5.5 SUPPLY OF PORTLAND CEMENT CONCRETE

5.5.1 DESCRIPTION

5.5.1.1 General

Portland cement concrete, shall consist of a mixture of Portland cement, fine aggregate, coarse aggregate, water, and admixtures where required, combined in proportions to meet the Specifications contained herein.

5.5.1.2 Class and Composition of Concrete

The Contractor shall supply Portland cement concrete in accordance with the following requirements for the Class of concrete specified or designated by the Consultant:

TABLE 4-1: CLASSES OF CONCRETE

Class of Concrete	Minimum Specified Compressive Strength @ 28 Days (MPa)	Nominal Maximum Aggregate Size (mm)	Range of Slump (mm)	Entrained Air Cont. (%)	Maximum Water/ Cementing Materials Ratio
A [1]	25	40 to 5	70±20	4 - 7	0.45
B	30	28 to 5	70±20	4 - 7	0.45
C	35	20 to 5	100±30	5 - 8	0.40
D	30	14 to 5	100±30	5 - 8	0.42
S	20	20 to 5[2]	100±30	5 - 8	0.50
Pile	30	20 to 5[2]	130±30	5 - 8	0.42

[1] The Contractor will be permitted to supply Class B concrete where Class A has been specified; payment will be as if Class A had been supplied.

[2] 28 to 5 mm nominal maximum coarse aggregate size may be utilized for Class S, or Pile concrete.

All properties shall be determined in accordance with the requirements of the latest version of CSA Standards A23.1, Concrete Materials and Methods of Concrete Construction, and A23.2, Methods of Test and Standard Practices for Concrete.

5.5.2 MATERIALS

Concrete shall consist of Portland cement, aggregates, water and admixtures or additives that confirm to the following requirements. All materials shall be supplied by the Contractor.

5.5.2.1 Portland Cement

Portland cement shall conform to the requirements of Specification 5.11, Supply of Portland Cement, and concrete products in accordance with CSA A23.1

Unless otherwise specified, directed or approved by the Consultant, Normal Type GU Portland Cement shall be used.

When High Sulphate Resistant cement is specified, Type HS or HSb cement shall be supplied unless otherwise specified. As an alternative to Type HSb cement, concrete intended for

placement in sulphate environments may be produced with combinations of Type GU cement and supplementary cementing materials provided current CSA A3004-C8 test data demonstrating compliance with CSA A3001 requirements for high sulfate resistance.

5.5.2.2 **Fly Ash**

Fly ash may be used in concrete mixes where the aggregate is assessed to be potentially alkali-silica reactive and/or the concrete will be exposed to sulphate conditions.

Fly ash shall not exceed 30% by mass of cementing materials. All fly ash shall conform to the requirements of CSA-A3001 Cementitious Material Compendium for Type “F” fly ash, with a maximum calcium oxide (CaO) content of 12%.

Only approved compatible super plasticizing admixtures and air entraining agents shall be used with fly ash.

5.5.2.3 **Water**

Water shall conform to the requirements of the latest version of CSA Standard A23.1 and shall be free from harmful amounts of alkali, organic materials or deleterious substances. The Contractor shall not use slurry water, treated wash water or water from shallow, stagnant or marshy sources. Water used in Portland cement concrete construction shall be subject to the prior approval of the Consultant.

5.5.2.4 **Aggregates**

The Contractor shall supply aggregates conforming to the requirements of the latest version of CSA Standard A23.1. Aggregates used in Portland cement concrete shall be subject to the prior approval of the Consultant.

5.5.2.5 **Admixtures**

All approved admixtures, such as water reducing agents, and super plasticizers shall conform to ASTM C494 and be compatible with all other constituents. The addition of calcium chloride, accelerators and air-reducing agents, will not be permitted, except when approved by the Department/Consultant. When approved by the Consultant, set controlling admixtures conforming to ASTM C494, Type B and/or D may be used for projects where haul times are expected to exceed the specified times. Air-entraining admixtures shall conform to the requirements ASTM C260.

Anti-washout admixtures shall conform to the US Army Corps of Engineers CRD-C 661

5.5.3 CONSTRUCTION

5.5.3.1 **Care and Storage of Materials**

All Portland cement concrete materials shall be handled and protected in such a way as to prevent segregation, damage and contamination.

All cement, aggregate and other concrete construction materials shall be stored in accordance with the requirements of the latest version of CSA A3001 and CSA A23.1. Any segregated, damaged, or contaminated materials shall be rejected.

5.5.3.2 **Aggregate Tests and Concrete Mix Design**

The Contractor shall be responsible to ensure that the concrete mix designs for each class of concrete are submitted to the Consultant for review a minimum of two weeks prior to the scheduled placing of concrete.

For each concrete mix design, the following aggregate analysis shall be provided:

- Sieve Analysis of Fine and Coarse Aggregate (CSA A23.2-2A)
- Amount of material finer than 80 µm in aggregate (CSA A23.2-5A)
- Test for organic impurities in fine aggregates for concrete (CSA A23.2-7A)
- Standard practice to identify degree of alkali-reactivity of aggregates and to identify measures to avoid deleterious expansion in concrete (CSA A23.2-27A)
- Sources of proposed aggregate

The analysis of the aggregates shall fully represent the material to be used in production.

If the fine aggregate consists of a blend from more than one source, the "Fine Aggregate Sieve" analysis shall show the gradation of the blended fine aggregates. Similarly in the case of blended coarse aggregates, the "Coarse Aggregate Sieve" analysis shall indicate the gradation of the blended coarse aggregates. Aggregate gradations for the coarse and fine aggregate shall meet the criteria outlined in Tables 10 and 11 of CSA A23.1.

Fine aggregate, tested in accordance with CSA Test Method A23.2-7A, "Organic Impurities in Sands for Concrete", shall produce a colour not darker than the Standard colour (Organic Plate Number 3). Aggregate producing a colour darker than the Standard colour will be rejected in the absence of a satisfactory record of performance of a similar CSA exposure class of concrete (minimum 30 tests over the last 12 months); provisions 4.2.3.3.3.2 (a) & (b) of CSA Standard A23.1shall not apply.

The potential for deleterious alkali-aggregate reactivity shall be assessed in accordance with CSA A23.2-27A. Test data, less than 24-months old, evaluating the potential alkali-silica reactivity of aggregates tested in accordance with CSA A23.2-14A or CSA A23.2-25A shall be provided by the Contractor for the Consultant’s review. In the absence of current test data and outside of areas of known highly reactive aggregate, the aggregate shall be presumed to be moderately reactive. This assessment shall include the risk level associated with structure type (CSA 23.2 Table 5) and environment (CSA 23.2 Table 3), the level of prevention related to service life requirements and the determination of the appropriate preventative measures. Unless otherwise indicated the service life is considered to be 50 years (St3)

For all concrete mixes the minimum cement content, excluding supplementary cementing materials, shall be 300 kg/m^3.

Concrete mixes that will be placed by concrete pump shall be designed for pumping.

The sampling and testing of aggregates, and the concrete mix design shall be completed by a CCIL/CSA certified and qualified concrete testing laboratory that has a permit to practice in the Province of Alberta. The testing laboratory shall provide an engineering opinion that concrete aggregate and mix designs are suitable for the intended use and are expected to perform to specified standards.

If, during the progress of the Work, it is determined that the concrete has inadequate workability, or does not meet the requirements of the Specification, the Contractor shall provide a new mix design for the Consultants approval.

All concrete shall be proportioned in accordance with the approved mix designs.

All costs associated with aggregate testing and providing the mix designs shall be the responsibility of the Contractor.

5.5.3.3 **Consistency**

The slump shall be in accordance with the Specifications contained herein, however, the slump for slip-formed concrete shall be limited to a maximum of 50 mm, or to such other value as may be necessary to enable the material to be slip-formed without subsequent distortion.

Generally, mass and mechanically vibrated concrete shall have slumps in the lower portion of the specified range, and heavily reinforced and/or inaccessible sections shall have slumps in the higher end of the range.

5.5.3.4 **Concrete Production**

Portland cement concrete shall be produced in accordance with the requirements of the latest version of CSA Standard A23.1, unless otherwise approved by the Consultant.

5.5.3.5 **Delivery**

Delivery of Portland cement concrete shall be regulated so as to enable continuous deposition until the placement of each concrete section is completed.

The concrete temperature at discharge shall be between 10°C and 25°C for all classes of concrete unless otherwise specified.

5.5.3.6 **Curing Concrete**

Curing of the placed concrete shall be in accordance with Section 7.7, Curing of CSA A23.1 for a Curing Type 2 concrete surface.

Concrete shall be protected from freezing, abnormally high temperatures or temperature differentials, premature drying, water damage and moisture loss for the curing period.

For a minimum of 7 days after finishing, or until the concrete has attained 70% of the specified concrete strength, whichever is greater; concrete shall be protected against damage by any form of traffic. The Contractor may block off areas containing fresh concrete to safeguard the Work from traffic.

Hot-weather curing requirements shall apply when the concrete is placed with an air temperature of 27ºC or higher, or when the air temperature is forecast to exceed this value during the 7 day curing period. During periods of hot-weather curing, the Contractor shall use a water spray or saturated absorptive fabric to achieve cooling by evaporation.

The Contractor shall submit a proposed cold weather concreting plan to the Consultant for review and acceptance a minimum of two weeks prior to any concrete placement. This plan shall outline how the contractor plans to protect the Concrete from freezing, using industry best practices. When the air temperature is, or is expected to be below 5°C as forecasted by the closest Environment Canada Meteorological Station during the placing and curing period, or when determined by the Consultant, the cold weather concreting plan shall be implemented by

the Contractor. Methods and materials used for protecting concrete from damage shall be the responsibility of the Contractor, and will be subject to prior approval of the Consultant.

Concrete damaged by moisture loss, freezing, rain, traffic, construction operations, or any other cause shall be repaired, or removed and replaced to the satisfaction of the Consultant, at the Contractor's expense.

5.5.4 SAMPLING AND TESTING

5.5.4.1 **Quality Control Testing**

Quality control testing will be the responsibility of the Contractor. The Contractor shall determine the type and frequency of testing required and shall provide and pay for all equipment and personnel necessary to complete such testing. Results of all quality control testing shall be submitted to the Consultant as they become available.

5.5.4.2 **Acceptance Sampling and Testing**

Acceptance testing is the responsibility of the Consultant. The Consultant will take samples, and carry out quality assurance testing and inspection of materials incorporated or being incorporated into the Work. The Contractor shall cooperate with the Consultant during the sampling, testing and inspection. Such inspection shall not relieve the Contractor from any obligation to perform all the Work strictly in accordance with the requirements of the Contract.

Locations for routine quality assurance testing shall be randomly selected as far as it is practical to do so. This will not limit the Consultant from testing at any additional locations as he deems necessary.

Results of the quality assurance tests will be made available to the Contractor for his information. The Contractor shall be responsible for interpretation of test results and alter his operation if necessary, so that the product meets the Specifications.

5.5.4.3 **Quality Assurance Testing Methods and Frequency**

Unless otherwise specified, the most recent editions of the following standard test methods and frequencies will be used to determine the material characteristics.

Test Description	Method No.	Frequency
Sampling Concrete	CSA A23.2-1C	Minimum of one per day (1)
Slump	CSA-A23.2-5C	Minimum of one per day (2)
Entrained Air	CSA-A23.2-4C	Minimum of one per day (2)
Making and Curing Compressive Strength Specimens	CSA-A23.2-3C	Minimum of one per day (1)
Compressive Strength	CSA-A23.2-9C	Minimum of one per day (1)
Temperature	CSA-A23.2-17C	Minimum of one per day (2)

(1) On larger pours a strength test will be taken on approximately each 30 m^3 portion of the concrete pour. A compressive strength test will consist of four standard test specimens. One cylinder will be tested at seven days. The 28 day test result will be the average of the remaining three specimens.

(2) For each compressive strength test, a slump, entrained air, and temperature test will be performed.

5.5.4.4 **Slump and Air Content**

In the event that slump and/or air content test results are outside the specified tolerance range as determined by the Consultant's testing, the Consultant may accept adjustments of the deficient condition as an alternate to rejection provided adjustments are made within 90 minutes from batching of the concrete. Concrete that does not meet this requirement is subject to rejection.

On-site addition of water to a concrete batch may be permitted by the Consultant provided the specified water-to-cementing materials ratio is not exceeded, no more than 60 minutes have elapsed from the time of batching, and no more than the lesser of 16 L/m^3 or 10% of the mixing water shall be added. The Consultant reserves the right to reject any batch in the event of confirmed unacceptability, and to require immediate removal of any concrete from this batch that may have already been placed.

Placed concrete that does not meet the specified air content criteria may be accepted by the Consultant if core sample testing conducted by the Contractor indicates that the air content and air-void system parameters of the suspect material is considered satisfactory in accordance with the latest version of CSA-A23.1 clauses 4.3.3.2 and 4.3.3.3.

Sampling and testing costs associated with verifying the suitability of suspect concrete will be the responsibility of the Contractor.

5.5.5 REQUIREMENTS FOR ACCEPTANCE

5.5.5.1 **General**

The Department reserves the right to reject any concrete whatsoever that does not meet all the requirements for the specified class of concrete. The Department may however, accept concrete the strength of which falls below the specified strength requirements.

In such cases, payment will be made in accordance with Subsection 5.5.5.2. The bid price can either be unit price or lump sum.

5.5.5.2 **Payment Scales**

Strength Test Result	**Minimum Compressive Strength Requirement @ 28 Days (MPa)**			
	20	**25**	**30**	**35**
35 MPa and over	Full Payment	Full Payment	Full Payment	Full Payment
34 MPa to 35 MPa	Full Payment	Full Payment	Full Payment	$10 /$m^3$ Penalty
33 MPa to 34 MPa	Full Payment	Full Payment	Full Payment	$20 /$m^3$ Penalty
32 MPa to 33 MPa	Full Payment	Full Payment	Full Payment	$30 /$m^3$ Penalty
31 MPa to 32 MPa	Full Payment	Full Payment	Full Payment	$40 /$m^3$ Penalty
30 MPa to 31 MPa	Full Payment	Full Payment	Full Payment	$50 /$m^3$ Penalty
29 MPa to 30 MPa	Full Payment	Full Payment	$10 /$m^3$ Penalty	$60 /$m^3$ Penalty
28 MPa to 29 MPa	Full Payment	Full Payment	$20 /$m^3$ Penalty	$70 /$m^3$ Penalty
27 MPa to 28 MPa	Full Payment	Full Payment	$30 /$m^3$ Penalty	Reject

Strength Test Result	Minimum Compressive Strength Requirement @ 28 Days (MPa)			
	20	25	30	35
26 MPa to 27 MPa	Full Payment	Full Payment	$40 /m^3 Penalty	Reject
25 MPa to 26 MPa	Full Payment	Full Payment	$50 /m^3 Penalty	Reject
24 MPa to 25 MPa	Full Payment	$10 /m^3 Penalty	Reject	Reject
23 MPa to 24 MPa	Full Payment	$20 /m^3 Penalty	Reject	Reject
22 MPa to 23 MPa	Full Payment	$30 /m^3 Penalty	Reject	Reject
21 MPa to 22 MPa	Full Payment	$40 /m^3 Penalty	Reject	Reject
20 MPa to 21 MPa	Full Payment	$50 /m^3 Penalty	Reject	Reject
19 MPa to 20 MPa	$10 /m^3 Penalty	Reject	Reject	Reject
18 MPa to 19 MPa	$20 /m^3 Penalty	Reject	Reject	Reject
17 MPa to 18 MPa	$30 /m^3 Penalty	Reject	Reject	Reject
16 MPa to 17 MPa	$40 /m^3 Penalty	Reject	Reject	Reject
15 MPa to 16 MPa	$50 /m^3 Penalty	Reject	Reject	Reject
Less than 15 MPa	Reject	Reject	Reject	Reject

The reduced payment shall apply to the volume of concrete as determined by the Consultant.

Removing and replacing of rejected concrete construction shall be done at the Contractor's expense. Any work deemed by the Consultant as defective or damaged by weather, traffic or other causes, shall be repaired or removed and replaced at the Contractor's expense.

5.5.6 PAYMENT

All costs associated with the supply and production of accepted Portland cement concrete shall be included in the unit price bid for the respective structure for which the concrete is being used; no separate or additional payment will be made.