VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
HYDRAULIC CEMENT CONCRETE OPERATIONS FOR MASSIVE CONSTRUCTION

January 13, 2016
Project: 0130-005-643, C501, B663

I. DESCRIPTION

This work shall consist of furnishing and placing hydraulic cement concrete for the massive cast-in-situ concrete bridge components, which shall be any concrete element whose minimum dimension exceeds 5 feet. This shall include footings, drilled shaft caps, piers, and abutments that meet this criterion. Work shall be performed in accordance with this special provision and in conformity with the dimensions, lines, and grades shown on the Contract Drawings or as established by the Engineer.

This Special Provision supplements and modifies Sections 217 and 404 of the Specifications.

II. MATERIALS

A. Class F fly ash or granulated iron blast-furnace slag shall be used in all concrete designated mass concrete.

B. High-early-strength (Type III) cement, calcium chloride, and accelerating type admixtures shall not be used.

C. A retarding admixture, pretested with job materials under job conditions, shall be used, if acceptable to the Engineer, whenever necessary to prevent cold joints due to the quantity of concrete placed, to permit revibration of the concrete, to offset the effects of high concrete temperature, or to reduce the maximum temperature and rate of temperature rise.

D. Fly ash, Class F, shall replace 25 to 40 percent by mass of the design cement content.

E. Granulated iron blast-furnace slag shall replace from 50 to 75 percent by mass of the design cement content.

F. Concrete used in mass concrete pours shall not exceed Class A4. Cementitious material content shall be the minimum required to meet the target strength. Water/Cementitious material ratio shall be limited to 0.4 maximum.

III. PROCEDURES

A. This Special Provision applies to all reinforced concrete elements (pier, abutment, footing, or drilled shaft cap) whose minimum dimension exceeds 5 feet. If any portion of a concrete element has a dimension that exceeds 5 feet, the entire element shall be treated as massive concrete and shall meet the requirements of this Special Provision.

B. This work shall be performed in accordance with the following American Concrete Institute's (ACI) publications, except as superseded by this Special Provision:

1. "Guide to Mass Concrete", ACI 207.1R-05.

2. "Report on Thermal and Volume Change Effects on Cracking of Mass Concrete", ACI 207.2R-07.

3. “Control of Cracking in Concrete Structures”, ACI 224R-01.

4. “Specifications of Structural Concrete”, ACI 301-10, Section 8.

C. Submittals:

The Contractor shall submit the following to the Engineer for review and approval:

1. Working Drawings: Describe the intended concrete placing sequence in the massive concrete bridge components. Indicate proposed locations of all thermocouples.

2. Shop Drawings: Reinforcing steel to be placed in the elements if different size, spacing, or depth of reinforcing bars to be used than those shown in the Plans.

3. Documentation: For each proposed concrete mix design, the following information shall be submitted:

   a. Describe the methods to be used to construct the massive concrete bridge components within the criteria set forth in this Special Provision. Illustrate dimensions of proposed mass concrete pours. Mass concrete pours shall be laid out to minimize surface area for a given volume. Pours that combine elements considered mass concrete and non-mass concrete shall not be permitted.

   b. Design calculations prepared to document that the methods chosen to install the massive concrete bridge components are in accordance with the referenced ACI publications as superseded by this Special Provision. Calculations shall include:

      1. A table of calculated peak temperatures for the range of expected air and concrete temperatures at time of placement.

      2. A calculation of maximum temperature gradients within the element during the curing period.

      3. A calculation of time to peak temperature.

      4. A calculated curve of maximum allowable temperature difference vs. concrete strength for each element under consideration, for the allowable crack widths indicated on the plans, or in Table 4.1 of ACI 224R-01 where no allowable crack widths are shown on the plans.

      5. Insulation requirements for the forms and exposed portions of the concrete to keep the thermal gradients within allowable limits.

      6. A calculation of the time to reach the peak temperature difference, as well as the estimated time to cool to the allowable differential temperature specified in Section III.E.3 below.

   c. Mix design showing proportions and sources for all components, and results of strength tests of sample cylinders. Mix designs shall also include the heat of hydration of the cementitious materials in the mix, as well as the thermal expansion coefficient of the concrete per USACE CRD-C39-81 if the allowable temperature difference curve will be used.

   d. Catalogue information on any admixtures proposed to be added to the concrete mix.

e. Proposed methods to reduce concrete temperatures and temperature differentials, such as pre-cooling of concrete or insulation. Internal cooling pipes shall not be permitted.

4. All submittals must be signed and sealed by a Professional Engineer registered in the Commonwealth of Virginia.

D. Placing:

The maximum temperature of the concrete for massive components when deposited shall be 95°F, or lower if required by the ACI 207R-07 analysis to prevent exceeding the maximum allowable temperature.

E. Curing and Protection:

1. The minimum curing period shall be 1 week. Curing methods shall be in accordance with Section 404 of the Specifications, and shall not result in excessive temperature differentials. With the Engineer's approval, the forms may be stripped prior to the end of the curing period.

2. The maximum allowable temperature in any portion of the mass concrete shall be 170°F for slag and cement mixes and 160°F for fly ash and cement mixes in the prescribed proportions. The Engineer may, at its sole discretion, direct that concrete that has exceeded these temperatures be removed, or otherwise mitigated, at no cost to the Department.

3. The maximum allowable thermal gradient between the core and skin temperatures of a pour is limited to 35°F, unless the analysis submitted under Section III.C.3.b.4 above demonstrates that the element is sufficiently reinforced to prevent crack widths in excess of those listed on the plans or in Table 4.1 of ACI 224R-01.

4. Thermocouples shall be placed in each pour of all mass concrete elements. One pair of thermocouples shall be placed at the centroid of the pour, or wherever the point of expected maximum temperature is anticipated. If there it is any doubt as to the location of the predicted maximum temperature, then additional thermocouples shall be placed as required or as directed by the Engineer.

5. For elements such as footings, slabs, or pier caps cast on the ground or in a horizontal position, in addition to the pair of thermocouples located at the point of maximum temperature, one pair each of thermocouples shall be cast at the elevation of the bottom mat and top mat of reinforcing steel vertically in line with the thermocouples cast in Section III.E.4 above. The thermocouples located at the elevation of the top and bottom mats shall have the same concrete cover as the reinforcing mats.

6. For elements such as columns and walls cast in a vertical position, in addition to the thermocouples located at the point of maximum temperature, one pair each of thermocouples shall be cast on the north face and one on the south face in line with the thermocouples cast at the centroid. These thermocouples shall be located in the same vertical plane as the reinforcing steel mats and shall have the same concrete cover as the reinforcing mats.

7. The Engineer may direct that additional thermocouples be placed if the area of maximum thermal gradient cannot be readily determined.

8. Both thermocouples from each pair shall be connected to a data logger or other recording device. The data logger shall record the temperatures at each thermocouple at least once

every hour from the time the thermocouple is covered with concrete until 3 days after the peak temperature is reached, or as directed by the Engineer. The data logger shall have a printed tape or electronic data storage capability. The Engineer may, at his sole discretion, discontinue monitoring of mass concrete elements deemed to be similar to previously monitored elements and placed under similar temperature conditions.

9. To determine concrete strength for stripping and allowable thermal gradients, the Contractor may elect to use either match-cured cylinders or a maturity curve. A separate analysis shall be required for each approved mass concrete design mix.

10. Match-cured cylinders shall be cured in ovens, water baths, or under the form insulation blankets to simulate the temperature of the coolest surface thermocouple in the pour. Sufficient number of cylinders shall be cast to allow an accurate plot of the strength development of the concrete. At a minimum, 18 pairs of cylinders shall be cast, with two cylinders each broken at the end of 1, 2, 3, 4, 5, 6, 7, 10, and 14 days. Additional cylinders may be required if it is anticipated that the concrete will not reach peak temperature until after 10 days from the pour.

11. Maturity curves shall be developed using the ASTM C1074 procedures for the “equivalent age” method.

12. The forms may be stripped when the concrete strength is high enough (as determined by the maturity curves or match-cast cylinders) to withstand the anticipated thermal gradient between the core temperature and the 48-hour average air temperature, or as directed by the Engineer. In no event will form stripping be allowed before the surface concrete reaches at least 80 percent of its design strength. After form striping, concrete shall be protected from freezing temperatures for 48 hours by the use of insulating blankets or other methods approved by the Engineer.

F. Remedial Measures:

If temperature differentials are exceeded and cracking occurs or if other damage is evident, the Contractor shall core or otherwise test the concrete elements as directed by the Engineer to determine the extent of damage.

The Contractor shall submit a proposed remediation plan for the approval of the Engineer. The Engineer may, at its sole discretion, direct that all or a portion of the damaged or unacceptable concrete be removed and replaced without additional compensation.

All cracks widths over 0.012 inch shall be epoxy injected. Epoxy bonding compounds shall be clear and the type shall be in accordance with Section 243 of the Specifications. All ports and mastic compound shall be removed from portions of the structure that will remain visible when construction is complete.

All remedial work, including coring and crack sealing required shall be incidental to the unit bid price for Concrete (Class).

IV. MEASUREMENT AND PAYMENT

Measurement and payment shall be in accordance with Section 404 of the Specifications. All work in this Special Provision required for installing the massive concrete bridge components as specified shall be considered incidental to the work required in Section 404 of the Specifications and will not be measured separately.