
SECTION 18 - CAST IN PLACE HIGH PERFORMANCE CONCRETE (HPC)

1.0 DESCRIPTION

This section details the requirements for materials and methods in the proportioning, mixing, transporting, placing, finishing and inspection of Cast in Place High Performance Concrete (HPC).

2.0 REFERENCES

All reference standards shall be current issue or latest revision at the first date of tender advertisement. This specification refers to the following standards, specifications, or publications:

- Division 5 Section 7, Cast in Place Concrete
- Alberta Transportation Technical Standards Branch – B388 – Specification for Concrete Sealers
- ASTM C309 – Liquid Membrane-Forming Compounds for Curing Concrete

3.0 SUBMISSIONS AND DESIGN REQUIREMENTS

Submission and design requirements shall be governed by the provisions found in Division 5 Section 7 of the Standard Specification, except that additional requirements as specified herein shall apply.

At tender closing the Contractor shall advise the Department of the qualified Concrete Supplier, sources of fine and coarse aggregate, cement, fly ash, and admixtures proposed for the project. The Contractor shall not be permitted to change the concrete supplier, Portland cement source, supplementary cementing materials source(s), admixture supplier(s) or alter mixture proportions without submitting written request to the Department and receiving written approval from the Engineer.

3.1 Mixture Proportions/Test Requirements. Mixture proportions shall be selected based on a 75-year design life and all concrete in the structure shall have a minimum compressive strength of 35 MPa in 28 days, unless otherwise specified. The Contractor shall provide testing conforming to the requirements of Division 5 Section 7, at least two weeks in advance of concrete placement, on the concrete mixture design proposed.

In the event the Contractor selects a Concrete Supplier not qualified in advance by the Department, the Contractor shall, no later than four (4) weeks prior to starting the concrete work, submit to the Engineer testing conforming to the requirements of Division 5 Section 7 on the concrete mixture design proposed.

4.0 MATERIALS

4.1 Aggregates. The fine and coarse aggregates shall be normal density and conform to the requirements of CSA A23.1:19 Section 4.2.3, except as modified herein. Upon acceptance of the aggregates, the source and method of manufacture shall not be altered for the duration of the contract. Aggregates shall be stored and maintained in such a manner to avoid the inclusion of foreign materials in the concrete and such that no equipment will be operated on the storage piles. The stockpiles shall be constructed to prevent segregation or contamination. The ready-mix concrete supplier shall have sufficient quantity of aggregates to complete the entire concrete section scheduled for that day at the place of production prior to the start of any concrete placement.

All aggregates shall be non-reactive with respect to Alkali Aggregate Reactivity (AAR). When tested in accordance with CSA A23.2-14A:19, the expansion of the test samples incorporating the aggregate source shall not exceed 0.04 percent at one year. In the absence of current test data developed using the test method of CSA A23.2-14A:19, existing aggregate sources having a satisfactory history of conformance and expansions not exceeding 0.150 percent at 14 days when tested in accordance with CSA A23.2-25A:19 shall be acceptable provided proof is also provided showing that testing is concurrently underway on the aggregate using CSA A23.2-14A:19.

A satisfactory history of non-reactive AAR conformance shall consist of at least five (5) consecutive passing tests performed in accordance with CSA A23.2-14A:19 over a period not to exceed ten (10) years and not less than five (5) years. An unsatisfactory history shall be established when a concurrent CSA A23.2-14A:19 presents unsatisfactory results or fails to complete testing within one (1) year of original CSA A23.2-25A:19 result submission.

Fine aggregate shall be washed and classified to conform to the gradation limits specified in Table 10 of CSA Standard A23.1, and not more than 45% of the fine aggregate shall pass any sieve and be retained in the next consecutive sieve. As per CSA A23.1:19 Clause 4.2.3.3.2.1, individual sands that are combined to meet the requirements of CSA A23.1:19 Table 10 do not need to individually meet the requirements of CSA A23.1:19 Table 10 provided that the final blend meets the requirements

Coarse aggregates shall consist of washed crushed stone and shall meet the grading limits specified in CSA A23.1:19 Table 11. The maximum combination of flat, elongated, and flat and elongated particles, as defined in CSA A23.2:19-13A, shall not exceed 20% of the mass as per CSA A23.1:19 Table 12.

4.2 Water/Admixtures. Water used in concrete production and curing shall conform to CSA A23.1:19 Section 4.2.2 and be clean and free from oil, acid, alkali soluble chlorides, organic matter, sediment or any deleterious substances.

As per CSA A23.1:19 Section 4.2.4, air entraining admixtures shall meet the requirements of ASTM C260. Other chemical admixtures shall meet the requirements of ASTM C494. Admixtures shall be stored above freezing temperatures at all times and in accordance with the manufacturer's recommendations. Calcium chloride or any admixtures containing chlorides shall not be used.

4.3 Cementing Materials. Portland cement, Portland limestone cement, blended cements, and supplementary cementing materials shall meet the respective requirements of CSA Standard A3001 and shall be specified by one or more of the types described in CSA A23.1:19 Table 6, 7, and/or 8.

4.4 Concrete Mixture Design and Properties. All mixture designs shall be proportioned as normal density concrete in accordance with CSA Standard A23.1, Alternative #1, and the Contractor shall accept responsibility for the concrete mixture and its properties. Concrete may be proportioned using a suitable combination of the following: Portland cement, fine and coarse aggregates, air entraining, water reducing, superplasticizing, and/or set retarding admixtures. Other supplementary cementing materials may include Class F fly ash, Type SF silica fume, and/or Type S ground granulated blast furnace slag. Set retarding admixtures may be used as ambient and site conditions warrant.

Concrete mixtures shall be designed to meet the following:

- Exposure Class appropriate to the exposure conditions as defined in CSA A23.1:19 Table 1.
- Max. water to cementing materials ratio to meet the requirements of CSA A23.1:19 Table 2.
- Air Content in fresh concrete 6.5 +/- 1.5 % (or as per A23.1 Table 4 based on nominal size coarse aggregate).
- Slump requirements shall be established by discussion between the Contractor and concrete producer to account for the placing conditions including reinforcing steel congestion.
- Min 28-day compressive strength 35 MPa, unless otherwise specified.
- Average spacing factor and air content in hardened concrete shall meet the requirements of CSA A23.1:19 Clause 4.3.3.3.
- Chloride ion penetrability within 91 days <1500 coulombs
- Maximum concrete temperature (from delivery equipment)
 - thickness ≥ 2 meters 20 °C
 - thickness < 2 meters 25 °C
- Maximum concrete temperature (in-situ) 70 °C
- Maximum temperature gradient 20 °C/meter

Superplasticizer shall be used in all concrete.

The mass of Type SF silica fume, if used and if added as a separate component to the mixture during the batching process, shall consist of full packages of the silica fume, rounded up to the next full package as required by the batch volume.

4.5 Curing and Finishing Materials. Curing compounds shall conform to ASTM C309 Type 2. Curing and finishing materials shall conform to the requirements listed in Division 5, Section 7 of the Department's Standard Specification.

Evaporation reducer forming a monomolecular film which retards evaporation shall be "MasterKure ER50" by BASF or an approved equivalent. Equivalent products shall be submitted to the Engineer and Highway Construction Services for approval prior to use. The mixing ratio for MasterKure ER50 shall not be less than one part of evaporation reducer to four parts of water.

4.6 Concrete Sealer. Concrete sealer shall be Type 1C silane penetrating transparent sealer, as per Alberta Technical Standard B388, and approved by the Department. The Contractor shall supply product data, manufacturer's recommended installation guidelines, and safety data sheet to the Department for approval prior to use.

5.0 CONSTRUCTION

5.1 General. Concrete shall be mixed, transported, placed, protected, cured, and finished in accordance with Division 5, Section 7 except as modified herein. The depositing of concrete shall be a continuous operation until the placing of the section is completed. To ensure that the concrete is continuous and monolithic in nature, the time between previously placed concrete and newly deposited concrete shall not exceed 30 minutes. If more than 30 minutes have elapsed, it shall be considered a construction joint and shall be formed with a bulkhead or sawcut back to competent concrete once the concrete is hardened. During placements where this action is not possible and a cold joint is formed, the cold joint shall be subject to repair or the concrete impacted by the joint shall be subject to full removal and replacement, as decided by the Engineer, at the cost of the contractor.

Special measures, as detailed in CSA A23.1:19 Clause 7.2.1, shall be taken by the Contractor to protect the concrete from the effects of hot and/or drying weather conditions when the ambient temperature is at or above 27°C, or is likely to rise above 27°C during the placement period. The temperature of the formwork, reinforcing steel or the material on which the concrete is to be placed, shall not exceed 27°C and shall not be less than 5 °C.

Concrete placing methods and equipment shall be such that the concrete is conveyed and deposited at the specified slump, without segregation, and without changing or affecting the other specified qualities of the mixture. Vibrators shall be used to consolidate the concrete in all phases of construction. Insertion of internal vibrators shall be made systematically at intervals such that the zones of influence of the vibrator overlap. Additionally, the vibrator shall penetrate the upper part of the previously placed lift of the concrete by its own mass and vibration as per CSA A23.1:19 Clause 7.5.4.2. Over vibration shall not be permitted.

The deck shall be finished using a self-propelled mechanical screed machine followed by bullfloating and final texturing. Final finishing, texturing, and curing shall be completed within 5 meters behind the screed machine. A work bridge (mobile catwalk) shall be used following the screed machine for bullfloating and finishing operations. An evaporation reducer shall be used directly after initial screeding and/or between finishing operations as needed.

Decks overlaid with a wearing surface shall be textured as indicated in Division 5, Section 7 of the Standard Specification.

If concrete placement in the bridge deck is carried out with pumps or cranes, the Contractor shall always during placement be required to have available on site a minimum of two pumps or cranes or combination thereof. Concrete placement in bridge decks shall not be permitted between December 1st and March 31st unless otherwise advised by the Engineer.

The Contractor shall take appropriate measures required to minimize defects in the concrete. These measures include but are not limited to: installation of wind breaks, installation of shelters, covering, protection from premature drying, timing of placements, additional workforce and/or equipment. Upon completion of the work, the Engineer will conduct a survey to determine the extent, if any, of defects present in the structure. The method of repair for defects identified

requiring remedial action shall be dependent upon the location and extent of the defect. Defects identified may result in repair or rejection and replacement.

5.1.1 Cracks. All cracks 0.25 mm and greater in width shall be repaired within the warranty period, regardless of location, size, or cause in accordance with the following methodology: Fine cracks are defined as less than 1 mm, medium cracks were 1 to 2 mm, and wide cracks were greater than 2 mm. Fine passive cracks identified for repair shall be filled with a low viscosity epoxy resin such as Sika Canada's Sikadur 52, Sikadur LV55, or Master Builder's MasterInject 1380 or an approved equal. The resin shall be applied by pressure injection or by gravity feed into the crack and allowing the sealant to be absorbed. Additional applications may be required, depending on the absorption and crack depth. Subsequent applications, if required by the Engineer, shall be made as soon as possible after the prior application has sufficiently set. All use and placement of resin materials shall be in accordance with the manufacturer's written instructions. Wider cracks, as identified from the survey may require a higher viscosity resin for repair. Polyurethane or other appropriate flexible sealants may be required to repair larger cracks where active movement occurs. The Contractor shall submit manufacturer's data for the proposed resin in this case for approval prior to use. Excess resin in the vicinity of the crack shall require removal by grinding and/or abrasive blast cleaning at the Engineer's direction.

5.2 Curing: Decks shall be cured by fogging prior to covering with wet burlap. Fogging shall commence directly after placement and between finishing operations after initial screeding and shall continue until the concrete achieves initial set to allow for the placement of the wet burlap. Water curing may be used in lieu of fogging, however, curing shall commence immediately to prevent the occurrence of cracking or drying of the surface. Burlap shall be pre-soaked by immersing in water for a period of 24 hours prior to placing. Two layers of burlap shall be applied to the surface overlapping each strip by 150 mm. Burlap shall be maintained in a continuously wet condition for seven consecutive days. Burlap shall be covered with a layer of moisture vapour barrier immediately following the placement of the burlap. Water shall not drip, flow, or puddle on the surface during fog misting, when placing burlap, or at any time before the concrete has reached final set.

In accordance with CSA A23.1:19 Table 19, the deck shall be maintained continuously wet for a period of not less than 7 days and for the time necessary to attain 70% of the specified strength. If work is conducted on other sections of the structure before the 7-day curing period is completed, the contractor must ensure that the deck is maintained wet at all times during this work and only exposed for the shortest duration necessary to complete the work in that area. Only the area required to complete the work shall be exposed.

All other sections of the structure may be cured with two (2) applications of curing compound (water based), applied within 20 minutes of initial screeding. Each application shall be applied at twice the manufacturer's suggested rate with the second application applied perpendicular to the first, with the second application being placed 1-2 hours after the first application.

Where bonding is critical between finished surfaces, concrete sections shall be moist cured only as described above for the deck.

If formwork is used to aid curing, it shall not be removed until seven days after the concrete placement. In addition to the forms, areas exposed shall be cured in accordance with Division 5, Section 7.

5.3 Concrete Sealer. The Contractor shall apply two (2) coats of a silane penetrating sealer to all exposed concrete surfaces on the bridge, excluding the bridge deck driving surface, soffit, approach slabs, prestressed girders (if applicable), and surfaces covered with a waterproofing membrane or an asphalt concrete pavement wearing surface. Sealer shall be applied to all vertical surfaces to a depth of 600 mm below proposed finish grade.

The sealer shall be applied in accordance with the manufacturer's written instructions, however, a minimum of two coats shall be applied and the second coat shall be perpendicular to the first coat. As a minimum, surface preparation shall consist of high pressure (minimum 20 MPa (3,000 psi)) water or abrasive blast cleaning to provide a uniform texture and appearance removing curing compounds, dirt, oil, grease, tar, and other deposits which may affect the absorption of the sealer. Prior to the application of the sealer, concrete shall be moist cured for a period of 7 days prior to air drying for an additional 14 days.

6.0 QUALITY ASSURANCE

Concrete shall be inspected, tested, and reported as per Division 5, Section 7 except as modified herein. The Department or its representative shall have the right to sample and test all materials used in the concrete mixture design and shall be given access to the production facilities of the Concrete Supplier as described in Division 5, Section 7. Materials failing to meet this specification shall be immediately rejected.

Concrete shall be tested for slump, air content, and temperature prior to and after the addition of superplasticizer (if added on site). Testing shall be carried out at the point of discharge from the truck and as close as possible to final deposit into the forms. The results obtained from testing as close as possible to final deposit into the formwork will be used for the purpose of acceptance and rejection. Sufficient superplasticizer shall be added to produce a consistency as indicated in Section 4 of this specification. Superplasticizer, added on site, shall be mixed into the load a minimum of five minutes prior to retesting.

No water shall be added after the initial introduction of the mixing water for the mix, except at the start of discharge only when:

- the measured slump is less than specified, and
- no more than 60 minutes have elapsed after water and cement have been combined, and
- the concrete is in a stationary or truck mixer, and
- does not exceed the batch mix design stated water to cementing materials ratio, and
- the Engineer, or Engineer's representative, is made aware prior to the addition.

When water is added to the mix, it shall comply with CSA A23.1:19 Section 5.2.5.3.2 and this specification.

7.0 METHOD OF MEASUREMENT

7.1 General. Measurement shall be made at the contract unit price per cubic meter for HPC. The quantity of concrete for payment shall be the volume in cubic meters computed from the dimensions shown on the drawings or as revised by the Engineer. No deductions shall be made for the volume of concrete displaced by steel reinforcement, joint material, structural shapes, chamfers, tops of piles, or cylindrical voids of 110 mm diameter or less.

8.0 BASIS OF PAYMENT

8.1 General. Payment will be made at the contract unit price bid per cubic meter for HPC or price adjusted as described below. The payment for HPC shall be considered full compensation for the cost of furnishing all materials, aggregates, cement, supplementary cementing materials, water, admixtures, including superplasticizers, and other materials, non-metallic expansion joint materials, tools, equipment, falsework, forms, bracing, labour, curing, surface finish, damp-proofing and all other items of expense required to complete the concrete work as shown on the plans, and as outlined in the specifications.

All costs associated with crack repair, or removal and replacement including additional testing, inspection, and/or reporting, as the result of the presence of defects, shall be borne by the Contractor.

8.1.1 Unit Price Adjustments (Penalty/Bonus). The penalty or bonus adjustment will apply to the calculated quantity of cubic meters of concrete incorporated into the work and accepted by the Engineer. The total adjustment added to or subtracted from payments due to the Contractor shall be the algebraic sum of all penalties and bonuses calculated for all the sub-lots (as described in Division 5, Section 7) in excess of 2 m³. Penalty/Bonus adjustment shall not apply if the sub-lot is less than 2 m³.

8.1.2 Penalty Adjustment for Compressive Strength. Penalty adjustment for Compressive Strength will be conducted according to the requirements listed in Division 5, Section 7 of the Department's standard specification.

8.1.3 Price Adjustment for Resistance to Chloride Ion Penetrability. Penalty adjustment for Resistance to Chloride Ion Penetrability will be conducted according to the requirements listed in Division 5, Section 7 of the Department's standard specification.

8.1.4 Air Void Parameters of the Hardened Concrete Price Adjustment. Penalty adjustment for Air Void Parameters of the Hardened Concrete will be conducted according to the requirements listed in Division 5, Section 7 of the Department's standard specification.

8.1.5 Appeals. Appeal criteria and procedures for the tests listed in this section shall be as defined in Division 5, Section 7 of the Department's Standard Specification.

8.2 Payment for Cold and Hot Weather Concreting. If additional costs are required to meet the cold and hot weather concrete practice requirements outlined in this specification, those costs must be included in the submitted unit price. No additional payment will be made from the Department outside of what is originally agreed upon.

8.3 Payment for Concrete Sealer. Payment for Concrete Sealer will be made at the contract lump sum price, which shall be full compensation for surface preparation, high pressure water and/or abrasive blast cleaning, installation, including labour, tools, equipment and incidentals necessary to complete the work to the satisfaction of the Engineer.

9.0 WARRANTY