Specification For Concrete For Bridge Work - 6300

1 GENERAL

1.1 Description

1.1.1 The Work shall consist of the developing a mix design, supply, placement, finishing, curing, quality management and testing of portland cement concrete at the locations and to the dimensions shown on the Plans. Concrete shall consist of cementitious materials, water, fine aggregate, coarse aggregate, and admixtures, and shall be proportioned, mixed, placed, finished and cured in accordance with this specification.

1.2 Applicable Standards

1.2.1 The following standards shall apply unless otherwise stated for in this Specification:

1.2.1.1 CSA Standard A23.1 Concrete Materials and Methods of Concrete Construction.

1.2.1.2 CSA Standard A23.2 Methods of Test for Concrete

1.2.1.3 CAN/CSA-A3000 Cementitious Materials Compendium.

1.2.1.4 CSA-S269.1 Falsework and Formwork.

1.2.1.5 CSA Standard A283 Qualification Code for Concrete Testing Laboratories.

1.2.1.6 ASTM Standards as noted in this specification.

1.2.1.7 ACI Manual of Concrete Practice.

2 MATERIALS

2.1 General

2.1.1 All materials shall be supplied by the Contractor.

2.2 Hydraulic Portland Cement and Supplementary Cementous Materials

2.2.1 The Contractor shall obtain a mill test report and a manufacturer's certificate of compliance from the Supplier for each delivered shipment of each type of cementitious material. The mill test reports shall be provided to the Ministry a minimum of two weeks before any concrete is placed. Hydraulic cement material test reports shall be in accordance with CSA A3000-18.

Hydraulic Portland-limestone cement material tests shall include the proportion and reference standard limit of limestone, limestone calcium carbonate ($CaCO_3$), methylene blue values, and total equivalent alkali (Na_2O).

Sulphate resistance expansion testing shall be completed by an independent laboratory certified to CSA A283. Sulphate resistance expansion test reporting for Type HS and Type HSL hydraulic cement shall be to three decimal places and include the date of testing, age of test specimen at time of testing, and reference testing standard.

2.2.2 General use hydraulic Portland cement shall conform to the requirements of CSA-A3000-18, Type GU.

2.2.3 General use hydraulic Portland-limestone cement shall conform to the requirements of CSA-3001-18, Type GUL. The proportion of limestone shall not exceed 15%.

2.2.4 High sulphate-resistant hydraulic Portland cement shall conform to the requirements of CSA-A3000-18, Type HS.

2.2.5 High sulphate-resistant hydraulic Portland-limestone cement shall conform the requirements of CSA-3001-18, Type HSL. The proportion of limestone shall not exceed 15%.

2.2.5.1 The sulphate resistance expansion of hydraulic Portland-limestone cement Type HSL shall be a maximum of 0.045% at 6 months or a maximum of 0.100% at 12 months measured in accordance with CSA A3004-18-C8. Sulphate resistance test results measured in accordance with CSA A3004-18-C6 will not be considered.

2.2.6 The total alkali content of hydraulic Portland cement and hydraulic Portland-limestone cement expressed as sodium oxide (Na2O) equivalent shall be 0.60% or less.

2.2.7 Blended hydraulic Portland cement or hydraulic Portland-limestone cement shall not be used without the approval of the Ministry.

2.2.8 Silica fume shall conform to the requirements of CSA-A3001-18, Type SF.

2.2.9 Metakaolin shall conform to the requirements of CSA-A3001-18, Type N and the following:

2.2.9.1	Minimum total SiO2 plus Al2O3 plus Fe2O3 content	70%
2.2.9.2	Maximum moisture content	3%

2.2.10 Fly ash shall conform to the requirements of CSA-A3001-18, Type F and the following:

2.2.10.1	Minimum total SiO_2 plus Al_2O_3 plus Fe_2O_3 content	70%
2.2.10.2	Maximum total Na_2O equivalent	4%

2.2.10.3 If approved by the Ministry, Fly ash with a Na_2O total equivalent greater than 4% may be used provided the concrete mix design can be demonstrated to be effective in mitigating the effects of alkali aggregate reactivity in accordance with CSA Standard A23.2-27A. Expansion of concrete test prisms shall be less than 0.04% after two years in accordance with CSA Standard 23.2-14A. Maximum fly ash content shall be limited to 25% of total cementitious content, except for Type DC concrete, the maximum fly ash content is 15%.

2.2.10.4 Type CH and Type CI fly ash shall not be used.

2.2.11 Slag shall conform to the requirements of CSA A3001 and the following:

2.2.11.1	Maximum total Na_2O equivalent	1%

2.3 Water

2.3.1 Water for use in concrete and for curing shall conform to the requirements of CSA Standard A23.1 and shall be clear and free from injurious amounts of oil, acid, alkali, organic matter, sediment, or any other deleterious substance.

2.3.2 Test results from an independent CSA certified testing laboratory shall be submitted to the Ministry at least two weeks before any concrete is placed.

2.4 Admixtures

2.4.1 Admixtures shall not be incorporated into the mix design and/or added to the concrete without the approval of the Ministry. All admixtures prescribed by the Ministry, Special Provisions, or Plans shall be supplied by the Contractor.

2.4.2 Admixtures requested by the Contractor to aid in the execution of the work require approval of the Ministry, and shall be supplied and added to the concrete at no direct cost to the Ministry.

2.4.3 All approved admixtures shall be compatible with all other admixtures and constituents used in the mix.

2.4.4 Air-entraining admixture shall conform to the requirements of ASTM Specification C260/C260M.

2.4.5 Water- reducing admixture shall conform to the requirements of ASTM Specification C494/C494M.

2.4.6 Superplasticizing admixture shall conform to the requirements of ASTM Specification C494 Type A and Type F and ASTM Specification C1017/C1017M Type I.

2.4.7 Antiwashout admixture shall conform to the requirements of ASTM Specification C494/C494M Type S.

2.4.8 Hydration Stabilizing Admixtures (HSA's) shall conform to the requirements of ASTM Specification C494/C494M Type B, retarding or Type D, water-reducing and retarding.

2.4.9 Calcium chloride or any admixture containing chloride ions shall not be used. If requested, a written statement from the manufacturer stating that the

admixture contains no intentionally added calcium chloride shall be provided to the Ministry.

2.5 Fine Aggregate

2.5.1 Sampling of fine aggregate shall conform to the requirements of CSA Standard A23.2, Test Method A23.2-1A.

2.5.2 Gradation of the fine aggregate as determined by CSA Standard A23.2, Test Method A23.2-2A shall be within the limits set forth in Table 6300.2.T1.

2.5.3 Not more than 45 percent by mass shall be retained between any two consecutive sieves.

2.5.4 Fineness modulus shall be between 2.3 and 3.1.

2.5.5 The fineness modulus shall not vary by more than ±0.2 from the fineness modulus of the initially approved fine aggregate used in the design mix.

TABLE 6300.2.T1

FINE AGGREGATE SEIVE

Sieve Size	Total Passing Sieve Percentage by Mass
10 mm	100
5 mm	95 – 100
2.5 mm	80 - 100
1.25 mm	50 – 90
630 µm	25 – 65
315 µm	5 – 35

160 µm	0 - 10

2.5.6 The amounts of deleterious substances and the physical properties as determined in accordance with the listed CSA Standard A23.2 test methods shall not exceed the limits set forth in Table 6300.2.T2.

2.5.7 Fine aggregate shall have a sand equivalent of greater than 80 percent as determined in accordance with the requirements of STP 206-5, Test for Sand Equivalent.

TABLE 6300.2.T2

FINE AGGREGATE PROPERTIES

CSA Standard A23.2 Test Method	Substance or Property	Maximum Percentage by Mass of Total Sample
A23.2-3A	Clay Lumps	0.5
A23.2-4A	Low density material	0.5
A23.2-5A	Material finer than 80 µm	3.0
A23.2-9A	Magnesium sulphate soundness loss	16
A23.2-23A	Micro-Deval abrasion loss	20

2.5.8 Fine aggregate shall conform to the requirements of CSA Standard A23.1, Section 4.2.3.3.3 for organic impurities.

2.5.9 Fine aggregate tested in accordance with the requirements of CSA Standard A23.2, Test Method A23.2-7A shall not produce a colour darker than standard colour No. 3.

2.5.10 The Contractor shall submit the results of a petrographic examination done in accordance with CSA Standard A23.2, Test Method A23.2-15A and certified by a Professional Engineer registered in the Province of Saskatchewan indicating the fine aggregate's suitability for its intended use.

2.5.11 Fine aggregate shall be assessed for alkali-aggregate reactivity in accordance with CSA Standard A23.2, Test Method A23.2-27A. The Contractor shall implement measures to avoid deleterious expansion of aggregates determined to be moderately reactive or highly reactive. Aggregates that are determined to be extremely reactive shall not be used.

2.6 Coarse Aggregate

2.6.1 Coarse aggregate shall consist of hard, durable, uncoated particles of crushed stone or gravel.

2.6.2 Sampling of coarse aggregate shall conform to the requirements of CSA Standard A23.2, Test Method A23.2-1A.

2.6.3 The maximum size of coarse aggregate for concrete shall be 40 mm.

2.6.4 Gradation of the coarse aggregate as determined by CSA Standard A23.2, Test Method A23.2-2A shall be within the limits set forth in Table 6300.2.T3.

2.6.5 The gradation of coarse aggregates shall be such that the percentage by mass passing any one sieve does not vary by more than 5% from the initially approved coarse aggregate used in the design mix.

TABLE 6300.2.T3

COARSE AGGREGATE SIEVE

Nominal Size of Aggregate mm	Total Passing Each Sieve, Percentage by Mass						
	40 mm	28 mm	20 mm	14 mm	10 mm	5 mm	2.5 mm
28-5	100	95-100	-	30-65	-	0-10	0-5
20-5	-	100	85-100	50-90	25-60	0-10	0-5
14-5	-	-	100	90-100	45-75	0-10	0-5

2.6.6 To prevent segregation, individual sized aggregates combined to make up the gradation for 28-5 nominal size aggregate shall be stockpiled and batched in two or more separate sizes as required by CSA Standard A23.1, Table 11.

2.6.7 The amounts of deleterious substances and the physical properties as determined in accordance with the listed CSA Standard A23.2 test methods shall not exceed the limits set forth in Table 6300.2.T4.

TABLE 6300.2.T4

COARSE AGGREGATE PROPERTIES

CSA Standard A23.2 Test Method	Substance or Property	Maximum Percentage by Mass of Total Sample
A23.2-3A	Clay Lumps	0.25
A23.2-4A	Low density material	0.5
A23.2-5A	Material finer than 80 µm	1.0
A23.2-13A	Flat and Elongated Particles (Procedure A, ratios 4:1)	20
A23.2-9A	Magnesium sulphate soundness loss	12
A23.2-16A	Los Angeles abrasion loss	Type DC Concrete 35 Other Concrete Types 50
A23.2-29A	Micro-Deval abrasion loss	17
A23.2-12A	Absorption	1.75
A23.2-24A	Freeze-thaw loss	6

2.6.8 The Contractor shall submit the results of a petrographic examination done in accordance with CSA Standard A23.2, Test Method A23.2-15A and certified by a Professional Engineer registered in the Province of Saskatchewan indicating the coarse aggregate's suitability for its intended use.

2.6.9 The maximum Petrographic Number (PN) for coarse aggregate as determined in accordance with CSA Standard A23.2, Test Method A23.2-15A shall not exceed 125.

2.6.10 Coarse aggregate shall be assessed for alkali-aggregate reactivity in accordance with CSA Standard A23.2, Test Method A23.2-27A. The Contractor shall implement measures to avoid deleterious expansion of aggregates determined to be moderately reactive or highly reactive. Aggregates that are determined to be extremely reactive shall not be used.

2.7 Testing of Aggregates

2.7.1 The Contractor shall engage the services of an independent CSA certified laboratory for testing of the fine and coarse aggregates to establish conformance to these specifications. The results of these tests shall be provided to the Ministry a minimum of two weeks prior to any concrete being placed. The Ministry at its discretion may undertake confirmation testing on this aggregate, and may reject concrete made from substandard aggregate.

2.7.2 The potential for deleterious alkali-aggregate reactivity and the measures to avoid deleterious expansion in concrete shall be assessed in accordance with CSA A23.2-27A. Test data less than 24 months after date of sampling shall be used to evaluate the potential alkali-silica reactivity of aggregates tested in accordance with CSA A23.2-14A or CSA A23.2-25A. Testing in accordance with CSA A23.2-28A to demonstrate the effectiveness of supplementary cementitious materials may be utilized as part of the alkali-aggregate reactivity assessment. In the absence of test data, the aggregate shall be presumed to be highly reactive. The level of risk for alkali-aggregate reactivity assessment shall be for concrete exposed to humid air and the design service life shall be greater than or equal to 75 years (St4).

2.7.3 When assessing alkali-aggregate reactivity mitigation in accordance with CSA A23.2-27A, Type F fly ash with a maximum CaO content of 15% shall be used. Expansion limits for aggregate testing in accordance with CSA A23.2-14A shall only apply for concrete supplied with hydraulic Portland cement. Aggregates for concrete supplied with hydraulic Portland-limestone cement shall be considered highly reactive.

2.8 Steel Fibers

2.8.1 Steel fibres shall conform to the requirements of ASTM Specification A820, Type 1, Cold Drawn High Tensile Deformed Steel Fibres.

2.8.2 The Contractor shall obtain a mill certificate from the supplier showing compliance with ASTM Specification A820 for each delivered lot. The mill

test reports shall be provided to the Ministry a minimum of two weeks prior to placing of concrete.

2.8.3 Steel fibres shall be one of the products listed in the Ministry's BM200 Bridge Materials Specifications.

2.9 Concrete Accessories

2.9.1 All concrete accessories shall be compatible with any sealers or waterproofing membrane used.

2.9.2 Liquid membrane-forming curing compound shall conform to the requirements of ASTM Specification C309.

2.9.3 Evaporation retardant shall be a monomolecular film forming compound intended for application to fresh concrete for temporary protection against moisture loss. The product data sheet shall be submitted to the Ministry for approval a minimum of 2 weeks prior to planned use. Evaporation retardant shall not be used as a finishing aid.

2.10 Crack Repair

2.10.1 The following are approved materials for crack repair:

2.10.1.1 Modified Methacrylate (MMA) or High Molecular Weight Methacrylate (HMWMA) shall be one of the products listed in the Ministry's BM100 Approved Products List.

2.10.1.2 Low viscosity (100 cps or less) epoxy resin penetrating sealer shall be one of the products listed in the Ministry's BM100 Approved Products List.

3 CONSTRUCTION

3.1 Storage and Handling of Materials

3.1.1 General

3.1.1.1 The storage and handling of all materials used in the production of concrete shall conform to CSA Standard A23.1, unless otherwise specified herein.

3.1.1.2 All materials shall be stored and handled in a manner that will prevent contamination or deterioration, otherwise they will be rejected.

3.1.1.3 Access shall be provided to the storage facilities to allow for inspection and sampling.

3.1.1.4 Where applicable, materials shall be identified by SDS sheets.

3.1.2 Aggregates

3.1.2.1 Each nominal size of aggregate, including coarse and fine shall be separately stockpiled, stored and handled in a manner that will prevent contamination, intermixing and segregation. A minimum of 10 m^3 of each aggregate size, in excess of the requirements of the daily concrete operations, shall be maintained in identifiable stockpiles at the batch site in order to ensure proper continuity of the work with approved aggregates.

3.1.2.1.1 Stockpiled aggregate, which is segregated, contaminated or intermixed with foreign matter of any kind, will be rejected.

3.1.2.2 Separate batch plant storage bins shall be provided for each size of aggregate to be batched.

3.1.2.3 Precautions shall be taken when moving, handling and transferring aggregates to prevent contamination, segregation or degradation in accordance with the following recommendations:

- A 150 mm thick layer of aggregate shall be left undisturbed on the ground as stockpiles are depleted.
- Aggregate transfer over stockpiles or storage bins of other sized aggregates shall be avoided unless otherwise approved by the Engineer.
- Storage bins should be filled only to 150 mm from the top unless a suitable extension rim is provided to prevent contamination.

- Front-end loader buckets should be filled by raising them vertically up the face of the stockpile not by thrusting into the stockpile in one place.
- Depositing aggregates into the batch plant storage bins should be made directly over the bins outlet.
- Storage bins should be kept as full as possible during batching to minimize segregation as the aggregates are withdrawn from the bins.
- Acceptable and uniform aggregate moisture content shall be obtained and maintained by necessary means to include the following:
    - Washed or wetted aggregates shall remain in stockpiles for a minimum of 12 hours to permit a uniform moisture content throughout the stockpile to be reached before aggregate transfer to batch plant storage bins.
    - After each day's concrete production during wet weather, fine aggregate bins shall be either emptied or covered with a suitable waterproof covering as approved by the Engineer.

3.1.3 Cementous Materials

3.1.3.1 All cementitious materials shall be stored in a suitable weather-tight structure capable of protecting the materials from dampness, hydration and contamination, otherwise they will be rejected.

3.1.3.2 Materials shall be free of lumps at all times during their use in the work and shall have a maximum temperature of 50°C.

3.1.4 Tanks

3.1.4.1 Tanks used for storing and/or hauling, concrete mixing and curing water shall be free from contamination by oil, acid, alkali, organic matter, sediment, rust or other deleterious substances.

3.1.5 Admixtures

3.1.5.1 All admixtures shall be stored in manufacturers' original labeled containers with clearly legible labels and be kept above freezing at all times and in accordance with the manufacturers' technical data sheets.

3.1.5.2 Admixtures damaged by any cause will be rejected.

3.1.6 Other Materials

3.1.6.1 Other materials, such as steel fibres, etc. shall be stored and handled in accordance with the manufacturer's recommendations and instructions.

3.2 Proportioning of Materials for Concrete Mixes

3.2.1 All mix designs shall use the "Absolute-Volume Method" for mix proportioning.

3.2.2 All concrete shall contain an air entraining admixture and a water-reducing admixture.

3.2.3 Concrete Type for each bridge element location shall be as shown in Table 6300.3.T5 unless noted otherwise in the Special Provisions or on the Plans.

3.2.4 Concrete mixes shall be proportioned by the Contractor such that they provide the properties listed in Table 6300.3.T5 and meet the following requirements:

3.2.4.1 Type DC Concrete:

- The maximum amount of aggregate passing the 5 mm sieve shall be 35% of the total mass of aggregate.
- Minimum portland cement content shall be 360 kg/m$^{3.}$
- The mix shall contain 6% -8% silica fume by mass of total cementitious materials or in lieu of silica fume 12% - 16% metakaolin by mass of total cementitious materials shall be used.
- Fly ash conforming to 6300.2.2.10 may be incorporated into the mix to a maximum of 15% by mass of total cementitious

materials. Fly ash shall not be used to reduce the minimum cement content.

- Slag conforming to 6300.3.2.11 may be incorporated into the mix to a maximum of 15% by mass of total cementitious materials. Slag shall not be used to reduce the minimum cement content. Slag based aggregates shall not be incorporated into the mix.

- The total of all supplementary cementitious material shall not exceed 20% by mass of total cementitious materials.

- The mix shall contain a superplasticizing admixture.

- Slump shall be 50 mm ± 20 mm prior to the addition of the superplasticizing admixture and 100 mm ± 20 mm after the addition of the superplasticizing admixture.

- Slump retention in superplasticized concrete shall be 75% after 45 minutes.

- Minimum entrained air content retention shall be 70% of initially measured entrained air content after one hour of mixing.

- Average Rapid Chloride Permeability as determined in accordance with ASTM Specification C1202 shall not exceed 1250 coulombs with no tests exceeding 1500 coulombs at 56 days.

- The hardened concrete air void system shall have an average Air Void Spacing factor of 230 µm with no individual test greater than 260 µm as determined in accordance with ASTM Specification C457/457M.

- Salt scaling potential shall be less than 0.4 kg/m^2 surface mass loss after 30 cycles of freezing and thawing as determined in accordance with
ASTM Specification C672.

    - The test surface shall be the unfinished/formed bottom face of the test specimen.

- When steel fibres are used, the concrete mix shall contain 50 kg of 30 mm or 50 mm length fibres per cubic metre. The Contractor shall submit test results of the aluminum content in the steel fibres to the Ministry for review and acceptance, a minimum of 2 weeks prior to placing concrete at site. When alternative steel fibres are proposed their equivalency and dosage rate shall be determined in accordance with ASTM C1609/C1609M. The toughness (T^{D}_{600}) shall be greater than or equal to that determined for the specified fibre type and dosage rate.

3.2.4.2 Type C, Type C1, Type P1 and Type P2 Concrete

- Minimum portland cement content shall be 360 kg/m^3.
- Fly ash conforming to 6300.2.2.10 may be incorporated into the mix to a maximum of 25% by mass of total cementitious materials. Fly ash shall not be used to reduce the minimum cement content. Type CH and Type CI fly ash shall not be used.
- Slag conforming to 6300.3.2.11 may be incorporated into the mix to a maximum of 25% by mass of total cementitious materials. Slag shall not be used to reduce the minimum cement content. Slag based aggregates shall not be incorporated into the mix.
- Superplasticizing admixture shall not be used unless approved by the Ministry. If approved for use the slump after addition of superplasticizing admixture shall be 100 mm ± 20 mm.

3.2.4.3 Type G1 Concrete

- Minimum Portland cement content shall be 360 kg/m^3.
- The mix shall contain 6% -8% silica fume by mass of total cementitious materials or in lieu of silica fume 12% - 16% metakaolin by mass of total cementitious materials shall be used.
- Fly ash or slag shall not be used.
- Superplasticizing admixture shall not be used unless approved by the Ministry.

3.2.4.4 Sulphate Testing

- For each class of concrete supplied with Type HSL containing hydraulic Portland-limestone cement, a sulphate resistance test shall be completed in accordance with CSA A3004-18-C8 using the combined cementitious materials of the reviewed and accepted concrete mix design. Sampling of the combined cementitious materials shall be at the source of concrete production (batch plant) as determined by the Consultant. Sulphate resistance expansion testing shall be completed by an independent laboratory certified to CSA A283.

TABLE 6300.3.T5

CONCRETE MIXES

Concrete Type	Location	Minimum Compresive Strength at 28 Days (MPa)	Maximum Nominal Size of Coarse Aggregate (mm)	Entrained Air Content (%)	Slump (mm) [1]	Maximum W/Cm Ration by Mass
Type DC	Deck Concrete: Abutment Slab, Approach Slab, Bridge Barriers, Bridge Curbs, Bridge Sidewalks, Bridge Medians, Precast Deck Panels	45	28-5	5 – 8	50 ± 20	0.38
Type C	**Cast-in-Place Concrete**: Beams, Stringers, Girders **Substructure Concrete:** Piers, Abutments, Retaining Walls, Precast Pile Caps, Precast Wall Panels	35	28-5	5 – 8	70 ± 20	0.40
Type C1	**Concrete Slope Protection**	30	20-5	5 – 8	50 ± 20	0.45
Type P1	**Pipe Pile Infill Concrete**	25	28-5	5 - 8	70 ± 20	0.4
Type P2	**Cast-in-Place Concrete Piling**	30	28-5	5 - 8	70 ± 20	0.40
Type G1	**Keyways between Box Stringers**	45	14-5	5 - 8	20 ± 10	0.38

Notes:

1. Prior to adding superplasticizer

3.3 Mix Design Submittals

3.3.1 The Contractor shall submit a report outlining the proposed mix design for each type of concrete to the Ministry for review and approval at least 2 weeks in advance of when concrete production is scheduled to commence.

3.3.2 Approval of the concrete will be based on the test results and the performance and quality of the concrete and concrete components placed on the project.

3.3.3 Delays to the Contract associated with revising and resubmitting the mix design shall be at the Contractor's expense.

3.3.4 No concrete shall be placed prior to receiving Ministry approval of the mix design.

3.3.5 Each mix design submittal shall include all of the following:

3.3.5.1 Project Specifics

- Name and location of the proposed supplier.
- Distance and expected travel time from batch plant location to the Project Site.
- Expected method of batching, transporting and placing concrete.
- Specified mix parameter requirements as listed or referenced in the Special Provisions or on the Plans.
- Name and contact information of certified quality control testing laboratory and certified testing personnel. Certification shall be in accordance with the requirements of CSA Standard A23.1.

3.3.5.2 Materials - All materials shall comply with the requirements as listed in Specification 6300.2.

- Cementitious Materials – Types and source of each material including mill test reports and manufacturer's certificates of compliance.

- Aggregates – Type and source of all individual aggregate produced for each type of concrete mix including individual gradations and all other aggregate quality testing as described in Table 6300.4.T8 for each type of aggregate and each aggregate source.

- Admixtures – Type and source of all admixtures, including expected dosage rates, point of addition to the mix, compatibility documentation, and individual technical data sheets.

- Water – The source of mixing water. (depending on the source, the Ministry may request additional test documentation).

- Miscellaneous – Documentation for all other materials proposed for the mix, showing conformance with applicable Ministry requirements and manufacturer/industry guidelines and standards.

3.3.5.3 Proportioning

- The concrete proportions expressed in terms of quantity of each component.

- Fresh and hardened concrete properties.

- The mass of materials in kilograms (kg) and the absolute volume in cubic metre (m^3) contributed by each material in the mixture.

- The quantity of each individual cementitious material added in a powder state shall be expressed as kilograms per cubic metre (kg/m3).

- Pozzolans that are added in slurry shall have their respective solid and water contents expressed as kilograms per cubic metre (kg/m^3).

- The quantity of each separately batched size of coarse aggregate and fine aggregate shall be expressed as kilograms per cubic metre (kg/m^3). in a saturated-surface-dry (SSD) condition.

- The quantity of water shall be the maximum amount allowed based on the maximum specified water-to-cementitious material ratio (W/Cm), corrected to account for any additional water that may be contributed by other materials used in the proposed mix.

- The quantity of water shall be expressed as kilograms (or Litres) per cubic metre (kg/m^3 or L/m^3). If ice is used for temperature control, it shall be expressed in incremental units (sacks, bags, or pails, etc.) and kilograms per cubic metre (kg/m^3) and shall be included in the maximum allowable water quantity.

- Admixtures dispensed as liquids shall be expressed as Litres per cubic metre and where applicable, expected dosage range stated.

- The quantity of any pre-measured, pre-packaged additives, such as fibres, shall be expressed in incremental units (sacks, bags, or pails, etc.) and kilograms per cubic metre (kg/m^3).

- The absolute volume of each material, air content and the total sum of the absolute volumes of all materials shall be provided in cubic metres (m^3).

- Slump, unit weight, air content, strength characteristics, and any other specified characteristic shall be reported for each set of mixture proportions intended for use.

3.3.6 Incomplete submittals may result in rejection.

3.3.7 Should a concrete supplier regard details of a mix design to be proprietary, the mix design shall be provided “in confidence” to the Ministry for their records. A Professional Engineer shall certify under seal that the concrete meets the requirements of the Contract.

3.4 Trial Mixes

3.4.1 The Contractor shall produce test batches of 4.0 m^3 volumes on all proposed Type DC Concrete mix designs.

3.4.2 The Contractor shall produce test batches of 4.0 m^3 volumes on other mix designs where deemed necessary by the Engineer.

3.4.3 Point of discharge sampling and testing shall be carried out by the Contractor to verify the pertinent parameters of the proposed mix design.

3.4.4 If placement is by pump, concrete shall be sampled and fully tested at both the truck chute discharge and at the pump discharge locations. Sampling and testing shall be in accordance with Table 6300.4.T9 and Table 6300.4.T10. Contrary to the Minimum Test Frequency shown in Table 6300.4.T9, the Minimum Test Frequency shall be per test batch.

3.4.5 Test parameters include all required properties of the fresh and hardened concrete, workability and finish ability of the mix, strength gain characteristics, including 7 and 28 day compressive strengths, and any other additional testing of the hardened concrete that may be required by the Engineer.

3.4.6 Batching, haul times and conveyance procedures used for the test batch must emulate the procedures expected during the actual concrete placement.

3.4.7 The Contractor shall be fully responsible for all costs associated with the test batches.

3.4.8 Test batch trials that do not meet the specified requirements shall be repeated.

3.5 Adjustments to Mix Designs

3.5.1 If, during the progress of the work, the mix design is found to be unsatisfactory, the Contractor shall make the necessary adjustments. Adjustments shall be submitted to the Engineer for approval prior to subsequent concrete placement.

3.5.2 Notwithstanding the Engineer's review of the proposed mix design, it remains the Contractor's responsibility to ensure that the concrete meets all specified requirements.

3.6 Falsework and Formwork

3.6.1 General

3.6.1.1 Formwork and falsework shall be designed, supplied, installed and removed in accordance with the applicable requirements of the following:

- CSA Standard S269.1 Falsework and Formwork.
- The Saskatchewan Employment Act and the Occupational Health and Safety Regulations, 1996.

3.6.1.2 Formwork and falsework support accessories shall not be welded to the permanent structural steelwork.

3.6.1.3 Formwork and associated temporary falsework design and drawings shall be prepared and sealed by a Professional Engineer registered in the Province of Saskatchewan and experienced in the design and construction of falsework and formwork structures similar to those required to construct this project.

3.6.1.4 No load shall be placed on the formwork or falsework until the Professional Engineer responsible for the design has inspected and certified, in writing, that the work has been carried out in accordance with the formwork drawings and specifications and a copy of the formwork design engineers' certification has been provided to the Ministry.

3.6.1.5 Detailed falsework and formwork drawings shall be submitted to the Ministry for review.

- The drawings shall be submitted a minimum of two weeks before the start of installation.
- The submission of falsework and formwork drawings to the Ministry shall in no way relieve the Contractor the full responsibility for the performance of the falsework and formwork.

3.6.1.6 All formwork and falsework shall be completely removed. Stay in place formwork will not be permitted.

3.6.2 Falsework Design

3.6.2.1 All falsework shall be designed and constructed to provide the necessary rigidity, stability and support for the loads without

unacceptable settlement or deformation. Piling shall be used to support all falsework over areas which cannot be founded on a satisfactory spread footing.

3.6.2.2 Screw jacks, hardwood wedges or other means approved by the Ministry shall be provided to properly align the formwork either before or during the placement of concrete. If unacceptable settlement occurs during concrete placing, the work shall be stopped, any concrete affected shall be removed and the falsework modified.

3.6.2.3 Falsework shall be constructed with a tolerance sufficient to allow for compression at the joints, shrinkage of material and shortening of members under load. Permanent camber shall be provided for if indicated on the Plans.

3.6.2.4 Falsework shall be constructed to a design prepared by a Professional Engineer registered in the Province of Saskatchewan.

3.6.3 Formwork Design

3.6.3.1 All forms shall be constructed with wood, metal or other materials approved by the Ministry, and shall be built mortar-tight and of sufficient rigidity to prevent distortion due to the pressure of vibrated concrete and other loads incidental to the construction operation. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

3.6.3.2 The forms shall be substantial and unyielding, and shall be designed so that finished concrete will conform to the dimensions and contours shown on the Plans.

3.6.3.3 Forms shall provide a smooth uniform surface to the concrete. At all edges and corners, a triangular fillet must be neatly inserted to give a chamfered face 20 mm in width equally inclined to each adjoining surface, unless otherwise shown. All forms used for exposed faces on curbs, sidewalks and underside of the slabs shall be lined or constructed with plywood, unless otherwise approved by the Ministry.

3.6.3.4 Metal form ties or anchorages shall be so constructed as to permit their removal to a depth of at least 50 mm from the face without injury to the concrete. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in colour.

3.6.3.5 Dry ties shall not be permitted, form tie rods shall remain embedded and terminate not less than 50 mm from the formed face of the concrete.

- Removable embedded fasteners on the ends of the rods shall be such as to leave holes of a regular shape for reaming and filling.

3.6.3.6 All forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods as hereinafter specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the defects shall be corrected before the placing of concrete commences or continues.

3.6.3.7 Forms may be reused if the shape, strength, rigidity, watertightness and surface smoothness is maintained. Any warpage or bulged lumber shall be discarded.

3.6.3.8 Temporary access shall be provided to allow removal of extraneous material immediately before placing the concrete for narrow walls and columns where the bottom of the form is inaccessible.

3.6.3.9 Wood and metal forms shall be treated with a non-staining parting agent immediately before placing the concrete.

3.6.4 Forming of Exposed Surfaces

3.6.4.1 All forms for exposed surfaces shall be mortar-tight.

3.6.4.2 All exposed corners shall have a minimum 20 mm chamfer.

3.6.4.3 Metal bolts or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 50 mm from the concrete surface.

3.6.4.4 Break-back type form ties shall have all spacing washers removed and the tie shall be broken back a distance of at least 50 mm from the concrete surface.

- All fittings for metal ties shall be of such design that, upon their removal, the cavities which are left will be of the smallest possible size.

3.6.4.5 Torch cutting of steel hangers and ties will not be permitted.

3.6.4.6 Formwork hangers for exterior surfaces of decks and curbs shall be an acceptable break-back type with surface cone, or removable threaded type.

3.6.5 Deck Formwork

3.6.5.1 Formwork for decks, curbs, sidewalks and barriers shall be fabricated so that the lines and grades shown on the Plans are achieved.

3.6.5.2 Deck formwork shall be designed to allow for an adjustable haunch to facilitate the casting of a constant depth deck slab as shown on the Plans.

3.6.5.3 Girders shall be fabricated with a camber equal to 110% of the total dead load deflection and it will be necessary to adjust the formwork to compensate for camber, variances in girder dimensions, positioning, and sweep.

3.6.5.4 In the event that actual girder camber values vary significantly from the values shown on the Plans, the Contractor shall modify the original design finished grade as directed by the Engineer.

3.6.6 Fibre Forms

3.6.6.1 Fibre forms may be used for forming circular columns. They shall be seamless and spirally constructed of laminated plies of fibre. The total wall thickness shall be as published by the manufacturer. The thickness of each ply shall be between 1 mm maximum and 0.5 mm minimum. The width of each ply shall be not less than 150 mm. Plies shall be laminated with non-water sensitive type adhesive that has a proven record of satisfactory service in forms for concrete.

3.6.6.2 The exterior surface shall be uniformly wax impregnated for weather and moisture protection. The three plies nearest to the exterior surface of the form shall be deckled or scarfed and overlapped to minimize the spiral gaps or seams on the column surface.

3.6.6.3 The inside ply shall have a minimum thickness of 0.5 mm. This interior ply shall allow uniform moisture penetration to prevent unequal expansion of the fibres with consequent dimpling of the concrete surface. A suitable vapour barrier shall be provided adjacent to the interior ply to prevent further penetration of moisture and to protect the dry strength of the fibres in the outer plies.

3.7 Installation of Miscellaneous Items

3.7.1 Miscellaneous items such as anchor bolts, expansion joint assemblies, drains and waterstops shall be installed according to details shown on the Plans or as directed by the Engineer.

3.8 Concrete Batching

3.8.1 Batching Equipment

3.8.1.1 Batching equipment shall comply with the requirements of CSA Standard A23.1.

3.8.1.2 Equipment shall conform to the following:

- Batching equipment, such as weighing mechanisms, gates, water lines and dispensing systems, shall be maintained in good working order.
- Batching bins shall be completely emptied of all material before the first and succeeding batches are measured.
- Batching equipment shall have the following capabilities and facilities:
    - Bins or silos for storage of aggregates, silos for storage of cement and pozzolan.

- Free movement of each type or size of material to discharge openings without contamination.
- Design of storage and hauling facilities to prevent:
  - Loss or intermingling of different sizes and types of materials.
  - Contamination by deleterious substances.
  - Harmful segregation and breakage.
- Covers to stockpiles of fine aggregates to ensure constant moisture content.
- All fulcrums, clevises and similar working parts maintained in clean condition.
- Provision made, in remote control plants and/or where batch cycles are timed, for the complete filling and discharge of the measuring unit for each batch.

- Batch Charging Mechanism – Batch Charging Mechanism requirements shall be as follows:
  - Material flow control within the specified tolerances.
  - Hopper construction to eliminate material accumulation and to permit the complete discharge of every batch.
  - Cement weighing hopper
    - Self-cleaning and properly ventilated to allow air to escape.
    - Accessible for inspection.
    - Dust sealed between the charging mechanism and the hopper to maintain weighing accuracy.

- Scales and Dispensing Mechanism – Scales and Dispensing Mechanisms shall conform to the following requirements:
  - Beam type or springless dial type.

- Other methods of weighing (electric, hydraulic, load cells, etc.) are acceptable provided the specified weighing tolerances and accuracy requirements are met.
- All accurate to ±0.4% of the total capacity of the scale when static load tested.
- Zero balance adjustment capability.
- Unaffected by binding or vibration due to vibrators or other appurtenances.
- Working range between 10% and 90% of the scale reading.
- Equipped with prominent markers with individual batch weight setting capabilities for dial scales.
- Calibration facilities including an adequate number of standard test masses.
- Beam type scales with provision for indicating to the operator that the required load in the hopper is being approached; the device shall indicate at least the last 100 kg of the load.
- All weighing and indicating devices shall be in full view of the operator while charging the hopper, and the operator shall have convenient access to all controls.

- Volumetric Devices for Water Measurement – Volumetric devices for water measurement shall be:
  - Fitted with such valves and connections as are necessary to divert the water measured for a batch to easily verify the accuracy of measurement.
  - Arranged so that measurements are unaffected by variable pressures in the water supply line.
  - Calibrated to an accuracy of 2% of the batch volume.
- Dispensing Systems for Liquid Admixtures - Dispensing systems for liquid admixtures, other than weigh systems, shall have the following capabilities:

- Visual, volumetric measuring or readout units located as close as possible to eye level for easy reading by the operator.
- Positioned in such a manner that discharge into the batch is observed by the operator from a normal working position.
- Volumetric measuring unit for periodic check of dispenser accuracy where a positive displacement system is used.
- Visual measuring unit for an accurate visual check of increments of 30 mL of air entraining agent or of chemical required to treat a maximum of 25 kg of cement.

- Certificate or Report of Inspection – A certificate or report of inspection, from a Weights and Measures approved, independent testing authority, and which is not more than one year old for the plant in its present position, shall be on display in the plant at all times.
  - The certificate or report will be accepted as proof of accuracy of the scales or weighing devices.
  - Where there is reasonable doubt concerning the accuracy of the scales or weighing devices the Engineer may require their recalibration and recertification at the Contractor's expense, during progress of the Work.
  - Plant relocation or major alterations shall require such recalibration and recertification.

3.8.2 **Batching of Materials**

3.8.2.1 Material may be weigh batched separately or cumulatively.

3.8.2.2 Aggregates shall be batched by mass.

3.8.2.3 Cement and mineral admixtures in powder form shall be batched by mass or bag.

3.8.2.4 The mass of any ingredient to be batched shall not be less than 10% nor greater than 90% of the scale capacity.

3.8.2.5 When batched by 40 kg bags, only full and sealed bags of cement shall be used with no fractional bags permitted.

3.8.2.6 Cement batched by mass shall be to an accuracy of ±1% for batch quantities between 30% and 90% of the scale capacity.

- When the mass of cement being batched is between 10% and 30% of the scale capacity, the mass of cement batched shall not be less than the required mass nor more than 4% in excess.
- Intermediate bulk cement shall be weighed to an accuracy of ±1%.

3.8.2.7 When aggregates are measured by mass, batch masses shall be based on the required mass of saturated surface dry aggregate corrected for the moisture conditions of the aggregate at the time of batching.

- Field determination of free moisture in the aggregates shall be made by any proven method such as CSA Standard A23.2, Test Method A23.2-11A or by the use of a device such as the "Speedy Moisture" gauge.
- Where doubt exists as to the accuracy of such methods, total moisture in the aggregate shall be determined in accordance with ASTM Specification C566.
- The minimum test frequency shall be once per each day's production.
- When individual aggregate weigh batchers are used, the scale reading for each material shall be within 2% of the specified mass.
- In a cumulative aggregate weigh batcher, the cumulative mass after each measurement shall be within 1% of the required cumulative amount when the scale is used in excess of 30% of its capacity.
- For cumulative measurement less than 30% of scale capacity, the allowable variation shall be ±0.3% of scale capacity or ±3.0% of the required cumulative mass, whichever is less.

3.8.2.8 Mixing water shall be measured by mass or volume to an accuracy of ±1%.

- Adjustments for free water contained in batched materials, such as free water in the aggregates, water contained in admixture solutions, shall be made to the quantity of water to be batched.
- The total amount of mixing water in the batch obtained from all sources shall be within ±3% of the specified quantity and shall not vary the designed water-to-cementitious material ratio of the mix by more than ±0.02.
- Mixers shall be completely emptied of all water prior to the loading of a concrete batch.

3.8.2.9 Admixtures shall be batched in liquid form by either mass or volume; in powdered form by mass or bag.

- Volumetric measurements of admixtures or air entraining agents shall be to an accuracy of ±3% of the required amount or 30 ml, whichever is greater.
- Measurement by mass shall be to an accuracy of ±3% of the required amount.

3.8.2.10 The addition of cement to a fully-batched load of aggregates will not be accepted.

3.9 Mixing

3.9.1 General

3.9.1.1 Sufficient plant capacity and transporting equipment shall be provided by the Contractor to ensure continuous delivery of concrete at the rate required with the necessary intervals between batches, for the proper handling, placing and finishing of the concrete without the formation of cold joints in the finished concrete. The methods of delivering and handling the concrete shall facilitate placing with the minimum of rehandling and without damage to the structure of the concrete.

3.9.2 Concrete Mixer

3.9.2.1 Concrete mixers shall conform to the following requirements:

- Manufacturer's rating plate carried in a prominent position, indicating rated mixing capacity, and recommended speed of mixing which must be in the range of not less than 4 nor more than 18 rpm.
- Demonstrated capability of operating satisfactorily at the recommended mixing speed.
- Number of revolutions of the drum or blades registered with a counter in working condition.
- Charge and discharge openings and chute free from appreciable accumulations of cement or concrete, and hopper and chute surfaces clean and smooth.
- Batch water measuring equipment in good operating condition.

3.9.2.2 Volumetric mobile mixers shall conform to the following requirements:

- Shall be auger type mixers.
- The mobile mixers shall be calibrated with the actual cement and aggregate products used in the concrete mix. Calibration tables and curves shall be submitted to the Engineer. The volume of the concrete produced shall be confirmed and shall be within 2%.
- Mobile mixers shall have separate flow controlled supply hoppers for each individual aggregate gradation and cementitious constituent material to be added volumetrically.
- May be used provided that the accuracy of batching and uniformity of concrete is as required by CSA Standard A23.1.
- Cement flow rates shall be checked before (during if required) each placing operation.
- The scale being used to calibrate the mobiles shall have a minimum capacity of 50 kg.

- The water tank shall have a stand pipe showing the amount of water in the tank.
- The mobile mixers shall have individual flow meters and admixture tanks for each admixture to be used as part of an admixture injection system.
- The mobile mixers shall be able to advance backwards and forwards from controls located at the back of the mobile.
- The mobile mixer auger shall be maintained at minimum of a 25° angle from horizontal when mixing and discharging, unless otherwise indicated by the manufacturer.

3.9.3 Mixing Concrete

3.9.3.1 Mixing drums shall be clean and empty before being charged.

3.9.3.2 The drum shall be rotated at the manufacturers' recommended mixing speed during charging and mixing.

3.9.3.3 Concrete shall be mixed to the uniformity requirements of CSA Standard A23.1, Section 5.2.4.

3.9.3.4 When a satisfactory mixing time is established it shall be maintained for all batches of the same design, mixed with the same equipment.

3.10 Delivery

3.10.1 The Contractor shall have sufficient plant capacity and transporting equipment to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing, and finishing of the concrete. The rate shall be such that the interval between batches shall not result in the formation of cold joints in the concrete. The methods of delivering and handling the concrete shall facilitate placing with the minimum of rehandling and without damage to the structure of the concrete.

3.10.2 Off-site mixed concrete, after being mixed, shall be transported to the job site in either truck agitators or truck mixers operating at the speed designated by the manufacturer of the equipment as agitating speed.

3.10.3 When concrete is being mixed in mixer trucks while in transit, the speed of the mixing drum shall be reduced to agitating speed once the mixing time has elapsed.

3.10.3.1 Delivery of mixed concrete in non-agitating equipment shall not be permitted.

3.11 Time of Hauling and Placing Concrete Cement

3.11.1 Concrete transported in a truck mixer, agitator, or other transportation device shall be discharged at the job and placed in its final position in the forms within the following time interval after the introduction of the mixing water to the cement and aggregate, or the cement to the aggregate, or before the concrete is of such slump that it can no longer be placed and properly consolidated, whichever comes first:

- Type DC concrete: 70 minutes
- Type C, Type C1, Type P1, Type P2 and Type G1 concrete: 90 minutes

3.11.2 Under conditions contributing to rapid stiffening of concrete the Contractor shall adjust the placing operations to suit reduced handling time.

3.11.3 Water may be added during the first 60 minutes from the time of batching up to the total water content specified for the mix design if approved by and in the presence of the Engineer. The mixer drum shall be turned at mixing speed for at least 30 revolutions after addition of water, or until the uniformity of concrete is consistent. The amount of water added and by whose authority shall be recorded on the delivery ticket.

3.11.4 Hydration Stabilizing Admixtures (HSA's) intended to retard the initial set of the concrete may be added if approved by the Ministry.

3.11.5 If approved by the Ministry, guidelines for the use of HSA's shall be as follows:

3.11.5.1 The design length of hydration stabilization shall be the difference of project haul time and the specified allowable haul time as per Specification 6300.3.11.1.

3.11.5.2 Any concrete that exceeds the design length of hydration stabilization plus the specified allowable haul time shall be rejected.

3.11.5.3 When HSA's are used, these time extensions are subject to preconstruction trials being conducted by the Contractor to establish the appropriate HSA dosage to provide suitable extended slump life of concrete without increasing the water/cementitious ratio of the concrete above that which would be required if HSA's were not used.

3.11.5.4 The use of HSA's shall in no instance modify the maximum concrete temperature required at time of placement.

3.11.5.5 A one-time only addition of HSA will be allowed, this will be during initial batching of the concrete or immediately at completion of batching as recommended by the admixture manufacturer.

3.11.5.6 Addition of HSA at any other time will be cause for rejection of the concrete.

3.12 Hauling and Placing Concrete

3.12.1 General

3.12.1.1 The strength of constructed bridge elements and the lateral stability of the girders shall be checked for all construction loads anticipated during the placement of the concrete. Girders shall be temporarily braced, if necessary, to facilitate the placement of concrete.

3.12.1.2 The Contractor shall provide a reasonable period of time between the completion of preparations for concrete placement and the actual placement to allow for inspection. Concrete placement shall not proceed until the Engineer's permission is given.

3.12.1.3 In preparation for the placing of concrete, all sawdust, chips and other construction debris and extraneous matter shall be removed from the interior of forms.

3.12.1.4 Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from inside the forms and not buried in the concrete.

3.12.1.5 Concrete shall be handled and placed so as to avoid segregation of the materials and the displacement of the reinforcement. Concrete shall be deposited in the forms as closely as practical to its final position.

3.12.1.6 When placing operations would involve dropping the concrete more than 1.5 metres, it shall be deposited through a hopper and either a downpipe or an elephant trunk, unless otherwise approved by the Ministry. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete.

3.12.1.7 After initial set of the concrete, the forms shall not be jarred and no force shall be placed on the reinforcement bars which project from the concrete until the time of form removal.

3.12.2 Delivery Ticket

3.12.2.1 Concrete delivered to the job site shall be accompanied by a ticket providing the Ministry with legible information, as follows:

- Serial number of ticket.
- Date, name and location of concrete supplier.
- Name of the Contractor.
- Specific job designation (name and location).
- Specific designation of concrete mix design.
- Truck number and volume of concrete in cubic metres.
- Addition of any materials added at the job site, at the request of the Engineer including but not limited to water and all chemical admixtures.
- Time concrete was batched, arrived at job site, and completely discharged.
- Amount of water added during batching including free moisture in aggregate, the maximum allowable amount of water that can

be added at the site to maintain the specified maximum W/Cm ratio.

3.12.3 Concrete Placing Equipment

3.12.3.1 General

- Equipment for the handling and placing of concrete, such as buggies, buckets, hoppers, chutes, belts and pumps, shall be of such design, size and condition to ensure a continuous and adequate supply of concrete to the point of deposition. This equipment shall be maintained in good working order, and kept clean of hardened concrete or foreign material. Water used to clean the equipment shall be discharged outside of the forms.

- Placing of concrete shall comply with CSA Standard A23.1 and the equipment specifications listed below.

3.12.3.2 Buggies

- Buggies shall have inflatable rubber tires. Inner surfaces of the bucket shall be smooth with filleted corners, mortar-tight and free of any excessive accumulation of hardened concrete, obstructions or deterioration interfering with the proper discharge of concrete.

- Grade and ramp-way surfaces shall be sufficiently smooth to prevent segregation of concrete being carried in buggies.

3.12.3.3 Bottom-dump Buckets and Hoppers

- Bottom-dump buckets and hoppers shall have side slopes not less than 60o from the horizontal and shall be equipped with wide free-working and tight-closing discharge gates.

- The discharge gates shall be constructed to regulate the concrete flow, spring loaded to ensure complete closure and be capable of immediate closure at any time during discharge.

- Buckets and hoppers shall be cleaned of any accumulation of partially hardened or hardened concrete before and during concrete placement.

- Gate control mechanisms shall be cleaned and lubricated before being used.

- When lifted by crane to the placement location, segregation of concrete from jarring or shaking shall be prevented.

- Side-dump buckets shall be used whenever necessary to avoid conflict with extended reinforcing steel or formwork.

3.12.3.4 Chutes and Conveyor Belts

- Open chutes, when used, shall either be made of steel or be steel lined.

- Chutes shall have a slope not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal and shall be capable of slope adjustment to permit flow without requiring a slump greater than that specified or required for placement.

- Baffles shall be used where necessary to prevent segregation of the concrete.

- Chutes shall be of rounded cross section to avoid the accumulation of concrete in corners.

- Flow may be controlled using baffles and/or changes in direction. The use of vibration, paddling or water spray to control flow will not be permitted.

- Chutes or belts shall be rigidly supported but sufficiently mobile to permit discharge as close as possible to the placement location as it progresses.

- Any long line of chutes or belts shall be covered during hot, dry or windy weather to prevent drying of concrete and excessive slump loss.

3.12.3.5 Conveyor Belt Operation Rate

- Conveyor operation rate shall be dependent on the proper placement and consolidation of the concrete with the belt inclination such that no segregation occurs from any sliding or roll-back of the concrete.

3.12.3.6 Hoppers

- Hoppers, set approximately level, shall be supported on specially framed bearers transmitting only vertical loads to the top of the formwork.

3.12.3.7 Pumps

- Pumps shall be of sufficient capacity to supply un-segregated concrete, using the design mix proportions at the design slump, to meet the required placement volume at the forms

- Satisfactory operation and performance of the proposed pumping equipment with the concrete materials and mixes otherwise suitable and appropriate for the job, along with the line layout and grate size opening, shall be demonstrated to the Engineer's satisfaction and acceptance.

- Any necessary priming of the concrete pump shall be done with a water/cement or water/cement/sand slurry.

- The prime slurry followed by approximately 0.25 m^3 of concrete shall not be included in the concrete placement. No other pump aid type admixtures will be permitted.

3.12.4 Temperature Control

3.12.4.1 The temperature of the plastic concrete mix at the time of discharge into the forms shall fall within the following limits:

- Concrete Types containing silica fume or metakaolin: 10°C - 18°C

- Concrete Types not containing silica fume or metakaolin: 10°C - 25°C

3.12.4.2 The temperature of the plastic concrete mix shall at no time exceed 25°C for Type DC concrete and 30°C for all other concrete types.

3.12.4.3 The initial temperature of concrete prior to placement may be estimated from the temperatures of its ingredients by using the following equation:

$$T = \frac{22(T_a M_a + T_c M_c) + T_w M_w + T_{wa} M_{wa}}{0.22(M_a + M_c) + M_w + M_{wa}}$$

Where T_a, T_c, T_w and T_{wa}

= temperature in °C of aggregates, cementing materials, added mixing water, and free water on aggregates, respectively

Where M_a, M_c, M_w and M_{wa}

= mass in kilograms of aggregates, cementing materials, added mixing water, and free water on aggregates, respectively

3.12.5 Consolidation

3.12.5.1 Concrete when being placed shall be thoroughly and uniformly consolidated. The consolidation shall be done by mechanical vibration subject to the following provisions:

- The vibration shall be internal.
- Vibrators shall be of a type and design approved by the Ministry.
- Diameter and frequency of vibrators shall conform to Table 6300.3.T6.
- Vibration intensity shall be sufficient to be visually observed on concrete with not more than 25 mm slump over a radius of at least 450 mm.
- The Contractor shall provide a sufficient number of vibrators to properly consolidate the concrete at the rate it is being placed. A standby gasoline-driven vibrator or AC generator shall at all times be available on the job.
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded fixtures and into corners and angles of the forms.
- Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted at a rate of 75 mm per second into the concrete in as nearly vertical plane as possible penetrating into the preceding layer at

least 50 mm and shall be withdrawn slowly in a vertical direction at a rate of 150 mm per second to facilitate the removal of entrapped air bubbles. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete, but shall not be continued at any one point to the extent that localized areas of grout are formed.

- Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective. Vibrators shall penetrate the upper part of the previously placed lift of concrete by its own mass and vibration.

- Vibration shall not be applied directly or through reinforcement to sections or layers of concrete which have hardened to a degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation.

- Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

TABLE 6300.3.T6

REQUIREMENTS FOR DIAMETER AND FREQUENCY OF VIBRATORS

Diameter (mm)	Frequency (Hz)	Rate of Placement per Vibrator (m^3/h)	Application
20-40	170-250	1-4	Very thin members
30-60	150-225	2-8	Walls and slabs 200mm – 200mm thick
50-90	130-200	5-15	Larger members

3.12.5.2 Form vibrators may be permitted only with the approval of the Engineer where rebar configuration would prohibit the use of internal vibrators.

3.12.5.3 Concrete shall be placed in horizontal layers not more than 300 mm thick except as hereinafter provided. Each layer shall be consolidated so as to avoid the formation of a construction joint with a preceding layer which has not taken initial set.

3.12.5.4 When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to sufficient depth to expose sound concrete.

3.12.5.5 Following the set of the concrete, all accumulations of mortar splashed upon any exposed reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be left inside the forms.

3.12.6 Construction Tolerances

3.12.6.1 Dimensional tolerances shall be as shown in Table 6300.3.T7.

TABLE 6300.3.T7

DIMENSIONAL TOLERANCES

Trueness of bearing surfaces	Such that there is no gap over 1mm under a 1m straight edge
Trueness of bridge deck surfaces	Such that there is no gap over 3mm under a 3m straight edge
Trueness of concrete slope protection surfaces	Such that there is no gap over 12mm under a 3m straight edge
Trueness of other surfaces exposed to view	Such that there is no gap over 12mm under a 3m straight edge
Curbs and barriers	Such that there is no gap over 3mm under a 3m straight edge
Horizontal distance to concrete surfaces	± 50mm
Elevations of concrete surfaces except bearings and decks	± 10mm
Elevation of bridge deck surfaces	± 15mm
Elevations of bearing surfaces	± 3mm
Variation from plumb	1:400, but not more than 30mm
Centreline of bearing to centreline of bearing dimension	± 3mm
Dimensions of members over 10m	-10mm, +25mm
Dimensions of members under 10m	-6mm, +15mm
Location of anchor bolts	± 3mm
Projections of anchor bolts, other embedments	± 10mm

3.12.6.2 The tolerances listed in Table 6300.3.T7 are acceptable only in so far as they do not prevent the proper fit of structural members.

3.12.7 Girders

3.12.7.1 Concrete in T-beams shall be placed in two separate operations, each of which shall be continuous, first to the top of the girder stems, and second, to completion. Concrete in girder webs shall be placed in uniform horizontal layers in such a sequence so as to preclude the formation of cold joints.

3.12.8 Columns

3.12.8.1 Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 12 hours before the caps are placed.

3.12.8.2 Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. The load of the superstructure shall not be transferred to the columns until the concrete compressive strength tests confirm the concrete has attained a minimum of 70 percent of the specified design compressive strength.

3.12.9 Pumping

3.12.9.1 A concrete pump shall be proven by demonstration or experience to have the capacity to pump the specified concrete, without major adjustments to the mix design, through the required line lengths and at the required rates. Aluminum pipe shall not be used for conveying the concrete. The equipment shall not impart harmful vibration to the freshly placed concrete nor cause any deformation or misalignment of the formwork. Washout water and excess grout or mortar used to lubricate the pipe shall be discharged outside the forms.

3.12.10 Depositing Concrete Under Water

3.12.10.1 When approved by the Ministry, concrete may be deposited under water using the tremie pipe method. Proposals outlining

procedures shall be submitted for review to the Ministry 3 weeks prior to placement of concrete.

3.12.10.2 Concrete shall not be deposited in water with a temperature less than 5°C.

3.12.10.3 Concrete deposited in water shall be carefully placed in a compact mass, in its final position, and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit.

3.12.10.4 The concrete shall be placed continuously from start to finish and the surface of the concrete shall be kept as nearly horizontal as practicable at all times. To ensure thorough bonding, each succeeding layer of a seal shall be placed before the preceding layer has taken initial set.

3.12.10.5 A tremie shall consist of a steel tube having a diameter of 8 times the maximum size of aggregate, but not less than 250 mm, and constructed in sections having flanged couplings fitted with gaskets. Tremies shall be positioned at a maximum spacing of six metres, and shall be supported as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of the work so as to prevent water entering the tremie and shall be kept entirely sealed at all times. If the charge is lost while depositing, the tremie shall be withdrawn and refilled. Once concreting has started, the tremie shall be kept full to the bottom of the hopper with the discharge end buried at least 0.5 metres in the previously placed concrete. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end while still keeping it in the deposited concrete.

3.12.10.6 The requirements and properties given in Specification 6300.3.2.4.2 and Table 6300.3.T5 for Type C concrete, shall be modified as follows for tremie concrete:

- Maximum nominal size of coarse aggregate: 20-5
- Minimum cement content: 420 kg/m^3

- Maximum W/Cm ratio by mass 0.40
- The concrete mix shall contain a superplasicizing admixture and an antiwashout admixture.
- For concrete supplied with Type GUL or Type HSL hydraulic Portland-limestone cement the minimum amount of supplementary Cementous material shall be 25% by mass of the Cementous materials.
- Slump shall be 50 mm ± 20 mm prior to the addition of the superplasticizing admixture and 150 mm ± 20 mm after the addition of the superplasticizing admixture.

3.12.10.7 Dewatering may proceed when the concrete has attained sufficient compressive strength to withstand the loads which will be imposed. All laitance or other unsatisfactory material shall be removed from the exposed surface by means which will not affect the function of the concrete.

3.13 Deck Slabs, Abutment Slabs and Approach Slabs

3.13.1 The Contractor shall submit to the Ministry for approval, at least four weeks prior to the start of placing any slab concrete, a complete written description of the method and equipment proposed for handling, placing and finishing of the slab concrete. It shall identify the equipment for transporting, distributing and vibrating the concrete, details of the finishing machine, screed rails, screed chairs, work bridge and complete details for support of such equipment.

3.13.2 Approval of these proposals by the Ministry shall not relieve the Contractor the full responsibility for a surface finish which complies with these specifications.

3.13.3 Concrete for slabs shall be placed in a direction and sequence specified on the Plans or as approved by the Ministry. Slab construction shall be placed full-width and the placing operation shall be continuous for any one slab pour.

3.13.4 For each individual pour, concrete shall be placed from lowest elevation to highest elevation.

3.13.5 Placement of concrete shall be between 6:00 pm to 10:00 am.

3.13.6 In the event of unexpected rain, concrete placing shall cease and the surface shall be protected immediately. Plastic concrete which has been rained on shall immediately be removed to the top of the reinforcing steel.

3.13.7 Slabs shall not be subjected to construction loads until the concrete has reached 70 percent of the design compressive strength. In no case shall loads exceed design loads.

3.13.8 Camber Survey

3.13.8.1 Prior to commencing deck construction and subsequent to the completion of the erection of girders, with the girders in a thermally neutral condition and with no dead load other than the dead load of the girders and necessary fall protection, the Contractor shall profile all the girders.

- Camber elevations shall be taken at a maximum spacing of 1.0 m on centre, at centrelines of all bearings and at ends of girders.

- The camber elevation locations shall be laid out to an accuracy of 25 mm horizontally and camber elevations taken to the nearest 1 mm vertically.

3.13.8.2 In the event that actual girder camber values vary significantly from the values shown on the Plans, the Contractor shall modify the original design finished grade as directed by the Engineer.

3.13.9 Screed Chairs and Screed Rails

3.13.9.1 Approved screed chairs and rails shall be installed to provide the finished roadway profile. The rails shall have sufficient stiffness and be adequately supported to maintain the required alignment.

3.13.9.2 The Contractor shall set the deck slab soffit formwork to within 2 mm of the haunch dimension as determined in accordance with Specification 6300.3.13.8.

3.13.9.3 After installation of the deck slab reinforcing, the Contractor shall set the screed rails for the deck finishing machine.

- Screed rails shall be installed to an accuracy of ± 2 mm and have a maximum deflection between supports of 1 mm.

- Allowance for dead load deflection of the structure shall be made in the screed rail setting as well as any anticipated deflection due to the loading of any formwork that may be supporting the screed rail system.

- The screed rails shall be adequately supported outside the area to be concreted and shall be completely installed before concrete is placed.

3.13.9.4 Prior to the placement of deck slab concrete and subsequent to the installation of deck slab reinforcing and screed rails, the locations of the top reinforcing steel in bridge decks shall be checked by running a full deck-width template along the longitudinal screeds.

- The lower edge of the template shall be set at the nominal cover dimension (as specified or noted on the Plans) plus any anticipated deflection of the screed rail support system below the level of the deck surface.

- No steel shall touch the template nor be more than 6 mm distant from it.

- Any discrepancies outside of these limits shall be corrected by the Contractor to the satisfaction of the Engineer.

- Where screed rails are supported on cantilevered formwork that could deflect under the weight of the fresh concrete and the deck finishing machine, the Contractor shall pre-load a section of the cantilevered formwork on each side of the bridge to determine deflections that will occur during concrete placement. The pre-load shall accurately represent all anticipated loading during concrete placement, including reinforcing steel, concrete, and the deck finishing machine. The formwork, machine and/or screed rails shall be adjusted to compensate for the expected formwork deflection.

3.13.10 Screeding and Finishing

3.13.10.1 An approved power driven mechanical finishing machine shall be used to finish the top surface of the concrete deck slab, the abutment slabs and the approach slabs.

- The finisher shall be capable of finishing slabs to within 500 mm of the vertical face of curbs or traffic barriers.
- The finisher shall be equipped with rollers which can be adjusted to conform to the required roadway cross-section.
- Prior to placing any concrete, adjustment and operation of the finishing machine shall be verified by moving the machine over the full length of the section to be placed and traversing the rollers completely across all end bulkheads. Measurements shall also be taken at deck edges, front face of curbs/barriers, deck joints, bulkheads, and any other locations as determined by the Consultant. Adjustment of the deck finishing machine and/or guide rails shall be completed such that the design grades, deck thickness, and reinforcing steel concrete clear cover are achieved.
- The finishing machine shall be capable of forward and reverse motion under positive control. Provision shall be made for raising the screeds to clear the screeded surface for travelling in reverse.
- The finishing machine shall be moved forward at a uniform rate as rapidly as proper compaction and surface finishing of the concrete permits.
- The rollers shall not be allowed to operate when the finishing machine is stationary.
- A roll of concrete shall be maintained along the front of the finishing rollers at all times to ensure proper filling and compaction of the concrete surface.

3.13.11 Diaphragms

3.13.11.1 Unless otherwise specified in the Special Provisions or on the Plans, diaphragms shall be placed either:

- A sufficient length of time ahead of the deck concrete, so that the diaphragm concrete attains a compressive strength of 15 MPa before the deck slab is cast; or

- 2 hours before the deck concrete.

    - In this case, diaphragm concrete shall have a slump less than 40 mm and shall be retarded so that it sets at the same time as the deck concrete.

3.13.11.2 Sequence for the placing of concrete for diaphragms at ends of girders on continuous and integral type spans shall be as shown on the Plans.

3.13.12 Floating

3.13.12.1 The concrete surface produced by the finishing machine shall be floated with a wood or magnesium bull float to produce a uniform surface, free from open texture, plucked aggregate and local projections or depressions.

3.13.12.2 Floating shall be done in both the transverse and longitudinal directions as necessary to remove high spots and ridges and to fill voids and holes left in the surface by screeding. Care shall be taken to preserve the crown, cross-slope and profile during the floating operation. The addition of water to the concrete surface to aid in finishing shall not be permitted.

3.13.13 Work Bridges

3.13.13.1 The Contractor shall provide two movable work bridges spanning the slab at right angles to the centreline of roadway to facilitate floating, hand finishing, inspection and application of curing aids to the freshly placed concrete. Hand finishing shall be kept to a minimum.

3.13.14 Surface Defects and Tolerances

3.13.14.1 After the floating has been completed and the excess water removed, but while the concrete is still plastic, the slab surface shall be tested for trueness with a straight-edge. For this purpose, the Contractor shall furnish and use an accurate 3 metre long straight-edge. Except across the crown, the

surface shall be such that when tested with the straight-edge placed anywhere, in any direction on the surface, there shall not be a gap greater than 3 mm between the bottom of the straight-edge and the surface of the concrete anywhere below the straight-edge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished.

3.13.15 Crack Repairs

3.13.15.1 28 days after the placement of the slab concrete, deck slabs, abutment slabs and approach slabs will be assessed for cracks.

3.13.15.2 Where the measured width of crack in the slab exceeds 0.2 mm, including transverse cracks, longitudinal cracks and cracks at control joints, the Contractor shall be responsible for all costs incurred to repair the cracks, and for the supply of approved repair material. The repair shall be done in a timely manner to the satisfaction of the Engineer.

3.13.15.3 The following procedure shall be used for the repair of cracks exceeding 0.2 mm in width:

- Blow out cracks clean and dry with a jet of oil-free compressed air.
- Seal cracks by a slow gravity feed of approved repair material to maximize penetration.
- Seal the surface with coarse sand.

3.14 Cold Weather Requirements

3.14.1 Cold weather, for the purpose of this specification, is assumed to exist when the air temperature is lower than 5°C, or when in the opinion of the Engineer, the air temperature is likely to fall below 5°C within the next 48 hours.

3.14.2 Concreting in cold weather will not be permitted for Type DC concrete.

3.14.3 Mixing

3.14.3.1 All aggregate and mixing water shall be heated to a temperature of at least 20°C but not more 65°C.

- The temperature of the combined water and aggregates shall not exceed 40°C when combined with the cement.

3.14.3.2 The temperature of the concrete shall be between 13°C and 25°C at the time of placement.

3.14.3.3 Aggregates shall be heated to eliminate frozen lumps, ice and snow without overheating or excessive drying.

- Aggregates shall not be heated above 65°C, and all lumps of frozen aggregate shall be excluded from the mix.

3.14.4 Placing

3.14.4.1 Before any concrete is placed, all ice, snow and frost shall be completely removed. Deicing salts shall not be used as a deicing agent in the forms. Concrete shall not be placed on or against any surface that will lower its temperature below 13°C during the curing process. This may necessitate enclosing the existing concrete, formwork and reinforcing steel, and preheating the area for a sufficient length of time to raise the temperatures to an acceptable level.

- Heat shall be applied uniformly and at a rate which will not induce excessive thermal stresses in the section being heated.

- Ambient air temperatures shall not exceed concrete temperatures by more than 13°C and shall be raised at a maximum rate of 2°C/hr.

- Projecting reinforcing steel shall be insulated when temperatures are between 0°C and -10°C for a minimum of 300 mm away from the fresh concrete and for a minimum of 600 mm when temperatures are below -10°C.

3.14.4.2 Concrete shall not be placed on frozen surfaces except in pile founded footings where a minimum layer of 25 mm rigid insulation shall be installed.

- Rock surfaces shall be hoarded and heated by forced air.

- Hoarding and heating shall continue until all standing frost crystals are dissolved.

- Frozen embankment shall be thawed and re-compacted prior to placing concrete thereon.

- The temperature of existing concrete work shall be raised to a minimum of 5°C and maintained at this temperature for a time sufficient to raise the entire mass of concrete to this temperature.

- When the ground temperature against which pile concrete is placed is below 5°C, the pile hole shall be hoarded and heated until the ground temperature is warmer than 5°C or oversized by 100 mm.

3.14.4.3 The concrete shall be placed rapidly and evenly as near to its final position as possible to reduce the risk of segregation, flow lines and cold joints. The concrete shall be covered as quickly as possible after placing with the protective material, or the housing closed up.

3.14.5 Protecting Placed Concrete

3.14.5.1 The Contractor shall protect, and heat when necessary, all concrete being placed during periods of cold weather, when the air temperature falls below 5°C during the cold weather protection period.

3.14.5.2 The cold weather protection period shall extend to 48 hours after moist curing ends.

3.14.5.3 For concrete supplied with Type HSL or Type HSe containing hydraulic Portland-limestone cement, the protection period shall be extended to 14 days.

3.14.5.4 The Contractor shall provide suitable protection, and heat where necessary, to ensure that the concrete cures at a temperature of at least 13°C for the curing period.

- Heated enclosures shall be kept at 95% minimum relative humidity.

- Concrete surfaces shall be protected by formwork or impermeable membranes from direct exposure to the combustion gases or drying from heaters.
    - Commercial curing compounds may be used, but these shall be completely removed by sandblasting prior to placing subsequent lifts or surface sealers.
- Heating with open flame and intense local heat is prohibited without approval of the Ministry.
- The enclosed air temperature shall not be less than 10°C nor more than 26°C.
- Where practical, insulated forms, capable of maintaining the surface of the concrete at not less than 13°C for a period of 7 days, may be used instead of enclosures and heating.
- If forms are insulated, exposed horizontal surfaces shall be protected with a similar layer of the insulating material securely fastened in place.
    - If the insulated forms do not maintain the proper temperature at the concrete surface, auxiliary protection shall be used to provide additional heat as described above.
- The determination and recording of air and concrete temperatures to verify compliance with the requirements for cold weather concreting shall be the responsibility of the Contractor.
- The Contractor is responsible for furnishing and using a 24-hour minimum/maximum or continuous temperature recording thermometer to record the air temperature within the enclosure and/or insulated forms.
- Daily records shall be submitted to the Ministry upon request.

3.14.5.5 Steel girders and ties that are in contact with the concrete shall be within the protection, or if not, shall be separately insulated.

3.14.5.6 The Contractor shall submit details of the protection proposals, including information on the insulating materials, to the Ministry

for approval. Such approval shall not relieve the Contractor the full responsibility for the adequacy of the protection.

3.14.6 Removal of Protection

3.14.6.1 At the end of the cold weather protection period, heating and protection shall be withdrawn in such a manner so as not to induce thermal shock stresses in the concrete.

3.14.6.2 The temperature of the concrete shall be gradually reduced at a rate not exceeding 10°C per day to that of the surrounding air.

3.14.6.3 To achieve this, in a heated housing, the heat shall be slowly reduced and then shut off, and the whole housing allowed to cool to air temperature before the housing itself is removed.

3.14.6.4 The protection shall not be removed until the temperature of the concrete has fallen to within 10°C of the temperature of the outside air.

3.15 Hot Weather Requirements

3.15.1 General

3.15.1.1 Prior to the placement of concrete, the Contractor shall submit to the Ministry for approval, the proposed placing operations complying with the requirements for hot weather concreting.

3.15.2 Type DC Concrete

3.15.2.1 Placing of concrete shall not commence if the anticipated air temperature during the pour is expected to exceed 20°C (as forecast by the nearest official meteorological office).

3.15.2.2 The temperature of the concrete during discharge into the forms shall be between 10°C and 18°C.

3.15.2.3 The temperature of the mix shall be maintained below the maximum permitted temperature by the inclusion of ice or liquid nitrogen to the mix at the batch plant as approved by the Ministry, taking care to maintain the design water to cementitious materials ratio and other plastic properties.

3.15.2.4 Concrete shall be protected from drying in accordance with the requirements of Clause 7.4.2.2 of CSA Standard A23.1, Severe drying conditions. The rate of evaporation shall be estimated using Figure D1 of Annex D of CSA Standard A23.1.

3.15.3 Type C, Type C1, Type P1, Type P2 and Type G1 Concrete

3.15.3.1 When the air temperature is at or above 25°C, exposed surfaces of freshly placed concrete shall be shaded from the direct rays of the sun and shall be sheltered from the wind. Alternatively, all placing and finishing may be done early in the morning or in the evening if weather conditions are more favourable.

3.16 Construction Joints

3.16.1 General

3.16.1.1 The definition of a construction joint is a joint between adjacent or successive lifts of concrete where the previously cast concrete cannot be plasticized with a vibrator, or any joint required by the Contractor's method of construction.

3.16.1.2 The location and details of construction joints shall be shown on the Plans. Construction joints not shown on the Plans shall be subject to approval by the Ministry and shall be located and designed so that the strength and appearance of the concrete are least impaired.

3.16.1.3 Shear keys or inclined reinforcement shall be used where necessary to transfer load between the two sections.

3.16.1.4 Construction joints generally shall be in accordance with the following requirements:

- Kept to a minimum.
- Concealed by a natural break or line in the structure.
- Provided for by the formwork design and placing techniques.

3.16.1.5 Emergency construction joints shall conform as nearly as possible to planned joints.

- In any case, concrete must be leveled as well as possible and, if lifts are partial, a vertical bulkhead shall be installed.

- Permission from the Ministry shall be required to complete the cast following any emergency joint installation.

3.16.2 Joint Edges

3.16.2.1 Joint edges shall be performed whenever possible for a true line upon form removal.

3.16.2.2 Pour-strip shall be positioned relative to form ties so as to minimize form bulge at the bottom of the subsequent cast, but concrete may be cast to the top of a form instead of the pour-strip.

3.16.2.3 Concrete surfaces outside of the reinforcing steel shall be steel trowelled to a true line.

3.16.3 Surfaces Preparation

3.16.3.1 Joint surfaces of the hardened concrete shall be thoroughly cleaned of foreign matter and laitance to present clean, sound surfaces with the coarse aggregate partially exposed and achieved by:

- Brushing immediately following initial set.

- Treatment with a surface set retardant, followed by green cutting.

- Sand blasting.

- Water blasting.

3.16.3.2 Where roughening of the hardened concrete is specified, the surface shall be roughened to a full amplitude of at least 5 mm.

3.16.4 Bonding of Joints

3.16.4.1 Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened, and the surface of the hardened concrete shall be roughened as required in a manner that will not leave loosened particles of aggregate or damaged

concrete at the surface. The surface shall be thoroughly cleaned of foreign matter and laitance.

3.16.4.2 Bonding of joints shall be achieved through the use of a water-cement slurry or, if specified, an epoxy-type bonding agent conforming with the requirements of ASTM Specification C881M applied in strict accordance with the manufacturer's specifications.

3.16.4.3 Slurry, when used, shall have a water-cement ratio equal to that of the concrete being placed and be brush applied to a 3 to 5 mm thickness for 100% coverage on to the cleaned existing concrete surface within five minutes of placing concrete.

3.17 Curing Concrete

3.17.1 Temperature During Curing

3.17.1.1 For mass concrete which has a minimum dimension of 1.0 m in all three dimensions, the Contractor shall provide a temperature management plan

3.17.1.2 For all concrete types the concrete temperature during the curing period shall be between 13°C and 70°C unless specified otherwise

3.17.1.3 The temperature differential between the core of the element and the surface of the element shall not exceed 20°C.

3.17.1.4 Thermocouples shall be installed at the following interior locations:

- A group of thermocouples consists of one at the core of the element and one near the surface. As a minimum, one group shall be installed and additional groups shall be installed for every 50 m^3 of concrete.

3.17.1.5 The Contractor shall monitor the temperature a minimum of every 4 hours for the first 72 hours after placement and 8 hours thereafter.

3.17.1.6 The Contractor shall provide the temperature readings to the Ministry within 48 hours of taking the readings.

3.17.1.7 Temperature monitoring devices shall supplied and installed by the Contractor at no additional cost to the Ministry.

3.17.2 Type DC Concrete

3.17.2.1 A fog mist shall be applied continuously from the time of screeding until the concrete is covered with burlap, curing blanket or other satisfactory material, in such a way as to maintain high relative humidity above the concrete and prevent drying of the concrete surface. Water shall not be allowed to drip, flow or puddle on the concrete surface during fog misting, while placing the burlap, curing blanket or other satisfactory material or at any time before the concrete has achieved final set.

3.17.2.2 Fogging equipment shall be such that the fog spray is produced from nozzles that atomize the droplets and are capable of keeping a large area damp without depositing excess water. Fogging equipment shall generate a minimum pressure of 8300 kPa (1200 p.s.i.) at a flow rate of 8.3 litres per minute (2.2 g.p.m.). Hand held weed sprayers will not be permitted.

3.17.2.3 The Contractor's fogging equipment and materials necessary for the wet cure systems shall be acceptably demonstrated and approved by the Ministry prior to scheduling and placing of the concrete.

3.17.2.4 Evaporation retardant shall be applied to all exposed surfaces immediately following the finishing operations in order to prevent premature drying until the concrete has set sufficiently to initiate moist curing. Evaporation retardant shall not be used as a finishing aid.

3.17.2.5 As soon as the concrete has set sufficiently, any exposed concrete surfaces shall be protected by covering with burlap, curing blanket or other satisfactory material and kept moist. Curing shall continue for a period not less than 7 days after placing the concrete and longer if necessary to attain compressive strengths of 0.7 f'c.

3.17.3 Type C, Type C1, Type P1, Type P2 and Type G1 Concrete

3.17.3.1 As soon as the concrete has set sufficiently, any exposed concrete surfaces shall be protected by covering with burlap, curing blanket or other satisfactory material and kept moist. Curing shall continue for a period not less than 5 days after placing the concrete and longer if necessary to attain compressive strengths of 0.7 f'c.

3.17.3.2 For concrete supplied with Type HSL or Type HSe containing hydraulic Portland-limestone cement, the curing period shall be extended to 14 days.

3.17.4 Commercial curing compounds may be used only if approved by the Ministry.

3.17.5 Curing compounds shall be applied evenly at the coverage rate recommended by the manufacturer. However, additional coats shall be applied if tests show areas that are insufficiently covered. Coverage is adequate if the surface repels water placed on it. Curing compounds, when used on a surface where a bond is required for additional concrete, shall be removed by blast cleaning.

3.17.6 Curing compounds shall be applied by spraying with pressure tank type equipment. To ensure complete coverage, approximately 50 percent of the quantity for a given area shall be applied in one direction and the remainder at right angles to this direction.

3.18 Removal of Falsework and Formwork

3.18.1 Where formwork and associated falsework have been engineered by a Professional Engineer, forms and their supports shall not be removed without the approval of the Professional Engineer responsible for the formwork and falsework design and without the approval of the Ministry.

3.18.2 In determining the time for the removal of falsework and formwork, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the curing of the concrete, and the materials used in the mix.

3.18.3 The following criteria based on concrete compressive strength tests, shall be used for deciding when forms and falsework may be removed.

- Centering under beams 0.9 f'c

- Slabs 0.7 f'c
- Walls 0.5 f'c
- Columns 0.5 f'c
- Sides of beams 0.3 f'c
- Footings 0.3 f'c

3.18.4 The cylinders shall be cured under conditions which are not more favourable than the most unfavourable conditions for the portion of the concrete which they represent.

3.18.5 Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight together with any construction loads likely to be imposed.

3.18.6 All formwork must be removed from the completed structure.

3.18.7 Removal shall be in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own mass. Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and falsework shall not be removed without the approval of the Ministry.

3.19 Finishing Concrete Surfaces

3.19.1 Surface finishes shall be classified as follows:

- Class 1 – Ordinary Surface Finish
- Class 2 – Rubbed Surface Finish
- Class 3 – Sealed Surface Finish
- Class 4 – Floated Surface Finish
- Class 5 – Floated Surface Finish, Broomed Texture
- Class 6 – Floated Surface Finish, Grooved Texture

3.19.2 Class 1, Ordinary Surface Finish

3.19.2.1 All exposed formed and unformed concrete surfaces and the top surfaces of abutment seats, pier caps and pile caps shall be given a Class 1, Ordinary Surface Finish.

3.19.2.2 Immediately following the placing and consolidation of concrete for unformed surfaces, the concrete shall be screeded to conform to the required surface elevations, and then floated to ensure that the surface is free from open texturing, plucked aggregate and local projections or depressions.

3.19.2.3 Following the removal of forms from formed surfaces, all fins, form marks, projections and irregularities shall be removed. The cavities produced by form ties and all other holes, honey-comb spots, broken corners or edges and other defects shall be thoroughly chipped out and cleaned. These areas shall be saturated with water for a period of not less than 30 minutes, then carefully pointed and trued with mortar, a non-shrink grout or patching product. Mortar shall be made from 1 part cement and 3 parts fine aggregate. The cement shall consist of 1 part masonry cement to 4 parts of portland cement. Mortar used in pointing shall not be more than one hour old. Other repair material shall be appropriate for the intended application, and shall be placed in accordance with the manufacturer's recommendations. Non-shrink grout or patching product shall be one of the products listed in the Ministry's approved products list. All repairs shall be moist cured as specified under Specification 6300.3.17 Curing Concrete.

3.19.3 Class 2, Rubbed Surface Finish

3.19.3.1 All exposed surfaces of solid shaft river piers shall be given a Class 2, Rubbed Surface Finish.

3.19.3.2 Following the removal of forms, all fins, form marks, projections and irregularities shall be removed. All lines that are not true shall be corrected by chipping, grinding or patching as necessary. Parging to correct irregularities will not be permitted. The cavities produced by form ties, air bubbles and all other holes, honey-comb areas, broken corners or edges and other defects shall be thoroughly exposed by wire brushing with a stiff bristled, powered, wire brush. The cleaned surface shall be filled with a non-shrink grout or patching product. The repair material shall be

appropriate for the intended application, and shall be placed in accordance with the manufacturer's recommendations. Non-shrink grout or patching product shall be one of the products listed in the Ministry's approved products list. The small surface voids formed by air bubbles shall be filled with a pre-bagged sack rub material placed in accordance with the manufacturer's recommendations. Sack rub material shall be one of the products listed in the Ministry's approved products list. All repairs and sack rubbed surfaces shall be moist cured as specified under Specification 6300.3.17 Curing Concrete. Curing compounds will not be permitted. When the patching and filling have adequately hardened, a carborundum stone shall be used to finish the surface to a smooth, uniform and closed texture. Any voids opened during the stone rubbing process shall be filled with a pre-bagged sack rub material placed in accordance with the manufacturer's recommendations. The prepared concrete surface, including all patching and filling shall be uniform in colour and texture. Any staining caused by cement, water, weather or other conditions shall be prevented, removed or covered.

3.19.4 Class 3, Sealed Surface Finish

3.19.4.1 The surfaces identified below shall be given a Class 3, Sealed Surface Finish.

3.19.4.2 The Class 3 Sealed Surface Finish shall consist of a concrete sealer applied to surfaces previously given a Class 1, Ordinary Surface Finish.

3.19.4.3 The exposed surfaces of grade separation piers, abutments, wing walls, retaining walls, girders, the underside of cantilevered slabs or curb sections, and portions of abutment backwalls located above the bearing seat and outside of exterior girders shall receive two coats of pigmented concrete sealer. The pigmented concrete sealer shall be one of the products listed in the Ministry's approved products list.

3.19.4.4 The top and traffic faces of curbs, the top and traffic faces of traffic barriers, posts, the top surfaces piers, the top surface of the abutment bearing seats, the seat and vertical face against which the approach slab rests, the exposed concrete adjacent to the expansion joint assemblies and the abutment backwalls located

above the bearing seat and between exterior girders shall receive two coats of penetrating concrete sealer. The penetrating concrete sealer shall be one of the products listed in the Ministry's approved products list.

3.19.4.5 Application rates shall be as recommended by the manufacturer plus an additional 30%.

3.19.4.6 Pigmented concrete sealer shall be applied so as to achieve a uniform colour.

3.19.4.7 Concrete sealer shall be applied no sooner than 72-hours after the end of either the curing period or a period of precipitation.

3.19.5 Class 4, Floated Surface Finish

3.19.5.1 The top surface of slabs shall be given a Class 4, Floated Surface Finish.

3.19.5.2 The top surface shall be screeded and floated as required by Specification 6300.3.13 to provide a smooth surface.

3.19.6 Class 5, Floated Surface Finish, Broomed Texture

3.19.6.1 The top surfaces of sidewalks and raised medians shall receive a Class 5, Floated Surface Finish, Broomed Texture.

3.19.6.2 The top surface of the concrete shall be screeded and floated as necessary to provide a smooth surface. The surface shall not vary more than 3 mm under a 3 metre long straightedge.

3.19.6.3 After the concrete has set sufficiently, the surface shall be given a coarse broom finish.

3.19.6.4 The broom shall be of a type approved by the Ministry.

3.19.6.5 Strokes shall be transverse, from edge to edge, with adjacent strokes slightly overlapped, and shall be made by drawing the broom without tearing the concrete, but so as to produce regular corrugations to a maximum depth of 2 mm. The surface as thus finished shall be free from porous spots, irregularities, depressions and small pockets or rough spots such as may be

caused by accidental disturbing, during the final brooming, of particles of coarse aggregate embedded near the surface.

3.19.6.6 An edging tool shall be used at all edges and expansion joints. Where indicated on the Plans, sidewalk surfaces shall be laid out in blocks using a grooving tool approved by the Ministry.

3.19.6.7 Surfaces receiving a Class 5 surface finish shall receive two coats of penetrating concrete sealer. The penetrating concrete sealer shall be one of the products listed in the Ministry's approved products list.

3.19.6.8 Application rates shall be as recommended by the manufacturer plus an additional 30%.

3.19.6.9 Concrete sealer shall be applied no sooner than 72 hours after the end of either the curing period or a period of precipitation.

3.19.7 Class 6, Floated Surface Finish, Grooved Texture

3.19.7.1 When indicated on the Plans or in the Special Provisions, the top surface of slabs shall be given a Class 6, Floated Surface Finish, Grooved Texture.

3.19.7.2 The Class 6 Floated Surface Finish, Grooved Texture shall consist of a grooved texture applied to deck surfaces previously given a Class 3, Floated Surface Finish.

3.19.7.3 Grooves shall be cut into the new concrete deck surface following the completion of the curing period. Grooving fresh concrete with a rake in place of cutting cured concrete will not be permitted.

3.19.7.4 Grooves shall be cut perpendicular to the direction of traffic flow.

3.19.7.5 Saw cuts shall be 2.5 mm wide and a minimum of 6 mm deep spaced at 25 mm on centre.

3.19.7.6 The area 600 mm in front of traffic barriers or curbs shall not be grooved.

3.19.7.7 Saw cuts shall extend to within 100 mm of expansion joint assemblies and deck drains.

3.19.7.8 The Contractor shall supply the water required to accommodate the saw cutting operation.

3.19.7.9 All run-off from grooving operations shall be collected in collection tanks and passed through several settling and filtration processes before being disposed of in an environmentally friendly way in accordance with all local and provincial regulations.

3.19.7.10 Surfaces receiving a Class 6 surface finish shall receive two coats of penetrating concrete sealer. The penetrating concrete sealer shall be one of the products listed in the Ministry's approved products list.

3.19.7.11 Application rates shall be as recommended by the manufacturer plus an additional 30%.

3.19.7.12 Concrete sealer shall be applied no sooner than 72 hours after the end of either the curing period or a period of precipitation.

3.19.8 Concrete Finishing Under Bearings

3.19.8.1 All concrete areas on which bearing plates or pads are to be placed shall be constructed at the required elevation with a horizontal, smooth plane surface. Projections of concrete around the anchor bolts shall be removed. Concrete surfaces shall be ground where necessary to provide finished surfaces which shall not vary more than 1 mm over an area extending beyond the dimensions of the bearing plates by 75 mm.

3.20 Foundation Waterproofing

3.20.1 Asphaltic waterproofing compound shall be applied to concrete foundation surfaces that retain granular or earth fill material.

3.20.2 Asphaltic waterproofing compound shall be one of the products listed in the Ministry's approved products list.

3.20.3 Application of the asphaltic waterproofing compound shall be done as recommended by the manufacturer.

3.20.4 This specification does not include the requirements for installation of a rubberized asphalt waterproofing membrane on concrete slabs.

3.21 Cleaning Steel Girders

3.21.1 Staining of unpainted structural steel surfaces caused by concrete or by curing water shall be removed by a brush-off blast in accordance with the requirements of the Steel Structures Painting Council Surface Preparation Specification SSPC-SP7, No. 7 Brush-off Blast Cleaning. The steel surfaces shall then be sprayed once with water.

4 QUALITY MANAGEMENT

4.1 General

4.1.1 The Contractor shall be responsible for quality control testing, inspections and documentation in compliance with the Contract at no direct cost to the Ministry.

4.1.2 The Contractor shall be responsible for quality control of all components of the concrete operation, including but not limited to, aggregate and component quality, proportioning, test batching, batching, mixing, transporting, placing, consolidating, finishing, curing and all necessary quality control testing of the components and the fresh and hardened concrete.

4.1.3 The Ministry may perform on-site sampling and testing for quality assurance. Any Ministry quality assurance testing will not relieve the Contractor the full responsibility for providing quality control.

4.1.4 Sampling and Testing

4.1.4.1 Required aggregate testing for normal density fine and coarse aggregate for each type of aggregate and for each aggregate source used in the production of concrete shall be as listed in Table 6300.4.T8.

4.1.4.2 Laboratory testing of concrete shall be carried out by a testing laboratory certified in accordance with the requirements of CSA Standard A283.

4.1.4.3 Field test procedures shall be undertaken by personnel certified in accordance with CCIL Category 1.

4.1.4.4 Field inspectors shall have extensive experience in on-site quality control testing of concrete, with the applicable admixtures being used, and with on-site batch adjustments.

4.1.4.5 Quality Control testing personnel shall be on-site and available to test concrete for the complete duration of any concrete placement operation.

4.1.4.6 Sampling and testing of concrete shall be in accordance with the test methods and minimum frequency levels as listed in Table 6300.4.T9.

4.1.4.7 Additional sampling and testing for concrete containing high range water reducers (superplasticizers) shall be in accordance with the test methods and minimum frequency levels as listed in Table 6300.4.T10.

4.1.4.8 Any test outside the specified range shall be immediately reported to the Engineer.

4.1.4.9 Copies of all test results shall be received by the Engineer within 48 hours.

TABLE 6300.4.T8

REQUIRED AGGREGATE TESTING

CSA Standard A23.2 Test Method	Test Description	Test Data Validity
A23.2-2A[(1)]	Sieve Analysis of Fine and Coarse Aggregate	Within 90 days
A23.2-5A[(1)]	Amount of Material finer than 80 µm in Aggregate	Seal Coat of the affected area
A23.2-3A	Clay Lumps in Natural Aggregate	Within 3 years
A23.2-4A	Low Density Granular Material in Aggregate	Within 3 years
A23.2-6A A23.2-12A	Relative Density and Absorption of Fine and Coarse Aggregate	Within 1 year
A23.2-7A	Test for Organic Impurities in Fine Aggregates for Concrete	Within 2 years
A23.2-8A[(3)]	Measuring Mortar-Strength Properties of Fine Aggregate	Within 2 years
A23.2-9A[(2)]	Soundness of Aggregate by Use of Magnesium Sulphate	Within 4 years
A23.2-14A	Potential Expansivity of Aggregates (Procedure for Length Change Due to Alkali-Aggregate Reaction in Concrete Prisms)	Within 1.5 years
A23.2-13A	Flat and Elongated Particles in Coarse Aggregate - Procedure A (Length to Width Ratio 4:1)	Within 3 years[(6)]
A23.2-16A[(7)]	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	Within 4 years

A23.2-23A[2]	Test Method for the Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	Within 4 years
A23.2-29A[2]	Test Method for the Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus	Within 4 years
A23.2-15A[4]	Petrographic Analysis of Coarse & Fine Aggregate specific for use as concrete aggregate; and Determination of the Petrographic Number	See Note 4
A23.2-24A[8]	Test Method for the Resistance of Unconfined Coarse Aggregate to Freezing and Thawing	See Note 8

Notes:

1. Each aggregate produced that may be used as a component of the proposed mix must have a washed sieved analysis performed showing the cumulative percent passing for each of the following sieve sizes; 40 mm, 28 mm, 20 mm, 14 mm, 10 mm, 5 mm, 2.5 mm, 1.25 mm, 630 µm, 315 µm, 160 µm and 80 µm. Sieve analysis reports shall include all relevant sampling information (date/sampled by/location/field sample size) and include the actual test specimen sample mass.
2. Subject to approval by the Engineer, Test Method A23.2-9A can be performed as an alternative to performing Test Method A23.2-23A and A23.2-29A. Refer to CSA Standard A23.1, Section 4.2, Table 12 for further information.
3. Test Method A23.2-8A is required only if the aggregate fails to meet the requirements of Test Method A23.2-7A as described in CSA Standard A23.1 Section 4.2.3.3.3.2
4. The Contractor shall submit the results of the Petrographic Analysis, certified by a Professional Engineer registered in the Province of Saskatchewan indicating the aggregate's suitability for its intended use.
   The petrographic analysis shall not be used to forfeit the requirement of performing other necessary aggregate quality testing.
5. Test data validity requirements are based on time periods prior to the expected initial date of concrete production. It is only applicable to aggregate sources proven to be materially consistent, based solely on historical test data. The Engineer, based on submitted test data and/or visual observations, may reduce the above listed time periods.

6. Quality control during aggregate production shall include the following test methods at the specified test frequencies: A23.2-2A & A23.2-5A (1 per 500 tonnes), and A23.2-13A (1 per 1000 tonnes).
7. Subject to approval by the Engineer, Test Method CSA A23.2-16A can be waived if CSA A23.2-29A test results meet the specified criteria.
8. This test shall be required should any of Test Methods A23.2-4A, A23.2- 9A, A23.2-16A or A23.2- 29A fail to satisfy the allowable limits.

TABLE 6300.4.T9

SAMPLING AND TESTING OF CONCRETE

Test Methodology	Test Description	Minimum Test Frequency
CSA Standard A23.2 Test Method A23.2-1C	Sampling plastic concrete	As stated below
CSA Standard A23.2 Test Method A23.2-3C CSA Standard A23.2 Test Method A23.2-9C	Making and curing concrete compression and flexural test specimens Compressive strength of cylindrical concrete specimens	One set for every 35 m3 or portion thereafter for each type of concrete placed within an individual structural element or component, and placed on any one-calendar day from a single supplier. A minimum of one set shall be taken per pour. The Engineer may request additional sets.
CSA Standard A23.2 Test Method A23.2-4C CSA Standard A23.2 Test Method A23.2-5C ASTM Specification C1064	Air content of plastic concrete by the pressure method Slump and slump flow of concrete Temperature of fresh concrete	Every individual load unless approved otherwise by the Engineer. Retests shall be performed following any load adjustments.
CSA Standard A23.2 Test Method A23.2-6C	Density, yield, and cementing materials factor of plastic concrete	Density and Yield tests shall be performed a minimum of once per element with every air test and compressive strength test.

TABLE 6300.4.T10

ADDITIONAL SAMPLING AND TESTING OF CONCRETE

Test Methodology	Test Description/ Sample Requirements	Minimum Test Frequency and Acceptable Criteria
ASTM Specification C457 (1)	Microscopic determination of parameters of the air-void system in hardened concrete	One test per individual test batch for each type of concrete. Acceptance criteria shall be in accordance with CSA Standard A23.1 Section 4.3.3. Further testing, during scheduled concrete pours may be required, as directed by the Engineer.
ASTM Specification C1202 (1)	Electrical indication of concrete's ability to resist chloride ion penetration (test age at 56 days)	One test per individual test batch for each type of concrete. For Type DC concrete acceptance criteria shall be an average coulomb rating not exceeding 1250 coulombs and no individual test exceeding 1500 coulombs. For all other types of concrete acceptance criteria shall be an average coulomb rating not exceeding 1500 coulombs and no individual test exceeding 1750 coulombs. Each test set includes two 100mm x 200mm cylinders, sampled at the final placement discharge point. Casting, transporting and curing shall be in accordance with Specification 6300.4.1.7.

Notes:

1. Testing requirement may be waived at the discretion of the Engineer

4.1.5 Sampling- Point of Acceptance

4.1.5.1 Determination of concrete properties for acceptance will be made based on samples taken at the final discharge end of the placement system.

4.1.5.2 The Engineer will not accept sampling at the truck discharge end.

4.1.5.3 If the concrete mix properties are inconsistent, the Engineer may require additional testing to be performed at the point of placement at a predetermined frequency throughout the placement period. Such additional testing, including all costs shall be deemed as part of the Contractor's quality control program.

4.1.6 Compresive Strength Tests

4.1.6.1 Unless otherwise specified in the Contract, a set of compressive strength test shall be the average 28-day compressive strength of two standard 100 mm x 200 mm test cylinders, sampled, cast, cured, transported, and tested in accordance with CSA Standard A23.2, Test Method A23.2-3C and Test Method A23.2-9C.

- The cylinder size shall however, meet the aggregate size limitations specified in Section 6.2 of CSA Standard A23.2, Test Method A23.2-3C.

4.1.6.2 For each compressive strength test, a third cylinder shall be cast for a 7-day compressive strength determination. A fourth cylinder shall be cast to be used as determined by the Engineer.

4.1.6.3 If one specimen in a compressive strength test, in the opinion of the testing agency shows evidence of improper sampling, casting, or testing, including damage from improper handling and transporting (and if agreed to by the Engineer), it shall be discarded and the remaining two specimen compressive strength tests averaged.

4.1.6.4 Additional cylinders may be cast, at the discretion of the Engineer.

4.1.6.5 The compressive strength of each type of concrete shall be considered satisfactory if:

- All sets of compressive strength tests shall equal or exceed the specified compressive strength.

- No individual test shows compressive strengths less than 90% of the specified compressive strength.

4.1.6.6 Each type of concrete shall be specified in the Special Provisions or on the Plans.

4.1.7 Test Cylinders

4.1.7.1 Making and curing concrete test cylinders shall be carried out in accordance with CSA Standard A23.2, Test Method A23.2-3C, except that the time for cylinders to reach the testing laboratory shall be between 20 and 48 hours from the initial time of casting.

4.1.7.2 The test cylinders shall be cast by the Contractor using standard CSA approved moulds.

4.1.7.3 The Contractor shall provide properly designed temperature-controlled storage boxes for test cylinder storage, as specified in Section 7.3.2.1 of CSA Standard A23.2, Test Method A23.2-3C, for a period of at least 20 hours, and further protection from adverse weather and mishandling before and during delivery to the testing laboratory for curing and testing.

4.1.7.4 The Contractor shall record the maximum-minimum temperature readings for each storage box.

4.1.7.5 The Contractor shall deliver the test cylinders to a CSA certified testing laboratory.

4.1.7.6 Handling and transporting of the cylinders shall be in accordance with CSA Standard A23.2, Test Method A23.2-3C.

4.1.7.7 No extra laboratory curing time will be allowed for cylinders that are delivered late to the laboratory.

4.1.7.8 A copy of the test results shall be forwarded to the Engineer within two days of each individual compressive strength test date.

- Test results shall include all information as described in CSA Standard A23.2, Annex B, Form for Reporting Compressive Strength of Concrete Test Cylinders.

4.1.8 Field Cured Test Cylinders

4.1.8.1 The Engineer may require field cured test cylinders be cast to check the adequacy of the Contractor's curing or cold weather protection.

4.1.8.2 The Contractor may also cast field cured test cylinders for determining interim compressive strengths that may be required for further work progress approval such as opening to traffic, formwork removal and/or girder erection, etc.

4.1.8.3 Casting, handling, transporting and testing shall be in accordance with CSA Standard A23.2, Test Method A23.2-3C and Test Method A23.2-9C.

4.1.8.4 Test cylinders shall be stored as near as possible to the point in the structure that the test cylinders represent, and shall be afforded the same temperature protection and moisture environment as the structure.

4.1.8.5 At the end of the curing period the test cylinders shall be left in place, exposed to the weather in the same manner as the structure.

4.1.8.6 All test cylinders shall be removed from the field storage and stored in lime water at 23° C ± 2° C for 24 h ± 4h immediately before time of testing to ensure uniform moisture conditions from cylinder to cylinder.

4.1.8.7 Test results on field cured test cylinders shall not be used as a basis for acceptance or rejection of the concrete.

4.1.9 Failure to Meet Minimum Compressive Strength Specifications

4.1.9.1 Where the compressive strength is not satisfactory, the Contractor shall prepare a plan for remedial measures and the plan shall be submitted to the Engineer for review.

- If the proposed plan is not acceptable to the Engineer then the Engineer may order replacement or reinforcing, or other remedial measures, at the Contractor's expense, for portions of the structure.

- Alternatively, at the Engineer's discretion, the under strength concrete may be accepted at a reduced price.

4.1.9.2 The coring of concrete, to verify its compressive strength, will be allowed only for concrete which is otherwise to be replaced or reinforced.

- Coring will not be allowed for concrete for which reduced payment is to be made for under strength.

- When coring is allowed, cores shall be taken at locations directed by the Engineer.

- Coring shall not commence until the Engineer is present.

- Where coring is allowed, it shall be carried out by an independent qualified testing firm.

    - Three cores shall be obtained and tested in accordance with CSA Standard A23.2, Test Method A23.2-14C "Obtaining and Testing Drilled Cores for Compressive Strength Testing" at each test location.

    - Concrete in the area represented by the core tests may be considered structurally adequate if:

        - The average compressive strength result of each set of three cores from the portion of the structure in question is equal to at least 100% of the specified compressive strength.

        - The compressive strength test result of any single core is not less than 80% of the specified compressive strength.

4.1.9.3 Notwithstanding the final result, the Contractor shall be responsible for all costs associated with the coring operation and testing, and will not be reimbursed for inconvenience or other associated costs.

4.1.10 Failure to Meet Slump or Entrained Air Content Specifications

4.1.10.1 In the event that the slump and/or entrained air content are outside the specified limits, the Engineer may accept adjustments to correct the deficient condition as an alternative to rejection. In such cases, adjustments must be completed within the maximum time allowed as specified in Specification 6300.3.11.1.

5 MEASUREMENT

5.1 Concrete will be measured in place, in cubic metres, on the basis of the actual volume within the neat lines of the structure as shown on the Plans.

6 PAYMENT

6.1 Payment for Concrete for Bridge Work will be at the contract unit price per cubic metre for Concrete Type DC, Concrete Type C or Concrete Type G1. The unit price will be full compensation for all equipment, tools, material, falsework, forms, bracing, labour, foundation waterproofing, supply of admixtures, aggregates and water, surface finishing and all other items of expense required to complete the work shown on the Plans, with the exception of reinforcing steel. The payment for Concrete for Bridge Work shall also include the development of the concrete mix design, testing, monitoring, heating and hoarding, and cooling. The payment for Concrete for Bridge Work shall include the cost of cleaning of steel girders and installing all joint fillers, drains, anchor bolts, waterstops, expansion joint assemblies, bearings and miscellaneous devices unless they are covered by other items in the Contract.

6.2 Payment for Type DC or Type C concrete used in the fabrication of precast concrete items will be included in the contract unit price for those items.

6.3 Payment for Type C1 concrete will be included in the contract unit price for Installation of Concrete Slope Protection.

6.4 Payment for Type P1 concrete will be included in the contract unit price for Piling.

6.5 Payment for Type P2 concrete will be included in the contract unit price for Concrete Piling.

6.6 Payment for Type G1 concrete will be included either in the contract lump sum price for Precast Prestressed Concrete Stringer Erection or in the contract lump sum price for Erection of Precast Prestressed Concrete Girders, whichever is applicable.

6.7 Pay adjustments will apply for Type DC concrete that is not in conformance with the specified 28-day compressive strength.

6.7.1 The volume of concrete used to adjust the contract unit price will be based on whole truckloads of concrete and will include all truckloads placed after a complying load up to and including the non-complying load to a maximum of 20 m^3 for any one test.

6.7.2 When Type DC concrete fails to meet the specified compressive strength, a penalty will be assessed in accordance with the Special Provisions.