Having a capacity of at least 4 kg and accurate to at least 0.1 g.
 - II. Sampling containers: Non-absorbent, sealable, bag or tub with a capacity sufficient for holding approximately 2000 grams of fine aggregate.
 - III. Scoop, shovel, or large spoon.
 - IV. Sheets of non-absorbent cloth, canvas, or polyethylene (approximate size: 24” (600 mm) x 24” (600 mm)).
 - V. Drying apparatus: A ventilated oven capable of maintaining temperature of $230 \pm 10^{\circ}\text{F}$ ($110 \pm 5^{\circ}\text{C}$) for 24 hours. In cases where the aggregate is not altered by overheating, other sources of heat, such as electric or gas hotplates, or electric heat lamps may be used.
 - VI. Disposable paper towels: Brown, commercial grade, either folder type or roll type, typically manufactured from post-consumer recycled paper.
 - VII. Metal heat resistant pans: With sufficient capacity to hold a minimum of 500 grams of fine aggregate in an oven or on a hot plate at the specified temperature.
- C. Procedure.**
- I. Obtaining Samples. For determination of absorbed and surface moisture content at the concrete plant, prior to mixing: After soaking, draining, and mixing the lightweight fine aggregate stockpiles, obtain a representative sample from the stockpile or plant storage bin. A minimum representative sample size of 2000 grams shall be obtained by combining and stirring three samples of LWFA from the top, middle, and bottom of the stockpile or plant storage bin. Another representative ‘reserve sample’ shall be collected at the same time in case the first collected representative sample did not achieve the minimum absorption rate requirements.
 - II. Immediately upon obtaining the composite sample, place it in a non-absorbent container to prevent loss of moisture prior to testing. Directly before performing subsequent measurements, quarter the sample into four sub-samples of approximately 500 grams each. Test “Sample #1” for total moisture content and “Sample #2” for absorbed moisture content. If the testing for “Sample #1” and “Sample #2” did not satisfy the specification requirements, repeat the testing with “Sample #3” and “Sample #4”
 - III. Total Moisture Content:
 1. Weigh one sub-sample to the nearest 0.1 grams, to be known as “Sample #1”
 2. Record weight of Sample #1 as $W_{T,1}$
 3. Dry Sample #1 using the drying apparatus to a constant mass to the nearest 0.1 percent.
 4. Record weight of dried Sample #1 as $W_{OD,1}$.
 - IV. Absorbed Moisture Content:
 1. Weigh the second sub-sample to the nearest 0.1 grams, to be known as “Sample #2”
 2. Record weight of Sample #2 as $W_{T,2}$
 3. Place Sample #2 on a 2- to 3-foot-long sheet of clean, dry paper towel.
 4. Spread Sample #2 uniformly across the paper towel while patting the sample with another paper towel. Continue patting and spreading the sample, replacing the sheets of paper towel whenever the paper becomes too damp or dirty to absorb moisture. Conduct this process as quickly and carefully as possible. Repeat the patting and spreading of the sample until no further moisture appears on the clean paper towels.
 5. After removal of the surface moisture, the aggregate is considered to be in the wetted surface dry (WSD) condition.

6. Weight Sample #2 after surface moisture is removed to the nearest 0.1 gram.
7. Record weight of Sample #2 as $W_{WSD,2}$.
8. Dry Sample #2 using the drying apparatus to a constant mass to the nearest 0.1 percent.
9. Record weight of dried Sample #2 as $W_{OD,2}$.

D. Calculations.

1. Calculate the “% Total Moisture (M_T)” Content as follows:

$$M_T = \frac{W_{T,1} - W_{OD,1}}{W_{OD,1}} \times 100\%$$

2. Calculate the “% Absorbed Moisture (M_A)” Content as follows:

$$M_A = \frac{W_{WSD,2} - W_{OD,2}}{W_{OD,2}} \times 100\%$$

3. Calculate the “% Surface Moisture (M_S)” Content as follows:

$$M_S = M_T - M_A$$

4. Calculate the “Wetted Surface Dry (WSD) Specific Gravity” as follows:

$$G_{WSD,1} = G_{OD}(1 + M_A)$$

* G_{OD} (oven-dry specific gravity) shall be obtained from the manufacturer testing data.

- E. Report.** Report % Total Moisture, % Absorbed Moisture, % Surface Moisture, and Wetted Surface Dry (WSD) Specific Gravity to the nearest 0.1%.