11. HPC SPECIFICATIONS

STATE PROJECT NO. 241-02-0040

SPECIFICATIONS FOR USE OF HIGH PERFORMANCE CONCRETE (HPC) ON THE CHARENTON CANAL BRIDGE

The design and construction of the Charenton Canal Bridge is part of a project to implement the use of High Performance Concrete (HPC) in Louisiana bridges. A research team headed by Tulane University and including Henry G. Russell, Inc. and Construction Technology Laboratories, Inc. (CTL) is assisting DOTD and Louisiana Transportation Research Center (LTRC) in the implementation program. The success of both the construction project and the research project requires that the researchers play an integral part in the construction process and that the contractor and subcontractors cooperate fully with the researchers. The following section describes special provisions required of the contractor and outlines the role of the researchers and LTRC in various aspects of the construction process. Details of the research program are given in "Implementation of High Performance Concrete in Louisiana Bridges - Interim Report."

COORDINATION OF WORK WITH CONTRACTORS: All aspects of the researchers' work shall be coordinated with the contractor. The contractor shall take all actions necessary to incorporate the research activities into the development of the construction schedule. The researchers shall cooperate with the contractor and shall minimize all delays.

Attendance at an open meeting prior to bid letting, where the researchers, DOTD and LTRC give presentations on details concerning the HPC bridge is mandatory for all contractors. It is also recommended that the prestressed concrete girder fabricator and the deck concrete contractor bidding on this contract also attend. After letting, a preconstruction meeting will be held with the contractor, pertinent subcontractors, researchers and sponsors (see page D-7.)

At all times, including during construction, coordination between the contractors' and researchers' representatives will be required to ensure implementation of the necessary measures for design and control of HPC. The researchers will be provided access to the work area, will install the instrumentation and will be responsible for measurements. Facilities necessary for installing and protecting the instrumentation and equipment will be provided by the contractor.

DEFINITION OF HIGH PERFORMANCE CONCRETE (HPC): For this contract, the cast-in-place concrete used for the approach slabs, barrier slabs and deck slab shall be high performance concrete Class AA (HPC). Bent caps shall be Class A (HPC). The precast concrete used in the prestressed concrete piles and girders shall be high performance concrete Class P (HPC).

HIGH PERFORMANCE CONCRETE MIX DEVELOPMENT: The researchers and LTRC will provide technical expertise to assist the contractor in developing and evaluating the HPC mix design and curing cycle. The design and control of the HPC will be in accordance with the Standard Specifications, Special Provisions and Contract Plans.

LABORATORY AND FIELD TESTING FOR RESEARCH: During HPC girder and deck construction, HPC specimens in addition to those required by the specifications and contract

plans will be made by the researchers and/or LTRC personnel. The contractor shall make the necessary provisions to allow sampling of the HPC as described in "Implementation of High Performance Concrete in Louisiana Bridges - Interim Report."
Concrete specimens made by the researchers at the precasting plant will be stored with the girders at the plant and at the bridge site. Concrete specimens made at the bridge site will be stored alongside the bridge deck at the bridge site. Contractor shall provide adequate space for storage and proper containers to protect cylinders from damage during shipping of specimens to CTL for testing. Contractor shall pay shipping costs.

STRUCTURAL MONITORING: The researchers have developed an instrumentation program to monitor the structural performance of the bridge and its components as described in "Implementation of High Performance Concrete in Louisiana Bridges - Interim Report." The contractor shall make available selected components and provide access to various locations to allow researchers to attach instrumentation and lead wires. It is planned to instrument four girders that will be cast in one bed at the same time. Instrumentation will also be installed in the deck. With proper planning and coordination, installation of instrumentation and data collection will not cause any significant delays to the contractor.

LOUISIANA STANDARD SPECIFICATIONS FOR ROADS AND BRIDGES: For this project, the *Louisiana Standard Specifications for Roads and Bridges*, 1992 Edition, is amended with respect to the Subsections cited below:

Subsection 105.05 Cooperation by Contractor

Add the following paragraph:

The contractor shall provide access to selected components and access to various locations to allow researchers to install instrumentation and lead wires and to collect data. The precast concrete producer shall provide 110v electrical power at required locations for use by the researchers. The contractor shall make the necessary provisions to allow sampling of concrete by the researchers. The contractor shall provide adequate space for the manufacture and storage of test specimens at the precast plant and bridge site. The contractor shall be responsible for shipping test specimens to the researchers' facilities.

Subsection 805.02 Materials

Add the following class of concrete:

Concrete Class	Use
P (HPC)	High-strength concrete precast bridge members
AA(HPC)	High performance concrete cast-in-place superstructure
A (HPC)	High performance concrete cast-in-place substructure

Subsection 805.10 Curing

Add the following paragraphs:

For Class AA (HPC) concrete used in the bridge deck, barrier rails, approach slabs and barrier slabs, the contractor shall comply with ACI 302—Guide for Concrete Floor and Slab Construction, ACI 308—Standard Practice for Curing Concrete and ACI 305—Hot Weather Concreting. As a minimum, if silica fume is used, the contractor shall under finish concrete by limiting finishing operations to screeding, bull floating and grooving. Continuous fogging above the surface of the concrete during the finishing operation shall be required. Fogging shall

continue until the surface will support wet burlap without deformation. Free-standing water on the concrete surface prior to concrete final set shall not be allowed to occur.

As soon as the surface will support the burlap without deformation, apply prewetted burlap to the textured concrete surface. The concrete shall be kept continuously wet with a fog nozzle system or soaker hoses for seven curing days as defined in Subsection 805.11 and until a concrete compressive strength of 3,200 psi is reached. Materials, equipment and labor necessary for continuous curing will be supplied by the contractor. The use of polyethylene sheeting or plastic coated burlap blankets shall not be permitted.

The Project Engineer may require placement to be made at night or during early morning hours if satisfactory surface finish cannot be achieved. Weather conditions (current and forecasted) shall be within limits of Subsection 901.11.

Subsection 805.11 Removal of Falsework and Forms

Add the following to the second paragraph:

Supporting forms and falsework for HPC bridge decks, approach slabs, barrier rails, and barrier slabs shall not be removed until both criteria determined by Methods 1 and 2 are met.

Add the following to Method 1:

Concrete Class	Compressive Strength (psi)
AA (HPC)	3200
A (HPC)	3200

Subsection 805.13 (e) (1) Striking Off

Replace last paragraph with the following:

Addition of water to the surface of Class AA (HPC) and Class A (HPC) concrete to assist in finishing shall not be permitted.

Subsection 805.14 (e) Curing

Revise as follows:

To establish adequacy of curing methods and to determine whether concrete has attained the required compressive strength, a minimum of eight test cylinders shall be made from the last batch of concrete and match cured under the same condition as the corresponding member. Three cylinders will be tested no later than 56 calendar days after casting to determine that the required strength has been achieved. The remaining five cylinders may be tested at any time as required by the contractor. However, no more than three cylinders will be tested in one day. If all five cylinders have been tested and concrete has not attained required strength, the members involved shall be held at the plant until the 56-day cylinders are tested. If the average 56-day concrete cylinder strength has not achieved the required strength, all members involved will be subject to rejection. Acceptance will be made in accordance with the Department's manual entitled "Application of Quality Assurance Specifications for Precast-Prestressed Concrete Plants." Curing methods other than heat curing shall be in accordance with Subsection 805.10. Hot weather concrete limitations as stipulated in Subsection 901.11(b) shall not be applicable for heat curing; however, precautions such as cooling of forms will be required.

Heat curing shall be done under a suitable enclosure to contain the heat in order to minimize moisture and heat losses. Initial application of heat shall begin only after concrete has reached its initial set as determined by ASTM C 403. When used, steam shall be at 100 percent relative humidity. Application of heat shall not be directly on concrete. During application of heat, concrete temperature shall be increased at a rate not to exceed 40 ^{o}F per hour until the desired concrete temperature is achieved. The concrete temperature shall not exceed 160 ^{o}F. Heat

curing may continue until concrete reaches release strength. At the contractor's option, the application of heat may be reduced or discontinued to ensure that the concrete temperature does not exceed 160 ^{o}F. If structural defects occur, the defective members will be rejected.
Contractor shall detension strands before the internal concrete temperature has decreased to 20 ^{o}F less than its maximum temperature. Two recording thermometers showing time-temperature relationship in the concrete shall be furnished for each 200 ft of bed. For girders, one thermometer shall be located at the center of gravity of the top flange and one at the center of gravity of the bottom flange. For piles, one thermometer shall be located in the top half of the pile and one in the bottom half. Both thermometers shall be located midway between the outside comers of the pile and the nearest edge of the center void. If a void is not provided, only one thermometer shall be provided at the center of gravity of the cross section.

Subsection 805. 14 (f) Transportation and Storage

Replace fourth paragraph with the following:

Prestressed members shall be held at the plant for at least 28 days after casting and until the concrete has attained the specified compressive strength. Specified compressive strength shall be attained no later than 56 days after casting.

Subsection 805.14 (g) Pretensioning Method

Replace the first paragraph with the following:

Prestressing strands shall be accurately held in position and stressed by approved jacks. A record shall be kept of the jacking force and tendon elongation produced. Several units may be cast in a continuous line and stressed at one time. Sufficient space shall be left between ends of members to permit access for cutting strands after concrete has attained required strength. Sufficient free strand shall be left in the line to ensure that cracking of the girders does not occur as the temperature of the girders decreases prior to detensioning of the strand. No bond stress shall be transferred to concrete nor shall end anchors be released until concrete has attained specified release strength as shown by cylinders made in accordance with DOTD TR 226 and match cured identically with members and tested in accordance with DOTD TR 230. Strand shall be cut or released in such order that lateral eccentricity of prestress will be a minimum in accordance with approved shop drawings.

Subsection 810.02 Materials

Concrete for bridge rail shall be Class AA (HPC).

Subsection 810.03 Construction, Fabrication, Erection and Painting

Replace the first sentence of the second paragraph with the following:

After completing the deck pour, a minimum of 7 days shall elapse before placing of reinforcing steel and form for railings.

Subsection 901.01 General

Add a new paragraph as follows:

Concrete Class P (HPC) shall conform to the following requirements:

Average Compressive Strength at 56 days 10,000 psi

Slump $\leq$ 10 in.

Concrete slump shall be selected by contractor to ensure that concrete does not segregate. Permeability (total charge passed) shall be less than or equal to 2,000 coulombs at 56 days.

Concrete Class AA (HPC) and Class A (HPC) shall conform to the requirements of Table 1 and the following:

Permeability (Total Charge Passed) shall be less than or equal to 2,000 coulombs at 56 days.

If used, silica fume shall be added as early as possible in the concrete batching and as directed by a technical representative of the admixture supplier to ensure uniform distribution.

High-range water-reducers may be used to control slump, water/cementitious material ratio and proper distribution of fly ash or silica fume. Admixtures shall be plant added. Retempering at the jobsite, if necessary, will be permitted. Air entraining and set controlling admixtures may be used. All admixtures shall be compatible. Compatibility shall be demonstrated with trial batches. Admixtures containing chlorides shall not be used.

Specimens for compressive strength testing and permeability testing shall be manufactured by the contractor and supplied to LTRC for testing.

Subsection 901 Table 1

Add the following:

Structural Class AA (HPC)[m] and Class AA (HPC)[m]		
Average Compressive Strength at 28 days		4200 psi
Grade of Coarse Aggregate	A[n]	
Minimum Bags of Cement (94 lb) per Cu Yd of Concrete[i]		7.0
Maximum Water per Bag of Cement[a i] (Gallons)		4.51P
Total Air Content (Percent by volume)[d]	5.5±1.5%	
Slump Range (Inches)		2-8

m Cement type shall be I, IB or III conforming to Subsection 1001.01

n Aggregates shall conform to Subsection 1003.02.

p Water content shall include weight of water, if any, in the admixtures. Cement content shall include all mineral admixtures.

Revise footnote i as follows:

i For mixes containing combinations of cement, fly ash and silica fume, the minimum cement and maximum water contents shown shall apply to the total cement/fly ash/silica fume content of the mix.

Subsection 901.02 Materials

Add the following:

The use of silica fume conforming to AASHTO M307 with the exception of Loss of Ignition (LOI) which shall not exceed 6.0 percent or ASTM C 1240 shall be permitted.

Subsection 901.06 Quality Control of Concrete

Add the following paragraph:

A representative of the admixture manufacturer shall be present for batching start up and during initial concrete placement.

Subsection 901.06 (a) Mix Design

Add the following paragraphs:

For Class P (HPC) concrete, the contractor shall make two demonstration trial batches, of at least 3 cu yd, on separate days at the prestressed concrete girder plant to show that the girder concrete sections can be cast with the proposed mix design. Materials used in concrete batches shall be identical to those that will be used in production. These demonstration batches and girders shall be made sufficiently before production girders are cast to demonstrate that design compressive strength can be achieved. Cylinders shall be made and match cured with the girder section. The cylinders shall be cured and tested in the same manner as acceptance cylinders in a production mode. The design trial batch shall meet the minimum design compressive strength before mix design approval will be given. Test results for slump, air content, wet unit weight and compressive strengths at concrete ages of 1, 3, 7, 28 and 56 days shall be submitted. The verified time-temperature history of the concrete during the initial curing period shall be submitted. If requested, the contractor shall furnish materials to the Department for verification of trial mixes.

For Class AA (HPC) and Class A (HPC), the concrete producer shall make trial batches as necessary to determine the proportions of the basic ingredients as well as the amount and proper sequencing of admixtures to produce the required concrete mix. Specimens for compressive strength testing and permeability testing shall be manufactured by the contractor and supplied to LTRC for testing. At least 28 days prior to placement of Class A (HPC) for the bridge cap, contractor shall construct a test slab 12x30 ft. The test slab shall be constructed using the proposed Class A (HPC) concrete and shall be finished and cured in accordance with the proposed procedures for the bridge deck. The Materials Engineer will approve the mix design when trial batching and test slab demonstrate the desired results.

The Contractor shall strictly adhere to the manufacture's written recommendations regarding the use of admixtures, including storage, transportation and method of mixing.

Subsection 901.07 Substitutions

Add the following:

P (HPC)	No substitutions
AA (HPC)	No substitutions
A (HPC)	No substitutions

Subsection 901.08

Add a new subsection as follows:

901.08 (g) Permeability

Permeability of concrete shall be determined in accordance with AASHTO T277 or ASTM C 1202. The permeability samples shall have a 4-in. diameter and a length of at least 4 in. Class A (HPC) and Class AA (HPC) concrete shall be moist cured until testing at 56 days after casting. Class P (HPC) shall be cured using the same procedures of the girders and piles until testing. The average value of three specimens shall be reported.

Subsection 901.08 (a) Cement and Aggregates

Add the following paragraphs:

For Class P (HPC), Class AA (HPC), and Class A (HPC) concretes, the contractor will be permitted the use of silica fume to a maximum of 10 percent by weight of the total combination of cement, fly ash and silica fume.

For Class P (HPC) concrete, the contractor will be permitted the use of fly ash with Type I,

I(B), I(C), II or III portland cement up to a maximum of 35 percent by weight for the total combination of cement, fly ash and silica fume.

For Class AA (HPC) and Class A (HPC) concrete, the contractor will be permitted the use of fly ash with Type I, I(B) and III portland cement up to a maximum of 30 percent by weight of the total combination of cement, fly ash and silica fume. A combination of fly ash and silica fume may be used with the total substitution by weight not to exceed 30 percent of the total combination of cement, fly ash and silica fume.

Subsection 901.08 (f) (1) Structural Concrete

Add the following paragraph:

Cylinders by which strength of Class P (HPC) concrete is to be determined shall be cured using the match-curing technique until detensioning of the strand. Thereafter, cylinders shall be cured alongside the members that they represent. For girders, thermocouples for use with the match- curing system shall be placed within 1 in. of the center of gravity of the bottom flange. For piles, thermocouples for use with the match-curing system shall be placed at the center of gravity of the cross section when a void is not present or midway between the outside corner of the pile and the nearest edge of the void in piles with voids.

Subsection 901.12 Acceptance and Payment Schedule

Add the following paragraph:

Acceptance and payment for Class AA (HPC) and Class A (HPC) concrete shall be in accordance with the schedule in Table 2 for Class AA concrete except the concrete will not be accepted and shall be removed if the specified 28-day compressive strength is not achieved by 56 days.

Subsection 1003.02 (a) Fine Aggregate

Add the following sentence at the end:

For Class P (HPC) concrete, other gradations of concrete sand will be permitted if demonstrated in trial mixes to produce the required concrete properties and accepted as part of the proposed mix designs.

Subsections 1003.02(b) Coarse Aggregate

Add the following sentence at the end:

For Class P (HPC) concrete, other gradations of uncrushed and crushed coarse aggregate will be permitted if demonstrated in trial mixes to produce the required concrete properties and accepted as part of the proposed mix design.

Subsection 1009.05 Steel Strand for Pretensioning

Add the following sentence:

The contractor shall obtain certification from the strand supplier that the strand will bond to concrete of a normal strength and consistency in conformation with the prediction equations for transfer and development length given in the *AASHTO Standard Specifications for Highway Bridges.*

TR 226M/226-95

For this project, DOTD Designation: TR 226M/226-95 is amended with respect to the following:

Part H. Apparatus

At the end of the first paragraph of A. Cylinder molds, add the following:

Match-cured cylinders shall have an inside diameter of 100 mm (4 in.) and a length of

200 mm (8 in.).

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Add the following new section:

3. Match-cure molds - Sure Cure Cylinder Mould System from Products Engineering.

Section IV. A. Compression Test Specimens

Add the following new section:

I.b. Match-cure molds - Follow manufacturer's instructions.

TR 23OM/230-95

For this project, DOTD Designation: TR 230M/230-95 is amended with respect to the following:

Section II. G. Testing Machines

Add the following at the end of the second paragraph:

For testing Class P (HPC) concrete, the testing machine shall have been calibrated within 6 months prior to the time of testing.

Part IV. Sample

Add the following paragraph:

Match-cure cylinders shall be molded to have a diameter of 102 mm (4.0 in.) and a nominal height of 203 mm (8 in.).

Section V. B. Determining the Cross-Sectional Area

Add a new section as follows:

3. For match-cured cylinders, determine cross-sectional area in accordance with V. B. 2.

Section V. D. Determining Compressive Strength

Add the following to the first paragraph:

Neoprene caps with a durometer hardness of at least 70 shall be used for testing Class P (HPC) concrete.