TENDER DOCUMENTS

SUBSECTION 6.33
CAST-IN-PLACE CONCRETE

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SUBSECTION 6.33 CAST-IN-PLACE CONCRETE

6.33.1 GENERAL

6.33.1.1 This subsection sets out the requirements related to the execution of concrete works within projects for the construction of new roadway infrastructures or the repair of existing roadway infrastructures under this Contract.

6.33.1.2 Any specific requirements related to cast-in-place concrete prescribed in this Contract are set out in Section 4 *Special Technical Conditions*.

6.33.1.3 The requirements related to concrete demolition are set out in subsection 6.21 *Demolition and Removal*.

6.33.1.4 The requirements related to reinforcing steel and anchors are set out in subsection 6.31 *Reinforcing Steel for Concrete.*

6.33.1.5 The requirements related to formwork are set out in subsection 6.32 *Formwork.*

6.33.2 REFERENCE STANDARDS

6.33.2.1 The **Contractor** shall perform all concrete work in accordance with the requirements of the following standards and documents to which the provisions of the Contract are added:

6.33.2.1.1 (AASHTO) American Association of State Highway and Transportation Officials

- AASHTO M182-05-UL *Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats*;
- AASHTO T026-79-UL *Standard Method of Test for Quality of Water to be used in Concrete*.

6.33.2.1.2 (ACI) American Concrete Institute

- ACI 304.2R-96 *Placing Concrete by Pumping Methods* ;
- ACI 306R-88 *Cold Weather Concreting (Reapproved 2002)*;
- ACI 309R-05 *Guide for Consolidation of Concrete.*

6.33.2.1.3 (ASTM) ATM International

- ASTM C109/C109M-07e1 *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*;
- ASTM C157/C157M-06 *Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete*;
- ASTM C171-07 *Standard Specification for Sheet Materials for Curing Concrete*;

- ASTM C260-06 *Standard Specification for Air-Entraining Admixtures for Concrete*;
- ASTM C295-03 *Standard Guide for Petrographic Examination of Aggregates for Concrete*;
- ASTM C309-07 *Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*;
- ASTM C348-02 *Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars*;
- ASTM C457-08b *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*;
- ASTM C494/C494M-08a *Standard Specification for Chemical Admixtures for Concrete*;
- ASTM C642-06 *Standard Test Method for Density, Absorption, and Voids in Hardened Concrete*;
- ASTM C666/C666M-03(2008) *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*;
- ASTM C672/C672M-03 *Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals*;
- ASTM C685/C685M-07 *Standard Specification for Concrete Made By Volumetric Batching and Continuous Mixing*;
- ASTM C881/C881M-02 *Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*;
- ASTM C882/C882M-05e1 *Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear*;
- ASTM C1017/C1017M-07 *Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete*;
- ASTM C1064/C1064M-08 *Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete*;
- ASTM C1152/C1152M-04e1 *Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete*;
- ASTM C1202-07 *Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration*;
- ASTM D512-04 *Standard Test Methods for Chloride Ion In Water*;
- ASTM D516-07 *Standard Test Method for Sulfate Ion in Water*;
- ASTM D4191-03 *Standard Test Method for Sodium in Water by Atomic Absorption Spectrophotometry*;
- ASTM D4192-03 *Standard Test Method for Potassium in Water by Atomic Absorption Spectrophotometry*;

- ASTM D5095-91(2007) *Standard Test Method for Determination of the Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments*;
- ASTM D5167-03 *Standard Practice for Melting of Hot-Applied Joint and Crack Sealant and Filler for Evaluation*;
- ASTM D5329-07 *Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements*.

6.33.2.1.4 (CSA) Canadian Standards Association

- CAN/CSA-A23.1-04/A23.2-04 *Concrete Materials and Methods of Concrete Construction/ Methods of Test and Standard Practices for Concrete*;
- CAN/CSA-A23.3-04 *Design of Concrete Structures*;
- CAN/CSA-A3000-08 Consolidation *Cementitious Materials Compendium (which Consists of A3001, A3002, A3003, A3004 and A3005)*;
- CAN/CSA S6-06 *Canadian Highway Bridge Design Code*.

6.33.2.1.5 (BNQ) Bureau de normalisation du Québec

- BNQ 2560-114/2007 *Travaux de génie civil – Granulats,* Partie IV *Béton de masse volumique normale*;
- BNQ 2621-900-2005 *Bétons de masse volumique normale et constituants;*
- BNQ 2621-905/2005 *Bétons de ciment de masse volumique normale et constituants – Protocole de certification*.

6.33.2.1.6 (MTQ) Ministère des Transports du Québec

- MTQ – *Cahier des charges et devis généraux* (CCDG);
- MTQ – *Normes – Ouvrages routiers* – Tome VII *Matériaux*, Chapitre 3 *Béton de ciment et produits connexes;*
- MTQ – *Normes – Ouvrages routiers* – Tome VII *Matériaux*, Chapitre 4 *Liants et enrobés bitumineux,* Norme 4401 *Produits de colmatage de fissures et de joints*.

6.33.2.1.7 (CGSB) Canadian General Standards Board

- CGSB 41-GP-35M *Polyvinyl Chloride Waterstop*.

6.33.2.1.8 In addition to the above standards, concrete placed under water shall meet the following standards :

6.33.2.1.8.1 (ACI) American Concrete Institute

- ACI 546.2R-98 *Guide to Underwater Repair of Concrete*

6.33.2.1.8.2 United States Army Corps of Engineers

- CRD-C61-89A *Test Method for Determining the Resistance of Freshly Mixed Concrete to Washing Out in Water* (12-01-1989).

6.33.3 MATERIALS

6.33.3.1 CEMENT AND SUPPLEMENTARY CEMENTING MATERIALS

6.33.3.1.1 Hydraulic cements shall conform to standards CAN/CSA-A23.1 and CAN/CSA -A3000.

6.33.3.1.2 The cementitious material used shall be a Type GU general-purpose hydraulic Portland cement or a GUb-SF, GUb-S/SF or GUb-F/SF blended hydraulic cement.

6.33.3.1.3 The total mass of supplementary cementing materials (fly ash, ground granulated blast furnace slag and silica fume) shall not exceed 30% of the total mass of the cementitious material.

6.33.3.1.4 Silica fume shall conform to standard CAN/CSA-A3000*,* Type U, in a ratio of 6% to 8% by mass of cement.

6.33.3.1.5 Fly ash, where required, shall meet the requirements for Type F in standard CAN/CSA-A3000, more specifically section A3001 – *Cementitious Materials for Use in Concrete*.

6.33.3.1.6 Unless otherwise indicated, the use of ternary cement is prohibited from October 15 to March 31.

6.33.3.2 WATER

6.33.3.2.1 Water used for mixing and curing concrete shall be fresh, clean, potable and free of oil and chemical or organic impurities and shall conform to the provisions of section 4 of standard CAN/CSA-A23.1.

6.33.3.2.2 Raw water used as mixing water shall conform to the following properties (from standard CAN/CSA-A23.1, clause 4.2.2):

Parameter	Maximum concentration in mixing water (mg/L)	Test method
Chlorides	500 (for pre-stressed concrete) 1,000 (for other reinforced concrete)	ASTM D512
Sulphates (SO_4)	3,000	ASTM D516
Alkalis ($Na_2O + 0.658\ K_2O$)	500 600	ASTM D4191 ASTM D4192
Total solids	50,000	AASHTO T026

6.33.3.3 AGGREGATE

6.33.3.3.1 All aggregate shall be clean, strong and free of deleterious materials and shall conform to the requirements of standard CAN/CSA-A23.1 applicable to the appropriate exposure class.

6.33.3.3.1.1 The **Contractor** shall submit to the Engineer for review a statement signed by the qualified person who carried out the petrographic examination of the fine and coarse aggregate (in accordance with standard ASTM C295) certifying that the aggregate used in the concrete will not lead to excessive expansion of or cracks in the concrete caused by the alkali-aggregate reaction or any other adverse reaction as prescribed in standard CAN/CSA-A23.1.

6.33.3.3.1.2 Aggregate shall consist of natural sand, gravel or crushed stone that conforms to the grading, strength and durability requirements in standard CAN/CSA -A23.1.

6.33.3.3.2 Normal-density fine aggregate

6.33.3.3.2.1 Normal-density fine aggregate shall consist of natural sand, manufactured sand or a combination thereof.

6.33.3.3.2.2 Fine aggregate shall be graded as follows:

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	10-35
160 μm	2-10
80 μm	0-3

6.33.3.3.3 Normal-density coarse aggregate

6.33.3.3.3.1 Normal-density coarse aggregate shall consist of crushed stone, natural gravel, air-cooled blast-furnace slag or a combination thereof conforming to standard CAN/CSA-A23.1.

6.33.3.3.3.2 Coarse aggregate shall be graded as follows:

Nominal size of aggregate, mm	Total passing each sieve, percentage by mass						
	28 mm	20 mm	14 mm	10 mm	5 mm	2.5 mm	1.25 mm
20-5	100	85-100	50-90	25-60	0-10	0-5	-
14-5		100	90-100	45-75	0-15	0-5	-
10-2.5			100	85-100	10-30	0-10	0-5

6.33.3.3.4 Alkali-aggregate reactivity

6.33.3.3.4.1 Aggregate used in the concrete shall not react with alkalis contained within the concrete to an extent that results in excessive expansion, cracking or both of the concrete.

6.33.3.3.4.2 Evaluation of the potential reactivity of an aggregate shall be performed following standard CAN/CSA-A23.2-14A *Potential Expansivity of Aggregates*.

6.33.3.3.4.3 Classification of the reactivity of aggregate is based on Table 2 in standard CAN/CSA-A23.2-27A *Standard Practice to Identify Potential for Alkali-Reactivity of Aggregates and Measures to Avoid Deleterious Expansion in Concrete* using concrete prism test results. Results obtained using the accelerated test will not be considered.

6.33.3.3.4.4 Aggregate classified as “highly reactive” shall not be used. Aggregate classified as “moderately reactive” may be used in combination with one of the following preventive measures:

6.33.3.3.4.4.1 limit the alkali content of the Portland cement in the concrete to 2.4 kg/m³ of Na_2O equivalent as prescribed in Table 5 *Preventive Measures* in standard CAN/CSA-A23.2-27A;

6.33.3.3.4.4.2 use GUb-S/SF or GUb-F/SF ternary cement in conformity to standard CAN/CSA-A3000 (more specifically, A3001), as prescribed in Table 6 of standard CAN/CSA-A23.2-27A.

6.33.3.3.4.5 Aggregates which present alkali-carbonate reactivity shall not be used.

6.33.3.4 ADMIXTURES

6.33.3.4.1 Air-entraining admixtures

6.33.3.4.1.1 Air-entraining admixtures shall conform to standard ASTM C260.

6.33.3.4.1.2 All concrete used by the **Contractor** shall contain an air-entraining admixture. Air-entraining admixtures shall be compatible with the other admixtures and the type of cement used.

6.33.3.4.2 Chemical admixtures

6.33.3.4.2.1 Chemical admixtures shall conform to standard ASTM C494/C494M or ASTM C1017/C1017M.

6.33.3.4.2.2 The chemical admixtures used shall not contain any chlorides; furthermore, Type C and Type E admixtures (accelerators) are prohibited.

6.33.3.4.2.3 Unless otherwise indicated, only Type A water reducers shall be used. The reducers shall reduce water demand by more than 5% compared with a control mixture that also contains entrained air.

6.33.3.4.2.4 For self-placing concrete, a polysaccharide or cellulose-based colloidal agent shall be used to prevent the concrete from segregating. The minimum mix proportions are:

6.33.3.4.2.4.1 polysaccharide colloidal agent: 1,100 mL/100 L water;

6.33.3.4.2.4.2 cellulose-based colloidal agent: 130 mL/100 kg cement.

6.33.3.4.2.5 The Engineer may also call for a retarder as prescribed by standard ASTM C494/C494M and an anti-shrinkage admixture. The methods and proportions recommended by the manufacturer shall be used.

6.33.3.4.2.6 Depending on the nature of the work and the related requirements, the Engineer may call for the use of a superplasticizer (high-range water reducer). Owing to some of the properties of this type of admixture, special measures shall be taken by the **Contractor** when it is used:

6.33.3.4.2.6.1 before the superplasticizer is added, the slump of the concrete shall be within the prescribed limits;

6.33.3.4.2.6.2 at the time it is incorporated into the component, the concrete shall have an air content within the prescribed limits.

6.33.3.4.2.7 Superplasticizer used for self-placing concrete shall be naphthalene sulphonate based.

6.33.3.4.2.8 Where superplasticizer is used, the slump measured after mixing on site shall be maintained at a maximum of 150 mm unless otherwise indicated by the Engineer.

6.33.3.4.3 Pulverulent admixtures

6.33.3.4.3.1 Pulverulent admixtures shall be made into a solution as recommended by the manufacturer prior to use.

6.33.3.4.3.2 Admixture solutions or suspensions shall be shaken in order to preserve their homogeneity.

6.33.3.5 CURING MATERIALS

6.33.3.5.1 Materials used to cure concrete shall conform to the requirements of the following standards: ASTM C171, ASTM C309 and AASHTO M182.

6.33.3.5.2 Membrane-forming curing products

6.33.3.5.2.1 Chemical curing products may not be used unless specifically authorized in the *Special Technical Conditions* or by the Engineer where he believes that wet curing will be difficult to achieve.

6.33.3.5.2.2 Membrane-forming curing products shall conform to standard ASTM C309 and shall be translucent with a fugitive dye (Type 1-D).

6.33.3.5.3 Absorbent fabric

6.33.3.5.3.1 Non-woven needle-punched absorbent fabric made of polyester or polypropylene synthetic fibres shall have a minimum surface mass of 300 g/m^2 and shall be white.

6.33.3.5.3.2 Absorbent fabric shall be at least 1 m wide and shall not contain any substances that could be deleterious to the concrete. New fabric shall be rinsed with running water to make it more absorbent and remove any soluble material.

6.33.3.5.4 Waterproof sheeting

6.33.3.5.4.1 Waterproof sheeting shall conform to the requirements of standard ASTM C171.

6.33.3.5.4.2 Waterproof sheeting may be:

6.33.3.5.4.2.1 a transparent or opaque white polyethylene film at least 0.1 mm thick, or

6.33.3.5.4.2.2 a fabric with a minimum surface mass of 305 g/m^2 covered on one side with an opaque white polyethylene film at least 0.1 mm thick.

6.33.3.5.4.3 Waterproof sheeting shall be at least 1 m wide, shall have no tears and shall not contain any substances that could be deleterious to the concrete.

6.33.3.6 CALCIUM CHLORIDE

6.33.3.6.1 Calcium chloride shall not be used at any time.

6.33.3.7 STANDARD CONCRETE

6.33.3.7.1 Standard concrete shall conform to the following properties:

28-day strength (MPa)	Min. mass of cement (kg/m^3)	Max. water/cementitious material ratio	Slump (mm)		Coarse aggregate (mm)	Air content (%)
			±30 mm(3)	±40 mm(3)		
35	340 (1) 365 (2)	0.45	80(4)		5-20	5-8
45	370(1)	0.40	80(4)		5-14	5-8
50	410 (1)	0.37		180	5-14	5-8

(1) Type GUb-SF cement.
(2) Type GUb-S/SF or GUb-F/SF cement.
(3) Tolerances on specified values apply for control purposes only.
(4) After superplasticizer is added, maximum slump shall be 150 mm.

6.33.3.8 SELF-PLACING CONCRETE

6.33.3.8.1 Self-placing concrete shall conform to the following properties:

28-day strength (1) (MPa)	Min. mass of ternary cement (kg/m^3)	Max. water/cementitious material ratio	Max. volume coarse aggregate (L/m^3)	Air content (%)	Spread (mm)	Max. flow (s)	Sand/paste volume ratio (4)
35	460	0.35-0.40(3)	330 (2.5-10 mm)	6-9	700 ±50 mm(2)	5	0.6-0.8
35	450	0.38-0.43(3)	300 (5-20 mm)	5-8	625 ±50 mm(2)	8	0.6-0.8

(1) Minimum compressive strength at 48 hours shall be 10 MPa.
(2) Tolerances on specified values apply for control purposes only.
(3) Indicates minimum to maximum ratio of water to cementitious material.
(4) Sand/paste volume ratio is sand/(cementitious material + water + air).

6.33.3.8.2 Bagged self-placing concrete is forbidden unless otherwise mentioned to the *Special Technical Conditions*.

6.33.3.9 ANTIWASHOUT CONCRETE

6.33.3.9.1 Antiwashout concrete for underwater applications shall conform to the following properties:

28-day strength (MPa)	Min. mass of GUb-SF cement (kg/m^3)	Max. water/cementitious material ratio	Coarse aggregate (mm)	Fine aggregate (%)(1)	Air content (%)	Slump (mm)
35	450	0.42	2.5-10	45-55	6-9	200 ±40

(1) Percentage in relation to total aggregate mass.

6.33.3.10 CEMENT MORTAR

6.33.3.10.1 Mortar shall be prepared, handled and applied in conformity to the manufacturer's requirements and based on the placement conditions at the repair site.

6.33.3.10.2 Cement mortar shall contain less than 5% coarse aggregate not passing through a 10 mm sieve.

6.33.3.10.3 Polymers used as components of cement mortar shall be used with or instead of mixing water.

6.33.3.10.4 Fibres used as components of cement mortar shall be made of a non-corroding material.

6.33.3.10.5 Cement mortar properties and test methods

Property	Test method	Criterion	Class of mortar		
			N(1)	R(1)	VR(1)
Compressive strength (MPa)	ASTM C109/ C109M	3 hours	-	-	17
		1 day	12	22	-
		7 days	30	35	45
		28 days	30	35	45
Flexural strength (MPa)	ASTM C348	7 days	6.0		
Concrete bond (MPa)	ASTM C882/C882M	1 day	7.0		
		7 days	10.0		
Water absorption (%)	ASTM C642	28 days max.	5.5		
Length change (%)	ASTM C157/ C157M	28 days (water)	+0.15		
		28 days (air)	-0.15		
Surface flaking Max. loss (kg/m²)	BNQ 2621-900	(56 cycles)	0.50		
Freezing and thawing Min. elasticity modulus (%)	ASTM C666/ C666M	(300 cycles)	80		
Chloride ion content (kg/m³)	ASTM C1152/ C1152M	N/A	0.60		

(1) N: Normal setting mortar, R: Rapid setting mortar, VR: Very rapid setting mortar

6.33.4 EQUIPMENT AND TOOLS

6.33.4.1 MOBILE CONCRETE MIXER

6.33.4.1.1 If concrete is to be placed at a rate slower than 2 m^3/h or if less than 5 m^3 of concrete is to be poured, the concrete can be made up and mixed on site in a mobile concrete mixer in conformity to standard ASTM C685/C685M.

6.33.4.1.2 If the **Contractor** opts to supply concrete from floating facilities, a barge-mounted mobile plant is permitted provided it conforms to all the requirements of standard ASTM C685/C685M. Mixing tests shall be conducted by the **Contractor**, as well as repeatability tests to determine the mixing order and times for each ingredient in the mix.

6.33.4.1.3 The mobile concrete mixer and its operator shall be identified, and only that mixer and that operator will be authorized to supply concrete during the works. The test results shall be recorded in writing, and a copy shall be given to the Engineer before concreting begins. Storage areas for materials shall conform to the requirements of standard CAN/CSA-A23.1 and shall be set up so as to protect the materials from dampness and other climatic conditions.

6.33.4.1.4 The first 0.25 m^3 of each batch of concrete supplied by the mobile concrete mixer and used to prepare and calibrate the equipment may not be used and shall be discarded.

6.33.4.2 VIBRATOR

6.33.4.2.1 Vibrators shall conform to the requirements of standard CAN/CSA-A23.1 and meet the following characteristics:

Minimum frequency while immersed in concrete (Hz)	Diameter of vibrator head (mm)	Rate of placement per vibrator (m^3/h)
170-250	20-40	1-4
150-225	30-60	2-8
130-200	50-90	5-15

6.33.4.3 CONCRETE PUMP

6.33.4.3.1 Pumping equipment shall conform to the requirements of standard CAN/CSA -A23.1.

6.33.4.3.2 The concrete pump used shall be capable of pumping the specified concrete through the specified lengths of pipe at the required flow rates without any change to the proportioning of the ingredients in the mix.

6.33.4.3.3 No adjustment of proportions to obtain a mix with a higher cement content, a high sand-stone ratio or a higher slump than the requirements in the specifications is permitted to meet the requirements of a specific marks and models of pump.

6.33.4.4 TREMIE

6.33.4.4.1 The tremie shall be watertight and sufficiently large in cross-section to allow a free flow of concrete.

6.33.4.4.2 The freefall height of the concrete shall not exceed 1.2 m, and if necessary, a tremie extended with down pipes or “elephant trunks” shall be used.

6.33.4.4.3 The inside diameter of the down pipe or “elephant trunk” of the tremie shall be at least eight (8) times the maximum dimension of the aggregate and at least 150 mm in order to ensure that the concrete is able to flow freely without having to be vibrated.

6.33.4.4.4 The maximum length of the concrete fall in an “elephant trunk” is 9 m. Where this maximum length must be exceeded, reception hoppers with a capacity greater than the inflow of concrete shall be used.

6.33.5 EXECUTION

6.33.5.1 PRE-CONCRETING MEETING

6.33.5.1.1 The **Contractor** shall hold a pre-concreting meeting at least fourteen (14) days before concreting begins. The **Contractor** shall at that time have the Engineer validate the following:

6.33.5.1.1.1 the concreting method proposed for each type of repair based on the drawings and specifications;

6.33.5.1.1.2 the repair materials proposed based on the requirements of these specifications, including any adjustments made as a result of suitability tests;

6.33.5.1.1.3 the quality control measures put in place by the **Contractor** to ensure the success of the work.

6.33.5.2 CONCRETE MIX

6.33.5.2.1 The **Contractor** is responsible for proportioning the ingredients in the proposed concrete mix and shall, fourteen (14) days before concreting begins, provide the Engineer with the proposed mix formulas and concreting methods.

6.33.5.2.2 The **Contractor** shall provide a technical data sheet on the concrete mix dated and signed by the manufacturer's head of quality control. The data sheet is valid for one (1) calendar year.

6.33.5.2.3 The data sheet shall include the following information:

6.33.5.2.3.1 a mix designation, number or code;

6.33.5.2.3.2 the plastic concrete density of the mix in kg/m³ for the specified air content and slump;

6.33.5.2.3.3 the cement mass of the mix in kg/m³;

6.33.5.2.3.4 the quantity of water in the mix in l/m³;

6.33.5.2.3.5 the mass of fine and coarse aggregate in the mix (saturated surface dry (SSD) condition) in kg/m³;

6.33.5.2.3.6 the water to cementitious material ratio, SSD condition;

6.33.5.2.3.7 the specified compressive strength;

6.33.5.2.3.8 the air content and slump limits;

6.33.5.2.3.9 the types of admixtures, product names, manufacturers and proposed quantities;

6.33.5.2.3.10 the type of cement, the source and the name of the cement plant;

6.33.5.2.3.11 a report not more than three years old from a recognized laboratory confirming the characteristics of the air void system in the supplied mix, namely, the air content, the air void spacing factor and the specific surface area;

6.33.5.2.3.12 the intrinsic manufacturing and complementary properties of the fine and coarse aggregate and their source for each calendar year;

6.33.5.2.3.13 the grade, the oven-dry rodded bulk density, the gross relative density (SSD condition), the percentage absorption of fine and coarse aggregate, and the fineness modulus and colour indicator of the fine aggregate;

6.33.5.2.3.14 a report not more than three years old from a recognized laboratory confirming the potential alkali-aggregate reactivity;

6.33.5.2.3.15 the results of performance and suitability tests if required by the *Special Technical Conditions*.

6.33.5.2.4 The mix formulas shall be reviewed and approved by the **Owner**'s laboratory. The **Owner** reserves the right to request changes to the formula so that the formula conforms to the specifications.

6.33.5.2.5 The Engineer may ask the **Contractor** to submit samples of the admixtures it intends to use.

6.33.5.2.6 A manufacturer's certificate shall accompany all samples of admixtures guaranteeing that they are the same in composition as those that will be supplied for application.

6.33.5.3 MIX PROPORTIONS AND PRODUCTION OF CONCRETE

6.33.5.3.1 The **Contractor** shall obtain its supply from a manufacturer capable of guaranteeing that the facilities, equipment and materials used in concrete production and all operations related to concrete production conform to standard CAN/CSA-A23.1.

6.33.5.3.2 The concrete manufacturer's plant shall hold a compliance certificate issued by the BNQ (Bureau de normalisation du Québec) in accordance with certification protocol BNQ-2621-905 *Normal Density Concrete and Materials – Certification Protocol*.

6.33.5.4 WAYBILL

6.33.5.4.1 Before unloading the concrete, the **Contractor** shall present the Engineer with a waybill showing the following information:

6.33.5.4.1.1 the corporate name of the concrete manufacturer and the name and location of the batching plant;

6.33.5.4.1.2 the date and identification number of the waybill;

6.33.5.4.1.3 the name of the **Contractor** to which the concrete is to be delivered;

6.33.5.4.1.4 identification of the roadway infrastructure or structural element;

6.33.5.4.1.5 the grade of the concrete;

6.33.5.4.1.6 the number of the formula, including the quantities of cement, water, coarse aggregate, fine aggregate and admixture actually incorporated into the mix;

6.33.5.4.1.7 the admixtures used;

6.33.5.4.1.8 the temperature limits specified for fresh concrete;

6.33.5.4.1.9 the air content limits;

6.33.5.4.1.10 the slump limits;

6.33.5.4.1.11 the quantity of concrete in cubic metres;

6.33.5.4.1.12 the truck number, total to date for the batch and load number;

6.33.5.4.1.13 the time the truck was loaded;

6.33.5.4.1.14 the arrival time at the site;

6.33.5.4.1.15 the start time of unloading;

6.33.5.4.1.16 the quantity of water added after the mix was prepared and the signature of the engineer who authorized that addition.

6.33.5.5 PREPARATION OF EXISTING SURFACES PRIOR TO CONCRETING

6.33.5.5.1 Existing surfaces (concrete or rock)

6.33.5.5.1.1 All surfaces shall be clean, solid and free of loose or broken pieces, sawdust, ice, snow and any other foreign matter or debris and shall be sufficiently rough to ensure a complete bond with the new concrete.

6.33.5.5.1.2 In the case of hard concrete surfaces, laitance shall be removed and the aggregate shall be partially exposed.

6.33.5.5.1.3 Rock surfaces may be cleaned using air blasting, water jet blasting, abrasive blasting or vigorous brushing.

6.33.5.5.1.4 Surfaces shall be rough, and the roughness of treated surfaces shall have an amplitude of at least 5 mm.

6.33.5.5.1.5 The **Contractor** shall then remove any excess water from the surfaces using air blasting alone.

6.33.5.5.1.6 The **Contractor** shall monitor and remove, to the satisfaction of the Engineer, any water that may have infiltrated and any puddles that may have formed in depressions**.**

6.33.5.5.2 Demolished concrete surfaces

6.33.5.5.2.1 The **Contractor** shall demolish any deteriorated concrete and prepare the surfaces in conformity to the requirements of subsection 6.21 *Demolition and Removal*.

6.33.5.5.2.2 After they are cleaned using water jet blasting, the surfaces shall be cleared of any excess water using air blasting alone.

6.33.5.5.2.3 Prior to placement of the concrete or repair product, the work area shall be checked for water that may have infiltrated, and any accumulation of water in depressions shall be removed to the satisfaction of the Engineer.

6.33.5.5.2.4 At least three (3) hours before the new concrete is placed, the **Contractor** shall thoroughly dampen the surfaces to be repaired so that they are in SSD (saturated surface dry) condition. Any excess water shall be removed using air jet blasting fifteen (15) minutes prior to concreting such that the concrete is in SSD condition at the time of placement.

6.33.5.6 TRANSPORTATION OF CONCRETE

6.33.5.6.1 All concrete shall be delivered to the work site by truck mixer or agitating truck or by mobile mixer in conformity to article 6.33.4.1 *Mobile Concrete Mixer*.

6.33.5.6.2 Concrete shall be transported so as to ensure that the ingredients do not segregate and the consistency is not altered.

6.33.5.7 TIME BETWEEN MIXING AND PLACEMENT

6.33.5.7.1 The time between the start of mixing and the end of unloading shall conform to the requirements of CAN/CSA-A23.1.

6.33.5.7.2 At no point shall the time between mixing and unloading exceed 120 minutes. Any departure from this requirement shall be approved by the Engineer before the concrete is placed.

6.33.5.7.3 If 90 minutes have elapsed since mixing, the air content and temperature of the concrete shall be rechecked by the **Contractor**.

6.33.5.7.4 Concrete that has not been placed within the prescribed time shall not be used.

6.33.5.8 TEMPERATURE CONTROL

6.33.5.8.1 The temperature of concrete delivered to the work site shall conform to standard CAN/CSA-A23.1 and be measured as it leaves the truck mixer in conformity to standard ASTM C1064/C1064M.

6.33.5.8.2 The temperature shall be as low as possible in order to limit the temperature rise caused by the heat of hydration and shall under no circumstances be higher than the temperature prescribed in the following table.

Thickness of smallest dimension of area to be concreted (m)	**Temperature of concrete, °C**	
	Minimum	**Maximum**
< 0.3	10	30
0.3-1	10	28
1-2	10	20
> 2	10	12

Note: The temperature of high-performance concrete shall at no time exceed 22°C.

6.33.5.8.3 Concreting in hot weather

6.33.5.8.3.1 When the air temperature is at or above 27°C or when there is a probability of it rising to 27°C during concreting (based on forecasts from the Environment Canada weather station closest to the work site), appropriate measures shall be taken to protect the concrete in place from the effects of hot or dry weather.

6.33.5.8.3.2 To obtain the required temperature, the **Contractor** shall use appropriate methods, such as cooling the mixing water with ice or sprinkling the aggregate.

6.33.5.8.3.3 In severe drying conditions, the formwork, reinforcing steel and concrete placing equipment shall be protected from direct sunlight or cooled by misting and evaporation.

6.33.5.8.3.4 When the temperature of the concrete remains above 25°C, use of a set-retarding admixture may be considered but shall require authorization from the Engineer.

6.33.5.8.3.5 The **Contractor** shall take such measures as are necessary to ensure that the evaporation rate is less than 0.5 kg/m²h. One or more of the following measures may be taken by the **Contractor** if evaporation exceeds or could exceed that limit:

6.33.5.8.3.5.1 erect wind screens around the concrete surfaces;

6.33.5.8.3.5.2 dampen the subgrade prior to placing the concrete;

6.33.5.8.3.5.3 erect sunshades over the concrete during finishing;

6.33.5.8.3.5.4 lower the temperature of the concrete;

6.33.5.8.3.5.5 cover the surface of the concrete with a polyethylene film between finishing operations;

6.33.5.8.3.5.6 begin curing immediately after trowelling;

6.33.5.8.3.5.7 place and finish the concrete at night.

6.33.5.8.4 Concreting in cold weather

6.33.5.8.4.1 When the minimum temperature of the mix cannot be attained under normal conditions, the ingredients of the concrete shall be warmed in conformity to the following requirements:

6.33.5.8.4.1.1 The temperature of any water that comes into contact with the cement shall be less than 40°C. If the temperature is higher, the water shall first be mixed with the aggregate. The temperature of the mixing water shall at no time exceed 80°C.

6.33.5.8.4.1.2 The aggregate shall be warmed so as to eliminate any frozen clumps, snow and ice. The average temperature of aggregate shall not exceed 40°C when the cement is added.

6.33.5.8.4.1.3 Use of hot mixing water to dissolve frozen clumps and snow in aggregate is prohibited.

6.33.5.8.4.2 When the air temperature is at or below 5°C or when there is a probability of it falling below 5°C within twenty-four (24) hours of placing (based on forecasts from the Environment Canada weather station closest to the work site), all equipment and materials needed to protect and cure the concrete shall be available and ready for use prior to the start of concreting.

6.33.5.8.4.3 Snow and ice shall be removed before concrete is placed on any surface. The **Contractor** shall not use calcium chloride or other salts to de-ice formwork. Concrete shall not be placed on or against any surface the temperature of which could lower the temperature of the concrete.

6.33.5.8.4.4 Any surface with which fresh concrete will come into contact shall first be warmed to a minimum temperature of 10°C and kept at that temperature for a continuous period of at least twelve (12) hours prior to placement of the concrete.

6.33.5.8.4.5 In cold weather, the **Contractor** shall provide appropriate protection for the concrete for the duration of the placement and curing process. Such protection shall be provided by means of heated enclosures, coverings, insulation or a combination thereof.

6.33.5.8.4.6 Enclosures shall be constructed to withstand wind and snow loads and shall be reasonably airtight. There shall be sufficient space between the concrete and the enclosure to permit free circulation of warm air.

6.33.5.8.4.7 The enclosure may be heated with live steam, forced hot air, stationary heaters or other types of heaters.

6.33.5.8.4.8 The capacity and number of heaters shall be sufficient to keep the concrete at the required temperature.

6.33.5.8.4.9 Where heaters that produce carbon dioxide are used, the **Contractor** shall ensure that the gas is exhausted from the enclosure. Under no circumstances shall carbon dioxide come into contact with the concrete.

6.33.5.8.4.10 For underwater work, no repairs shall be carried out when the temperature of the water is below 5°C.

6.33.5.9 CONTROL OF SLUMP AND AIR CONTENT

6.33.5.9.1 All adjustments to slump and air content shall be authorized by the Engineer and made in conformity to clause 5.2.4.3 of standard CAN/CSA-A23.1.

6.33.5.9.2 Unless otherwise indicated, water may not be added to the water contained in the concrete mix while the mix is in transit or after it arrives at the work site.

6.33.5.9.3 If authorized by the Engineer, the slump of the concrete may be adjusted if it is less than the prescribed value and if no more than sixty (60) minutes have elapsed since the concrete was mixed.

6.33.5.9.4 The quantity of water added shall not exceed 12 litres/m^3 or 8% of the prescribed mixing water, and the addition shall be approved by and carried out under the supervision of the Engineer.

6.33.5.9.5 The use of set retarders to extend the unloading time requires authorization from the Engineer.

6.33.5.9.6 Where superplasticized concrete does not meet the slump requirements because of a delay, the concrete shall be adjusted by the supplier using superplasticizing admixtures only. The addition of water is prohibited. The quantity of admixture added under the supervision of the Engineer shall be recorded on the waybill.

6.33.5.9.7 Sampling for uniformity testing of mixed concrete shall be done in conformity to clause 2.3 of standard CAN/CSA-A23.2-1C *Sampling of Plastic Concrete*.

6.33.5.10 PLACEMENT OF CONCRETE

6.33.5.10.1 Concrete shall be placed in conformity to clause 7.2.4 of standard CAN/CSA -A23.1 and the following requirements.

6.33.5.10.2 Concreting shall not begin until the **Contractor** has obtained written authorization from the Engineer.

6.33.5.10.3 Slump and air content shall conform to articles 6.33.3.7 *Standard Concrete*, 6.33.3.8 *Self-placing Concrete* or 6.33.3.9 *Antiwashout Concrete* depending on the type of concrete to be placed.

6.33.5.10.4 All equipment used to transport and deposit concrete shall allow fresh concrete to be discharged continuously, and any hardened concrete shall be cleaned off prior to use.

6.33.5.10.5 Concrete shall be placed in forms so as to prevent segregation and in a place as close as possible to the final position.

6.33.5.10.6 Self-placing concrete shall be placed continuously without stopping in order to preserve the thixotropic properties and prevent stiffening of the concrete.

6.33.5.10.7 Concrete shall be placed in horizontal layers, and the rate of placement shall be such that each new layer can be vibrated to ensure a bond with the preceding layer.

6.33.5.10.8 Concrete shall be placed in horizontal layers not more than 500 mm thick.

6.33.5.10.9 To minimize the lateral movement of concrete in the forms that could lead to segregation, the distance between discharge points shall not exceed 5 m.

6.33.5.10.10 Collector hoppers and chutes or vertical or inclined pipes shall be used as needed to keep the freefall height of the concrete under 1.2 m.

6.33.5.10.11 Where concrete is transported in dump trucks, the **Contractor** shall use trucks that have wide gates which open downward and allow the concrete to be discharged so as to prevent segregation and obtain a slump in the range of 20 to 80 mm.

6.33.5.10.12 The **Contractor** shall ensure that reinforcing steel and other embedded elements are not shifted during placement of the concrete.

6.33.5.11 PUMPED CONCRETE

6.33.5.11.1.1 Pumped concrete shall be placed in conformity to the requirements of standard ACI 304.2R.

6.33.5.11.1.2 The **Contractor** shall cut surfaces that may trap air or place vent pipes in the formwork as needed.

6.33.5.11.1.3 To prevent the concrete from segregating, the pump line shall be kept full at all times during pumping and shall terminate with a reducer section 75 mm in diameter.

6.33.5.11.1.4 Where a pump is used to place high-performance concrete (HPC), the air content, slump and temperature of the concrete shall be measured at the outlet of the pump.

6.33.5.12 UNDERWATER CONCRETING

6.33.5.12.1 The requirements of clause 7.2.6 of standard CAN/CSA-A23.1 apply, in addition to the following requirements:

6.33.5.12.1.1 the loss of mass due to washout prescribed by standard CRD-C 61 shall be less than 5% measured in conformity to that standard;

6.33.5.12.1.2 tremies shall be equipped with a valve or equivalent device to prevent water from entering the tremie pipe;

6.33.5.12.1.3 a sponge or equivalent device shall be installed inside the concrete pump pipe to prevent concrete from washing out when it enters the water;

6.33.5.12.1.4 concrete shall not be placed when the water temperature is below 5°C;

6.33.5.12.1.5 the tremie shall be watertight and sufficiently large in cross-section to allow a free flow of concrete;

6.33.5.12.1.6 concrete shall be discharged and spread by moving the tremie so as to ensure as even a flow as possible; if the tremie loses its load during concreting, the **Contractor** shall remove and reload it;

6.33.5.12.1.7 the seal of the tremie shall be maintained by sinking the end at least 0.3 m into the placed concrete and lifting the tremie tube as the level of concrete rises;

6.33.5.12.1.8 the concrete surface emerging from the water shall be cleared of any laitance formed by washout, and the **Contractor** shall continue placement at the dry end of the formwork so as to push the water and fresh concrete toward the surface at the other end.

6.33.5.13 CONSOLIDATION OF CONCRETE

6.33.5.13.1 The requirements of clause 7.2.5 of standard CAN/CSA-A23.1 apply in addition to the following requirements:

6.33.5.13.1.1 internal vibrators shall be used to consolidate the concrete, taking into account the size and spacing of the reinforcing steel bars inside the formwork; the **Contractor** may also use external form vibrators or vibrating screeds;

6.33.5.13.1.2 vibrators shall conform to the requirements of standard CAN/CSA-A23.1 and the characteristics listed in the table in article 6.33.4.2 *Vibrator*;

6.33.5.13.1.3 there shall always be at least one extra vibrator over and above the number prescribed in standard CAN/CSA A23.1 at the concrete placement location at all times;

6.33.5.13.1.4 generally, the distance between vibrator immersion points shall be approximately 1.5 times the observed radius of vibration, which is the equivalent of approximately six (6) times the diameter of the vibrator;

6.33.5.13.1.5 the vibrator shall penetrate the entire thickness of the layer of concrete and at least 150 mm into the preceding layer;

6.33.5.13.1.6 the vibrator shall then be slowly withdrawn vertically and at a speed of less than 100 mm per second (approximately four (4) seconds for a 400 mm layer);

6.33.5.13.1.7 at no time shall a vibrator touch embedded elements, reinforcing steel or formwork;

6.33.5.13.1.8 to eliminate air bubbles trapped on the surface of the formwork where there is rapid spread or architectural treatment, the thickness of layers shall be reduced and greater attention shall be paid to the vibration procedure; the **Contractor** shall reduce the immersion distance, increase the vibration time and reduce the speed at which the vibrator is withdrawn;

6.33.5.13.1.9 the vibration frequency of the vibrators shall be checked and adjusted from time to time at intervals determined by the Engineer.

6.33.5.14 CONSTRUCTION JOINTS

6.33.5.14.1 Construction joints represent breaks in construction work or concrete placement and may be made only in the locations indicated on the drawings or in Section 4 *Special Technical Conditions.*

6.33.5.14.2 Construction joints not indicated on the drawings are subject to authorization by the Engineer and shall be located and designed so that the strength of the concrete and the appearance of the structure are impaired as little as possible.

6.33.5.14.3 Where a construction joint must be made, the surface of the set concrete shall be suitably roughened, thoroughly cleaned of foreign matter and laitance, saturated with water and kept in a damp condition with no free water on the surface until the placement of concrete resumes, in conformity to article 6.33.5.5.1 *Existing surfaces (concrete or rock)*.

6.33.5.14.4 The showing edge of construction joints shall be brought to a neat line by the use of chamfer strips when forming.

6.33.5.14.5 The first layer of concrete placed upon the hardened previously placed concrete shall be approximately 150 mm thick. The fresh concrete shall be vibrated uniformly with internal vibrators immersed approximately every 500 mm.

6.33.5.14.6 Watertight construction joints

6.33.5.14.6.1 All construction joints required by the *Special Technical Conditions* to be watertight shall have a moulded water stop.

6.33.5.14.6.2 Moulded water stops shall conform to the requirements of article 6.37.7 *Water Stops* in subsection 6.37 *Miscellaneous Products for Concrete Work.*

6.33.5.14.6.3 Concreting shall be done so as to prevent any loss of laitance where the trim and formwork meet (elastomer joint) and prevent warping of the moulded water stop. The half of the trim protruding through a form shall be protected, if necessary, by a board or wood support on each side so that the trim is not bent or damaged.

6.33.5.14.7 Control Joints

6.33.5.14.7.1 The requirements of clause 7.3.2 of standard CAN/CSA A23.1 apply in addition to the following requirements:

6.33.5.14.7.1.1 control joints, also called contraction joints, can be formed by diamond sawing, hand tooling or inserting preformed crack-inducing strips into the surface of the concrete;

6.33.5.14.7.1.2 control joints are indicated on the drawings;

6.33.5.14.7.1.3 unless otherwise indicated, control joints shall be spaced at a maximum of 4.5 m on centre in square panels;

6.33.5.14.7.1.4 tooled joints and preformed crack-inducing strips shall be embedded in the concrete to a minimum depth of 25 mm.

6.33.5.14.8 Joint Rustication

6.33.5.14.8.1 Unless otherwise indicated, all horizontal and vertical construction joints and contraction joints shall be rusticated by the use of 20 mm chamfer strips installed on the formwork.

6.33.5.14.8.2 The chamfer strips shall consist of the same material as that used in the forms.

6.33.5.14.8.3 The chamfer strips shall be so installed as to leave a neat regular groove in the concrete at all construction joints, along the vertical showing edge of contraction joints and at all exposed corners and edges of the concrete.

6.33.5.14.8.4 Care shall be taken to ensure that all chamfer strips are uniform in cross-section and that the strips are installed level and the ends of the strips can be matched during installation.

6.33.5.15 SURFACE FINISH

6.33.5.15.1 The surface of the concrete shall be formed while the concrete is sufficiently plastic to produce the described texture, grades and levels.

6.33.5.15.2 Excessive bleeding of water and fine particles shall not appear on the surface of the concrete.

6.33.5.15.3 Surfaces shall not deviate from the prescribed limits by more than 5 mm when measured with a 3 m straightedge.

6.33.5.15.4 Unformed surfaces shall be finished with a wooden trowel in order to obtain a texture similar to the texture of the adjacent concrete.

6.33.5.15.5 For formed concrete surfaces, the tie rods of the formwork and other metal parts shall be removed or cut back to at least 40 mm relative to the surface of the concrete.

6.33.5.15.6 Holes left by tie rods, hollows and depressions shall be sufficiently deep and their edges sufficiently perpendicular to hold repair mortar.

6.33.5.15.7 Hollows and depressions shall be saturated with water and repaired after the surface is brushed with a pure cement paste and filled with a mortar containing the same sand and cement as used for the concrete.

6.33.5.15.8 The surfaces shall be kept damp for a continuous period of three (3) hours preceding filling with concrete or mortar.

6.33.5.15.9 The mortar shall be pressed or packed firmly into the depression so as to fill it completely, then finished so as to give it the same texture as the adjacent surface.

6.33.5.15.10 For finishes subject to freeze-thaw cycles, the action of de-icing salts or both at the same time, the **Contractor** shall use a pre-bagged material containing an acrylic or styrene-butadiene latex that can withstand freeze-thaw cycles and is resistant to de-icing salts.

6.33.5.16 CURING

6.33.5.16.1 Curing method

6.33.5.16.1.1 Curing shall begin immediately following the placing and finishing operations and shall provide the temperature and moisture conditions for the period of time necessary for the concrete to develop its strength, durability and other properties.

6.33.5.16.1.2 Curing of concrete shall be done by means of continuous sprinkling. The curing water shall not have any deleterious effect on the concrete. Any other method shall require authorization by the Engineer.

6.33.5.16.1.3 The exposed surfaces of freshly placed concrete shall be kept in a continuously moist condition for at least seven (7) consecutive days.

6.33.5.16.1.4 Concrete curing may be carried out using any of the following methods:

Method	Comments
Ponding or continuous sprinkling	This method is used primarily for mass concrete.
Absorbent mats or burlap kept continuously wet with polyethylene film	The mats or burlap shall overlap 75 mm and shall be attached in order to prevent shifting. They shall be covered with polyethylene in order to reduce the water evaporation rate.
Continuous vapour or vapour mist bath	The temperature of the water vapour shall never exceed 60°C.

6.33.5.16.1.5 Leaving wood formwork in place for seven (7) days is an acceptable method of curing provided the formwork is sprayed to keep it moist.

6.33.5.16.1.6 Steel formwork left in place while the concrete cures shall be loosened slightly upon authorization from the Engineer after the concrete has initially set in order to permit spraying that allows the water to run between the formwork and the surface of the concrete.

6.33.5.16.1.7 In the case of mass concrete, curing shall be done specifically by continuous spraying or the use of absorbent mats, burlap and polyethylene film kept continuously damp. The temperature of the water shall be equal to or not less than 10°C below the temperature of the concrete.

6.33.5.16.1.8 Payment will not be made for concrete that is placed without curing that conforms to the requirements of the specifications or the Engineer's instructions. Moreover, the **Owner** reserves the right to have concreting redone at the **Contractor**'s expense if, in the Engineer's opinion, the concrete work suffered a loss of quality as a result of improper curing.

6.33.5.16.2 Cold-weather curing

6.33.5.16.2.1 Concrete shall be kept at a temperature of at least 10°C for the minimum curing period of seven (7) days.

6.33.5.16.2.2 This minimum period of concrete protection shall be extended until the concrete reaches 70% of the required twenty-eight (28) day strength or the strength specified in the *Special Technical Conditions*.

6.33.5.16.2.3 The capacity and number of heaters shall be sufficient to keep the concrete at the required temperature.

6.33.5.16.2.4 Where heaters that produce carbon dioxide are used, the **Contractor** shall ensure that the gas is exhausted from the enclosure. Under no circumstances shall carbon dioxide come into contact with the concrete.

6.33.5.16.2.5 Following the protection period, the temperature of the concrete shall be gradually lowered over the first twenty-four (24) hours. The rate of decrease shall not exceed 10°C/h. The concrete shall not be exposed to outdoor air if the difference between the temperature of the concrete and the temperature of the outdoor air is more than 20°C.

6.33.5.16.2.6 For the duration of the protection period, the **Contractor** shall supply and install a sufficient number of thermometers that record low and high temperatures to check the temperature of the placed concrete and a thermometer to check the temperature of the outdoor air.

6.33.5.16.2.7 Any concrete damaged by freezing, inadequate protection or improper curing shall be removed and replaced by the **Contractor** at no additional cost to the **Owner**.

6.33.5.16.3 Application of chemical curing agents

6.33.5.16.3.1 The use of chemical curing agents shall be authorized by the Engineer. The **Contractor** shall accordingly submit the type, method and application rate with all the manufacturer's technical data sheets.

6.33.5.16.3.2 If authorized by the Engineer, a membrane-forming curing product shall be applied so as to form a sufficiently thick and unbroken film over the surface of the concrete. The proportioning of ingredients and method of application shall conform to the manufacturer's recommendations. The film shall be protected so that it remains intact for the duration of the curing period.

6.33.5.17 REPAIR OF CONCRETING DEFECTS

6.33.5.17.1 Concreting defects identified by the Engineer shall be repaired using methods approved by the Engineer.

6.33.5.17.2 Any cracks 0,3 mm or wider in new concrete shall be repaired at the **Contractor**'s expense based on the criteria in subsection 6.35 *Injection.*

6.33.5.17.3 Honeycombs identified after the forms are removed shall not be repaired until they have been inspected and the perimeter determined by the Engineer.

6.33.5.17.4 Where honeycombs have formed in non-structural elements, the perimeter of the areas to be repaired shall be outlined with saw cuts 20 mm deep perpendicular to the surface.

6.33.5.17.5 After sawing and roughening but before filling, each hole shall be cleaned with a brush and compressed air, washed and kept saturated for a continuous period of at least three (3) hours.

6.33.5.17.6 The surface of the areas to be repaired shall be brushed, then filled with a mortar containing the same sand and cement as used for the concrete.

6.33.5.17.7 For repairs subject to freeze-thaw cycles, the action of de-icing salts or both at the same time, the **Contractor** shall use a pre-bagged material containing an acrylic or styrene-butadiene latex that can withstand freeze-thaw cycles and is resistant to de-icing salts.

6.33.5.17.8 Where honeycombs have formed in structural elements, corrective measures shall be taken as directed by the Engineer.

6.33.5.17.9 Areas that have been repaired shall undergo a curing operation in conformity to article 6.33.5.16 *Curing*.

6.33.5.18 SURFACE REPAIRS TO EXISTING CONCRETE

6.33.5.18.1 Identified surface repairs to existing concrete shall be carried out using methods approved by the Engineer.

6.33.5.18.2 Where honeycombs have formed in non-structural elements, the perimeter of the areas to be repaired shall be outlined with saw cuts 20 mm deep perpendicular to the surface.

6.33.5.18.3 After sawing and roughening but before filling, each hole shall be cleaned with a brush and compressed air, washed and kept saturated for a continuous period of at least three hours.

6.33.5.18.4 The surface of the areas to be repaired shall be brushed, than filled with a cement mortar.

6.33.5.18.5 For repairs subject to freeze-thaw cycles, the action of de-icing salts or both at the same time, the **Contractor** shall use a pre-bagged material containing an acrylic or styrene-butadiene latex that can withstand freeze-thaw cycles and is resistant to de-icing salts.

6.33.5.18.6 Where honeycombs have formed in structural elements, corrective measures shall be taken as directed by the Engineer.

6.33.5.18.7 Areas that have been repaired shall undergo a curing operation in conformity to article 6.33.5.16 *Curing*.

6.33.5.19 JOINT SEALANT

6.33.5.19.1 The top of joints shall be closed with a sealant compatible with the material used to fill the joint.

6.33.5.19.2 The joint sealant shall be applied as directed by the manufacturer.

6.33.5.19.3 The air temperature at the time of application of the sealant shall not be lower that 5°C or the minimum temperature specified by the manufacturer.

6.33.5.19.4 The **Contractor** shall not apply sealant until:

6.33.5.19.4.1 the concrete is fully cured;

6.33.5.19.4.2 the surface of concrete to which the sealant is to be applied is abrasive-blasted to remove weak and/or poorly adhering material and cleaned by means of a compressed air jet;

6.33.5.19.4.3 the surface is dry and meets the manufacturer’s requirements.

6.33.6 QUALITY CONTROL

6.33.6.1 INSPECTIONS AND TESTS

6.33.6.1.1 In addition to the quality control carried out by the **Contractor**, inspections and tests of the concrete and its components shall be carried out by a testing laboratory hired by the **Owner**. Under no circumstances shall such inspections and testing limit or modify the **Contractor**'s obligations under the Contract.

6.33.6.1.2 The **Contractor** shall provide the facilities and access needed to collect test cylinders.

6.33.6.1.3 At least twenty-four (24) hours prior to each placement of concrete, the **Contractor** shall send a written concreting notice to the Engineer so that the Engineer can notify the **Owner**'s laboratory, and the **Contractor** shall ensure that a representative of that laboratory is present during placement, failing which the Engineer will not allow concreting to proceed.

6.33.6.1.4 Unless otherwise indicated, the **Owner**'s test laboratory shall collect six (6) test cylinders from every placement of 50 m^3 or smaller. Four (4) additional cylinders will be collected for every additional 50 m^3 of concrete placed.

6.33.6.1.5 The test laboratory will never collect fewer than six (6) cylinders a day for each class of concrete placed for each type of structural element.

6.33.6.1.6 Three (3) additional test cylinders will be collected by the **Owner**'s test laboratory where concreting is done in cold weather. The **Contractor** shall ensure that these cylinders are cured on site.

6.33.6.1.7 The cylinders kept on site shall be laid out such that they are exposed to the same curing conditions as the concrete placed in the structure. The **Contractor** shall ensure that its employees do not move the test cylinders while they are curing.

6.33.6.1.8 Whenever a test cylinder is collected, the **Owner**'s laboratory shall check the air content, the temperature and the plasticity of the concrete. This work shall be carried out on site.

6.33.6.1.9 If the quality of the concrete does not conform to the requirements of these specifications, the **Contractor** shall redo the defective components at its expense and cover the cost of the additional tests.

6.33.6.1.10 The non-destructive test methods used for concrete shall conform to standard CAN/CSA-A23.2.

6.33.6.2 ADHESION BETWEEN REPAIR CONCRETE AND EXISTING CONCRETE

6.33.6.2.1 The **Contractor** shall provide and locate inside the formwork indicators to ensure that the bond tests that will subsequently be conducted using core sampling do not conflict with the reinforcing steel.

6.33.6.2.2 For bond tests, the **Contractor** shall collect, in the presence of a representative of the **Owner**'s laboratory, a minimum number of core samples per concrete placement as required by the *Special Technical Conditions*.

6.33.6.2.3 The minimum requirements in terms of adhesion between repair concrete and existing concrete are as follows:

6.33.6.2.3.1 the minimum value is 0.4 MPa at seven (7) days or 1.0 MPa at twenty-eight (28) days;

6.33.6.2.3.2 the adhesion value of a pour (concreting phase) is determined by the average adhesion test results;

6.33.6.2.3.3 the method used to conduct the bond test is the direct tension test method which shall be based on the provisions of CAN/CSA-A23.2-6B standard.

6.33.6.2.4 If any of the criteria set out in paragraph 6.33.6.2.3 are not met, the **Owner** reserves the right to demand that the work be redone at the **Contractor**'s expense.

6.33.6.3 APPLICABLE PENALTY

6.33.6.3.1 If the actual strength of the concrete at twenty-eight (28) days is below the prescribed strength, the following penalties will be applied :

Prescribed strength 35 MPa		**Prescribed strength 50 MPa**	
Strength at 28 days (MPa)	**Penalty (%)(1)**	**Strength at 28 days (MPa)**	**Penalty (%)(1)**
34.0-34.9	2%	49.0-49.9	2%
33.0-33.9	4%	48.0-48.9	4%
32.0-32.9	6%	47.0-47.9	6%
31.0-31.9	8%	46.0-46.9	8%
30.0-30.9	10%	45.0-45.9	10%
29.0-29.9	25%	44.0-44.9	20%
28.0-28.9	40%	43.0-43.9	40%
27.0-27.9	55%	42.0-42.9	80%
26.0-26.9	70%	< 42.0	See paragraph 6.33.6.3.2
25.0-25.9	85%		
< 25.0	See paragraph 6.33.6.3.2		

(1) % of Tendered unit price for the pertinent item in the Price Table for deficient quantities.

6.33.6.3.2 If the twenty-eight (28) days strength of the concrete is less than the lower limit in the table in paragraph 6.33.6.3.1, the **Owner** reserves the right to have the non-conforming work redone at the **Contractor**'s expense.

6.33.6.3.3 No penalty applies where the strength is greater than that prescribed. However, the **Owner** reserves the right to demand that the **Contractor** modify the mix or its quality control measures, particularly with regard to the proportion of cement and the water content of the aggregate, if the strength is significantly greater than specified and the strength values, in the Engineer's opinion, adversely affect the quality of the work, particularly in terms of creating excessive cracking.

END OF SUBSECTION