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 describes the requirements relating to concrete structure construction work covered by this Contract.

6.33.1.2 Any specific requirements, if any, pertaining to cast-in-place concrete covered by this Contract are set out on the plans and in Section 4 *Special Technical Conditions*.

6.33.1.3 The requirements relating to temporary structures are described in subsection 6.15 *Temporary Structures*.

6.33.1.4 The requirements relating to concrete demolition are described in subsection 6.21 *Demolition and Removal*.

6.33.1.5 The requirements relating to reinforcing steel and anchors are described in subsection 6.31 *Reinforcing Steel for Concrete.*

6.33.1.6 The requirements relating to formwork are described in subsection 6.32 *Formwork.*

6.33.1.7 The requirements relating to prestressing are described in subsection 6.36 *Prestressing.*

6.33.1.8 The requirements relating to miscellaneous products for concrete work are described in subsection 6.37 *Miscellaneous Products for Concrete Work.*

6.33.1.9 The requirements relating to the precasting of concrete elements are described in subsection 6.39 *Precast Concrete Elements.*

6.33.1.10 The requirements relating to concrete pavement are described in subsection 6.83 *Cement Concrete Pavement.*

6.33.2 MEASUREMENT UNITS

6.33.2.1 The measurement units and respective symbols thereof used in this subsection are described as follows:

Measurement Unit	Designation	Symbol
length	meter	m
length	millimeter	mm
length	micrometer	µm
area	square meter	m^2
volume	cubic meter	m^3
volume	liter	L
volume	milliliter	mL
mass	gram	g
mass	kilogram	kg
mass	milligram	mg
stress, pressure	megapascal	MPa
temperature	Celsius degree	°C
angle plan	degree	°
time	hour	h
speed	millimeter/second	mm/s

6.33.3 REFERENCE STANDARDS

6.33.3.1 The Contractor shall carry out all concrete work in accordance with the following standards and documents, to which the provisions of this Contract are added:

6.33.3.1.1 (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*.

6.33.3.1.2 (ACI) American Concrete Institute:

- ACI 223R-10 *Guide for the Use of Shrinkage-Compensating Concrete;*
- ACI 304.2R *Placing Concrete by Pumping Methods (Reapproved 2008)*;
- ACI 306R *Guide to Cold Weather Concreting*;
- ACI 309R *Guide for Consolidation of Concrete*;
- ACI 546.2R *Guide to Underwater Repair of Concrete*.

6.33.3.1.3 (CSA) Canadian Standards Association:

- CAN/CSA-A23.1/A23.2 *Concrete Materials and Methods of Concrete Construction/ Methods of Test and Standard Practices for Concrete*;
- CAN/CSA-A23.3 *Design of Concrete Structures*;
- CAN/CSA-A3000 Consolidation *Cementitious Materials Compendium (which Consists of A3001, A3002, A3003, A3004 and A3005)*;
- CAN/CSA S6 *Canadian Highway Bridge Design Code*;
- CAN/CSA S269.1 *Falsework for Construction Purposes.*

6.33.3.1.4 (ASTM) ATM International:

- ASTM C109/C109M *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*;
- ASTM C157/C157M *Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete*;
- ASTM C171 *Standard Specification for Sheet Materials for Curing Concrete*;
- ASTM C260/C260M *Standard Specification for Air-Entraining Admixtures for Concrete*;
- ASTM C295/C295M *Standard Guide for Petrographic Examination of Aggregates for Concrete*;
- ASTM C309 *Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete*;
- ASTM C348 *Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars*;
- ASTM C387/C387M *Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar*;
- ASTM C457 *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*;
- ASTM C494/C494M *Standard Specification for Chemical Admixtures for Concrete*;
- ASTM C642 *Standard Test Method for Density, Absorption, and Voids in Hardened Concrete*;
- ASTM C666/C666M *Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing*;
- ASTM C672/C672M *Standard Test Method for Scaling Resistance of Concrete Surfaces Exposed to Deicing Chemicals*;
- ASTM C685/C685M *Standard Specification for Concrete Made By Volumetric Batching and Continuous Mixing*;
- ASTM C881/C881M *Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete*;

- ASTM C882/C882M *Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear*;
- ASTM C1017/C1017M *Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete*;
- ASTM C1064/C1064M *Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete*;
- ASTM C1152/C1152M *Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete*;
- ASTM C1202 *Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration*;
- ASTM C1611/C1611M *Standard Test Method for Slump Flow of Self-Consolidating Concrete*;
- ASTM D512 *Standard Test Methods for Chloride Ion In Water*;
- ASTM D516 *Standard Test Method for Sulfate Ion in Water*;
- ASTM D4191 *Standard Test Method for Sodium in Water by Atomic Absorption Spectrophotometry*;
- ASTM D4192 *Standard Test Method for Potassium in Water by Atomic Absorption Spectrophotometry*;
- ASTM D5095 *Standard Test Method for Determination of the Nonvolatile Content in Silanes, Siloxanes and Silane-Siloxane Blends Used in Masonry Water Repellent Treatments*;
- ASTM D5167 *Standard Practice for Melting of Hot-Applied Joint and Crack Sealant and Filler for Evaluation*;
- ASTM D5329 *Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements*.

6.33.3.1.5 (BNQ) Bureau de normalisation du Québec:

- BNQ 2560-114 *Travaux de génie civil – Granulats,* Partie IV : *Béton de masse volumique normale*;
- BNQ 2621-905 *Béton prêt à l'emploi - Programme de certification*.

6.33.3.1.6 (ICRI) International Concrete Repair Institute:

- ICRI *Guide No 03732 Select and specify the proper preparation of concrete surfaces for the application of sealants, coatings and polymeric coatings.*

6.33.3.1.7 (MTQ) Ministère des Transports du Québec:

- MTQ – *Cahier des charges et devis généraux (CCDG) – Construction et réparation*;
- 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*.

6.33.3.1.8 United States Army Corps of Engineers:

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

6.33.3.1.9 US Department of Transportation, Federal Highway Administration:

- FHWA RD 78-35 *Styrene Butadiene Latex Modifiers for Bridge Deck Overlay Concrete*.

6.33.4 MATERIALS

6.33.4.1 CEMENT AND CEMENT ADDITIVES

6.33.4.1.1 Hydraulic cements shall comply with standards CAN/CSA-A23.1 and CAN/CSA A3000.

6.33.4.1.2 The cementitious binder used shall be a general use GU Portland hydraulic cement or a GUb-SF, GUb-S/SF, GUb-F/SF, HEb-SF or HEb-N blended hydraulic cement.

6.33.4.1.3 The total mass of cement additives (fly ash, finely ground granulated blast furnace slag and silica fumes) shall not exceed 30 % of the total binder mass.

6.33.4.1.4 The silica fume shall comply with standard CAN/CSA-A3000, Type U, in a ratio of 6 % to 8 % by cement mass.

6.33.4.1.5 The fly ash, where required, shall meet the requirements for Type F of standard CAN/CSA-A3000 and, more specifically, of the section A3001 *Binders used in Concrete*.

6.33.4.1.6 Unless otherwise indicated on the plans, the use of ternary cements during the period extending from October 15th to March 31st is prohibited.

6.33.4.2 WATER

6.33.4.2.1 The water used for mixing and curing the concrete shall be fresh, clean, potable and free of oil and chemical or organic impurities and shall comply with the provisions of Section 4 of standard CAN/CSA-A23.1.

6.33.4.2.2 The raw water used as mixing water shall have the following properties (from standard CAN/CSA-A23.1, Article 4.2.2):

Parameters	Maximum Concentration in Mixing Water (mg/L)	Standard
Chlorides	500 (for Prestressed Concrete) 1,000 (for Other Reinforced Concrete)	ASTM D512
Sulphates (SO_4)	3,000	ASTM D516
Alkalis ($Na_2O + 0.658\ K_2O$)	600	ASTM D4192
Total of solids	50,000	AASHTO T026

6.33.4.3 AGGREGATE

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

6.33.4.3.1.1 The Contractor shall submit to the Engineer, for review, a statement signed by the qualified person who conducted the petrographic examination of the fine and coarse aggregate, in accordance with standard ASTM C295/C295M, certifying that the aggregate used in the concrete will not lead to excessive expansion of and cracks in the concrete caused by the alkali-aggregate reaction or by any other adverse reaction, as prescribed in standard CAN/CSA-A23.1.

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

6.33.4.3.2 Normal-density fine aggregate

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

6.33.4.3.2.2 The grading limits for the fine aggregate are the following:

Sieve Size	Percentage of the Total Mass Passing the Sieve
10 mm	100
5 mm	95 to 100
2.5 mm	80 to 100
1.25 mm	50 to 90
630 µm	25 to 65
315 µm	10 to 35
160 µm	2 to 10
80 µm	0 to 3

6.33.4.3.3 Normal-density coarse aggregate

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

6.33.4.3.3.2 The grading limits for the coarse aggregate are the following:

Nominal Size of Aggregate, mm	Percentage of the Total Mass Passing each Sieve						
	28 mm	20 mm	14 mm	10 mm	5 mm	2.5 mm	1.25 mm
20 to 5	100	85 to100	50 to 90	25 to 60	0 to 10	0 to 5	-
14 to 5		100	90 to100	45 to 75	0 to 15	0 to 5	-
10 to 2.5			100	85 to 100	10 to 30	0 to 10	0 to 5

6.33.4.3.4 Alkali-aggregate reactivity

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

6.33.4.3.4.2 The assessment of the potential reactivity of an aggregate shall be tested in accordance with standard CAN/CSA-A23.2-14A *Potential Expansivity of Aggregates*.

6.33.4.3.4.3 The classification of the degree of reactivity of the aggregate is based on Table 2 of 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 the concrete prism test results. The results obtained using the accelerated test shall not be considered.

6.33.4.3.4.4 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:

6.33.4.3.4.4.1 limit the alkali content of the Portland cement in the concrete to a maximum of 2.4 kg/m^3 of equivalent Na_2O as prescribed in Table 6 *Preventive Measures* of standard CAN/CSA-A23.2-27A;

6.33.4.3.4.4.2 use GUb-S/SF or GUb-F/SF ternary cement compliant with standard CAN/CSA-A3000 (more specifically, A3001), as prescribed in Table 7 of standard CAN/CSA-A23.2-27A.

6.33.4.3.4.5 The aggregate presenting alkali-carbonate reactivity shall not be used.

6.33.4.4 ADMIXTURES

6.33.4.4.1 Air-entraining admixtures

6.33.4.4.1.1 Air-entraining admixtures shall comply with standard ASTM C260/C260M.

6.33.4.4.1.2 Air-entraining admixtures shall be synthetic detergent-based.

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

6.33.4.4.2 Chemical admixtures

6.33.4.4.2.1 Chemical admixtures shall comply with standard ASTM C494/C494M or ASTM C1017/C1017M.

6.33.4.4.2.2 The chemical admixtures used shall not contain any chlorides. Furthermore, Type C and Type E admixtures (set accelerators) are prohibited.

6.33.4.4.2.3 Unless otherwise indicated, only Type A water reducers shall be used. They shall produce a water reduction greater than 5 % compared with the control mix that also contains entrained air.

6.33.4.4.2.4 For self-consolidating concrete, a polysaccharide or cellulose derivative colloidal agent shall be used to prevent the concrete from segregating. The minimum dosages are the following:

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

6.33.4.4.2.4.2 cellulose derivative colloidal agent: 130 mL/100 kg cement or 260 mL/100 kg cement for Type XIV-RE self-consolidating concrete.

6.33.4.4.2.5 When concreting in cold weather, the use of calcium chloride as set accelerator is prohibited.

6.33.4.4.2.6 The Engineer may also prescribe the use of a set-retarding admixture as prescribed in standard ASTM C494/C494M and of an anti-shrinkage admixture. The methods and proportions recommended by the manufacturer shall be complied with.

6.33.4.4.2.6.1 The use of a water reducer as set retarder is prohibited.

6.33.4.4.2.7 On the basis of the nature of the work and requirements thereto related, the Engineer reserves the right to require the use of a water-reducer superplasticizer. Due to some of the properties of this type of admixture, the following special measures shall therefore be taken by the Contractor during the use thereof:

6.33.4.4.2.7.1 only Type F or G superplasticizers compliant with standard ASTM C494/C494M or Type I or II compliant with standard ASTM C1017/C1017M are authorized.

6.33.4.4.2.7.2 before the superplasticizer is added, the concrete shall have a slump within the range specified in Article 6.33.4.8 *Standard Concrete*;

6.33.4.4.2.7.3 at the time of being incorporated into the structure, the concrete shall have an air content within the range specified in Article 6.33.4.8 *Standard Concrete*.

6.33.4.4.2.8 The superplasticizers used for self-consolidating concrete shall be naphthalene sulphonate based.

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

6.33.4.4.3 Shrinkage reducing and compensating admixtures

6.33.4.4.3.1 The shrinkage reducing and compensating admixtures shall comply with Type G of standard ACI 223R-10.

6.33.4.4.3.2 The shrinkage reducing and compensating admixtures shall not be included in the calculation of the water/binder ratio.

6.33.4.4.3.3 The shrinkage reducing and compensating admixtures shall replace an equivalent volume of sand.

6.33.4.4.3.4 The shrinkage reducing and compensating admixtures shall be added at the plant according to the manufacturer's recommendations.

6.33.4.4.3.5 The shrinkage reducing and compensating admixtures shall be the product *Conex* manufactured by The Euclid Chemical Company or equivalent authorized by the Engineer.

6.33.4.4.4 Pulverulent admixtures

6.33.4.4.4.1 Pulverulent admixtures shall be placed in solution prior to use and as recommended by the manufacturer.

6.33.4.4.4.2 Admixtures in solution or suspended admixtures shall be stirred to maintain the homogeneity thereof.

6.33.4.5 LATEX

6.33.4.5.1 The latex used shall be Type “styrene butadiene” and meet the requirements listed in Report FHWA RD 78-35 “*Styrene Butadiene Latex Modifiers for Bridge Deck Overlay Concrete*”.

6.33.4.5.2 The latex shall have, without however being limited to, the following main characteristics:

6.33.4.5.2.1 have a solids content ranging between 46 % and 49 %;

6.33.4.5.2.2 have a butadiene content of 34 % ±1.5 %;

6.33.4.5.2.3 have a styrene content of 66 % ±1.5 %;

6.33.4.5.2.4 have a pH ranging between 9 and 11;

6.33.4.5.2.5 be white.

6.33.4.6 CURING COMPOUNDS

6.33.4.6.1 The compounds used to cure the concrete shall meet the requirements of standards ASTM C171, ASTM C309 and AASHTO M182.

6.33.4.6.2 Membrane-forming curing compounds

6.33.4.6.2.1 A chemical curing compound may not be used unless specifically indicated on the plans or authorized by the Engineer when, in his opinion, a wet curing will be difficult to achieve.

6.33.4.6.2.2 The membrane-forming curing compound used shall comply with standard ASTM C309 and shall be translucent with a fugitive dye (Type 1-D).

6.33.4.6.3 Absorbent fabric

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

6.33.4.6.3.2 The absorbent fabric shall be at least 1 m wide and shall not contain any substances that might be deleterious to the concrete. New fabric shall be flushed out thoroughly with water in order to make it more absorbent and remove any soluble materials.

6.33.4.6.4 Waterproof sheets

6.33.4.6.4.1 The waterproof sheets shall meet the requirements of standard ASTM C171.

6.33.4.6.4.2 The waterproof sheet shall be:

6.33.4.6.4.2.1 a transparent or opaque white polyethylene film of a minimum thickness of 0.1 mm, or

6.33.4.6.4.2.2 a fabric with a minimum mass surface density of 305 g/m^2 covered on one side with an opaque white polyethylene film of a minimum thickness of 0.1 mm.

6.33.4.6.4.3 The waterproof sheet shall be at least 1 m wide, have no tears and not contain any substances that might be deleterious to the concrete.

6.33.4.7 ADHESION GROUT

6.33.4.7.1 The adhesion grout shall be the product *AmbexGrout VM* with *Ambexcrete SB-23* latex products manufactured by Ambex, or equivalent authorized by the Engineer. The mix and application rate shall meet the manufacturer's requirements.

6.33.4.8 STANDARD CONCRETE

6.33.4.8.1 Bagged standard concrete is prohibited.

6.33.4.8.2 The standard concrete shall have the following properties:

Type	28-day strength (MPa)	Min. binder mass (kg/m^3)	Type of binder(1)	Max. water/binder ratio or within the interval	Slump (mm) (2)	Coarse aggregate (mm)	Air content(3) (%)	L max (µm)	Max. chloride ion permeability (Coulombs)
I	30	340 390	GU, GUL, MS, MH, HE(4) GUb-S	0,45	80 ± 30(6)	5-20	5-8	230	–
II	30	330	GUb-SF, GUb-F/SF, GUb-S/SF	0,45	80 ± 30(6)	5-20	5-8	230	–
IIIA	35(8)	340	GU, GUL, MS, MH, HE(4) GUb-SF GUb-F/SF, GUb-S/SF	0,45	40 ± 20	5-20	5-8	230	–

Type	28-day strength (MPa)	Min. binder mass (kg/m^3)	Type of binder[1]	Max. water/binder ratio or within the interval	Slump (mm) [2]	Coarse aggregate (mm)	Air content[3] (%)	L max (µm)	Max. chloride ion permeability (Coulombs)
IIIB	35[8]	335	GU, GUL, MS, MH, HE[4] GUb-SF GUb-F/SF, GUb-S/SF	0,45	40 ± 20	5-28	5-8	230	–
IV	35	410 420	GU, GUL, MH, HE[4] GUb-S[5]	0,40	80 ± 30[6]	5-20	5-8	230	–
V	35	340 365	GUb-SF GUb-F/SF, GUb-S/SF	0,45	80 ± 30[6]	5-20	5-8	230	1500
V-DC	35	340	GUb-SF	0,35	–[7]	5-20	5-8	230	1000
V-E	35	375	GUb-SF	0,40[13]	150 ± 30	5-14	5-8	260	–
V-P	35	390 410	GUb-SF, HEb-SF[6], HEb-N[6] GUb-F/SF, GUb-S/SF	0,45	150 ± 30	5-20 5-14	5-8	230	1000
V-S	35	340 365	GUb-SF GUb-F/SF, GUb-S/SF	0,38 à 0,42	130 ± 30	5-20	5-8	230	1000
VI	35	390	GU, MS, MH, HE[4]	0,40	30 ± 20	5-20	5-8	230	–
VII	35	340 350	GUb-SF GUb-F/SF, GUb-S/SF	0,45	30 ± 20	5-20	5-8	230	–
VIII	50	410	GUb-SF	0,37	180 ± 40	5-14	5-8	230	1000
IX	60	410	GUb-SF	0,35	180 ± 40	5-14	5-8	230	1000
XI	30	340 330	GU, GUL GUb-F/SF, GUb-S/SF	0,50	150 ± 30	5-20	4-7	–	–
XII	15	220	GU, MS, MH, HE[4] GUb-SF GUb-F/SF, GUb-S/SF	0,75	80 ± 30	5-20	5-8	–	–
XIII	50	410	GUb-SF GUb-F/SF, GUb-S/SF	0,34 à 0,38	170 ± 30	5-14	5-8	230[11]	1000

Type	28-day strength (MPa)	Min. binder mass (kg/m^3)	Type of binder[1]	Max. water/binder ratio or within the interval	Slump (mm) [2]	Coarse aggregate (mm)	Air content[3] (%)	L max (µm)	Max. chloride ion permeability (Coulombs)
XV	35	450	GUb-SF	0,42	200 ± 40	2,5-10[9]	6-9	230	1500
XVI-5	35	390	GUb-SF GUb-F/SF, GUb-S/SF	0,40	120 ± 30	2,5-10	4-8	230	1000
XVI-15	35	390	GU	0,40	150 ± 30	2,5-10	3-7[10]	300	1000

(1) GUb-SF type binder shall contain at least 8 % silica fumes.

GUb-F/SF and GUb-S/SF type binders shall contain at least 5 % silica fumes and at least 15 % fly ash or slag. Total mass of supplementary cementing materials (fly ash, silica fumes and slag) shall not exceed 30 % of the total cement mass.

HEb-N type binder shall contain at least 12 % metakaolin.

(2) Unless otherwise indicated on the plans, the tolerances on the specified values apply only for control purposes.

(3) The air content shall comply with the specifications listed in the table, whether there is addition of superplasticizer or not.

(4) The HE binder is only permitted if the outside temperature is below 15^{0}C.

(5) The GUb-S type binder can be used as a substitute for GU type cement as long as a maximum replacement rate of 10% is respected.

(6) After the addition of the superplasticizer, the slump shall be 120 mm ± 30 mm.

(7) Concrete with no slump.

(8) The bending strength at twenty-eight (28) days, determined by means of a single girder loaded at one-third of the span, shall be at least 4.5 MPa.

(9) The proportion of fine granulate shall be between 45 and 55 %, calculated percentage relative to the total granulate.

(10) The requirement of 3 to 7 % applies for the mobile concrete mixer. For the dosing unit, the air content shall be 5 to 8 %.

(11) At the outlet of the pump, the spacing factor shall be less than or equal to 323 µm.

(12) With the exception of the first twenty-four (24) hours of curing in wet conditions, the curing of the test specimens shall be carried out at a temperature of 23°C ± 2°C and at ambient humidity of the laboratory.

(13) The standard 35 MPa concrete with blowing agent shall contain a reducing admixture and shrinkage compensator at a rate of 6 % of the binder mass.

6.33.4.9 SELF-CONSOLIDATING CONCRETE

6.33.4.9.1 The self-consolidating concrete shall have the following properties:

Type	28-day strength (MPa)	Min. binder mass (kg/m^3)	Type of binder[1]	Max. water/binder ratio or within the interval	Spread (mm) [2]	Coarse aggregate (mm)	Air content[3] (%)	L max (µm)	Max. chloride ion permeability (Coulombs)
XIV-C	35[4]	400 420	GUb-SF GUb-F/SF, GUb-S/SF	0,45	625 ± 50	5-14	6-9	230[7]	1000
XIV-R	35[4]	460	GUb-F/SF, GUb-S/SF	0,35 à 0,40[5]	675 ± 50	2,5-10[6]	6-9	230[7]	1000

Type	28-day strength (MPa)	Min. binder mass (kg/m^3)	Type of binder[1]	Max. water/binder ratio or within the interval	Spread (mm) [2]	Coarse aggregate (mm)	Air content[3] (%)	L max (µm)	Max. chloride ion permeability (Coulombs)
XIV-RE	35	450	50% GU et 50% GUb-SF	0,42[5]	660 ± 50[8]	2,5-10[6]	6-9	230[7]	1000
XIV-S	35	–	GUb-SF, GUb-F/SF, GUb-S/SF	–	650 ± 50	2,5-10	5-9	300	1500
XVII	35	400 420	GUb-SF GUb-F/SF, GUb-S/SF	0,41	500 ± 50	5-14 5-20	6-9	230	1000

(1) GUb-SF type binder shall contain at least 8 % silica fumes.

GUb-F/SF and GUb-S/SF type binders shall contain at least 5 % silica fumes and at least 15 % fly ash or slag. Total mass of supplementary cementing materials (fly ash, silica fumes and slag) shall not exceed 30 % of the total cement mass.

HEb-N type binder shall contain at least 12 % metakaolin.

(2) Unless otherwise indicated on the plans, the tolerances on the specified values apply only for control purposes.

(3) The air content shall comply with the specifications listed in the table, whether there is addition of superplasticizer or not.

(4) The minimum compressive strength at forty-eight (48) hours shall be 10 MPa.

(5) The volume ratio sand / (binder + water + air) shall be between 0.6 and 0.8.

(6) The maximum volume of coarse aggregate shall be 330 L of the total volume of the mixture.

(7) At the outlet of the pump, the spacing factor shall be less than 260 µm.

(8) The time (T_{50} in accordance with ASTM C1611/C1611M) required to achieve a spread of 500 mm shall be between two (2) and seven (7) seconds.

6.33.4.9.2 Unless otherwise indicated on the plans, bagged self-consolidating repair concrete is prohibited.

6.33.4.9.3 In cases where the use of bagged self-consolidating repair concrete is permitted, the concrete shall meet, without however being limited to, the following requirements:

6.33.4.9.3.1 The mix properties shall be those of Type XIV-S indicated in the table of paragraph 6.33.4.9.1.

6.33.4.9.3.2 The bags used for bagging shall be made of a moisture resistant material.

6.33.4.9.3.3 The bagged self-consolidating concrete shall be accompanied by a technical data sheet which shall include, without however being limited to, the following information:

6.33.4.9.3.3.1 the recommended use;

6.33.4.9.3.3.2 the manufacturer’s mixing recommendations (amount of water and mixing equipment);

6.33.4.9.3.3.3 the properties of Type XIV-S concrete showing compliance with the requirements of the table of paragraph 6.33.4.9.1;

6.33.4.9.3.3.4 the precautions and limitations;

6.33.4.9.3.4 The following information shall appear on Type XIV-S concrete bags, without however being limited thereto:

6.33.4.9.3.4.1.1 the manufacturer's name;

6.33.4.9.3.4.1.2 the name of material;

6.33.4.9.3.4.1.3 the dry mass of the self-consolidating concrete;

6.33.4.9.3.4.1.4 the performance;

6.33.4.9.3.4.1.5 the batch number.

6.33.4.9.4 Rapid setting self-consolidating concrete

6.33.4.9.4.1 The rapid setting self-consolidating concrete shall be the product *RS-SCC-35* manufactured by Ambrex, or equivalent authorized by the Engineer.

6.33.4.9.4.2 The use of bagged self-consolidating concrete is authorized for rapid setting self-consolidating concrete.

6.33.4.9.4.3 At three (3) hours of age, the rapid setting concrete shall have a minimum compressive strength of 20 MPa. At twenty-eight (28) days of age, the rapid setting concrete shall have a minimum compressive strength of 35 MPa. The rapid setting self-consolidating concrete shall contain a retarder so as to maintain the spread thereof at 675 mm ±50 mm during thirty (30) minutes.

6.33.4.10 ANTI-WASHOUT CONCRETE

6.33.4.10.1 The anti-washout concrete for underwater works shall have the following properties:

Strength at 28 Days (MPa)	Mininimum GUb-SF Cement Mass (kg/m^3)	Maximum Water/Binder Ratio	Coarse Aggregate (mm)	Fine Aggregate (%)(1)	Air Content (%)	Slump (mm)
35	450	0.42	2.5 to 10	45 to 55	6 to 9	200 ±40

(1) Percentage calculated relative to total aggregate mass.

6.33.4.10.2 The Contractor shall use an anti-shrinkage agent in the anti-washout concrete used for the shafts. The Contractor shall submit to the Engineer, for review, the proposed product and dosage. The dosage shall make it possible to reduce the concrete shrinkage by 50 % relative to the anticipated normal shrinkage.

6.33.4.11 CEMENTITIOUS MORTAR

6.33.4.11.1 The mortar shall be prepared, handled and applied in accordance with the manufacturer's recommendations and according to the placement conditions at the repair site. The cementitious mortars authorized under this Contract shall be the product *Sika Top 123 Plus* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer.

6.33.4.11.2 The cementitious mortars shall contain less than 5 % of coarse aggregate retained on the 10 mm sieve.

6.33.4.11.3 The polymers used as a component of the cementitious mortar shall be used with or in replacement of mixing water.

6.33.4.11.4 The fibres used as a component of the cementitious mortar shall consist of a non-corroding material.

6.33.4.11.5 For superficial repairs of the deck slab when reopening the lanes to traffic is a major issue, Category VR (very rapid setting) cementitious mortar may be accepted by the Engineer.

6.33.4.11.6 Cementitious mortar properties and test methods:

Properties	**Test Methods**	**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		
Bond to concrete (MPa)	ASTM C882	1 day	7.0		
		7 days	10.0		
Water absorption (%)	ASTM C642	Maximum 28 days	5.5		
Length change (%)	ASTM C157/C157M	28 days (water)	+0.15		
		28 days (air)	-0.15		
Surface scaling Maximum loss (kg/m²)	BNQ 2621-905	(56 cycles)	0.50		
Freeze-thaw Min. elastic 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

6.33.4.12 THREE-HOUR RAPID SETTING CONCRETE

6.33.4.12.1 The three-hour rapid setting concrete may be authorized by the Engineer to repair a concrete slab and to replace expansion joints when reopening the lanes to traffic is a critical issue.

6.33.4.12.2 The concrete supplied shall meet all the requirements of this subsection as well as the following:

6.33.4.12.2.1 specified flexural strength at three (3) hours according to standard CAN/CSA-A23.2-8C *Flexural Strength of Concrete (Using a Simple Beam with Third-Point Loading)*: minimum 3.1 MPa;

6.33.4.12.2.2 specified compressive strength at three (3) hours according to standard CAN/CSA-A23.2-9C *Compressive Strength of Cylindrical Concrete Specimens:* minimum 20 MPa;

6.33.4.12.2.3 specified compressive strength at twenty-eight (28) days according to standard CAN/CSA-A23.2-9C *Compressive Strength of Cylindrical Concrete Specimens*: minimum 35 MPa.

6.33.4.12.3 The relative durability factor after three hundred (300) freeze-thaw cycles according to standard ASTM C666/C666M shall be equal to or greater than 80 %. The preparation and curing of the specimens shall meet the manufacturer's requirements.

6.33.4.12.4 The loss of residues after fifty-six (56) spalling cycles according to standard BNQ 2621-905 shall be equal to or less than 0.50 kg/m². The preparation and curing of the specimens shall meet the manufacturer's requirements.

6.33.4.12.5 The chloride-based accelerators are prohibited and the chloride ion content shall be less than 0.15 % of the concrete mass.

6.33.4.12.6 The Contractor shall, using previous results from other projects, demonstrate that the specified strengths indicated at paragraph 6.33.4.11.6 are reached within the prescribed period of three (3) hours.

6.33.5 EQUIPMENT AND TOOLS

6.33.5.1 MOBILE CONCRETE MIXER

6.33.5.1.1 If the concrete is to be placed at a rate lower than 2 m^3/h, if less than 5 m^3 of concrete is to be poured or for rapid setting concrete pours, the concrete can be proportioned and mixed on worksite in a mobile concrete mixer in accordance with standard ASTM C685/C685M.

6.33.5.1.2 The mobile concrete mixer shall have a minimum capacity of 6 m^3 and shall be equipped with a latex modifier storage tank.

6.33.5.1.3 The mixer shall be equipped with two (2) meters to measure the discharge of polymer emulsion:

6.33.5.1.3.1 one meter shall record the flow rate with an accuracy of ±0.5 L per minute;

6.33.5.1.3.2 one meter shall record the total volume discharged with an accuracy of ±1.5 %.

6.33.5.1.4 The mobile concrete mixer shall have the equipment required to measure the actual quantity of cement incorporated into the mix with a recording meter visible at all times and equipped with a ticket printer that indicates that quantity.

6.33.5.1.5 The Engineer may require the recalibration of the cement feed meter as he deems necessary.

6.33.5.1.6 The mixer shall control the water flow introduced into the mix. The water flow shall be subject to the cement and aggregate feed mechanisms and shall be easily adjustable to make changes rendered necessary due to the moisture content of the aggregate. The mixer shall be equipped with a water flow recording meter capable of recording, with an accuracy of ±1.5 %, the number of liters of water introduced into the mix.

6.33.5.1.7 If the Contractor elects to supply the concrete from floating facilities, a barge-mounted mobile plant is permitted if it meets 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 sequences and time for each ingredient of the mix. The results of these tests shall be documented and a copy shall be given to the Engineer prior to the commencement of concreting.

6.33.5.1.7.1 The operator of the mobile plant shall be identified and only he is authorized to mix and supply the concrete during the work.

6.33.5.1.7.2 The storage areas for materials shall meet the requirements of standard CAN/CSA-A23.1 and shall be set up so as to protect the materials from moisture and weather conditions.

6.33.5.1.8 The first 0.25 m^3 of each concrete pour supplied by the mobile concrete mixer shall be used exclusively to prepare and calibrate the equipment and may not be used for another purpose.

6.33.5.2 VIBRATORS

6.33.5.2.1 The vibrators shall meet the requirements of standard CAN/CSA-A23.1 and have the following characteristics:

Minimum Frequency while Immersed in Concrete (Hz)	Vibrator Head Diameter (mm)	Rate of Placement per Vibrator (m^3/h)
170 to 250	20 to 40	1 to 4
150 to 225	30 to 60	2 to 8
130 to 200	50 to 90	5 to 15

6.33.5.3 CONCRETE PUMP

6.33.5.3.1 The pumping equipment shall meet the requirements of standard CAN/CSA-A23.1 and the pump line shall be equipped with S-shaped reducer sections.

6.33.5.3.1.1 The reducer section shall reduce the pump line diameter by at least 33 % and be located at the end thereof.

6.33.5.3.1.2 The S-shaped section shall be formed of two (2) 45º elbows, each of a minimum length of 275 mm and shall be located on the pump line just before the pump enters inside the formwork.

6.33.5.3.1.3 When the last portion of the pump line is in the vertical position over more than 1200 mm, a closing device shall be installed at the end of the pump line; this device shall be activated every time the pump is stopped in order to maintain the pump line full at all times.

6.33.5.3.1.4 After the S-shaped section, the concrete pump shall end with a reducer section in order to maintain a positive pressure inside the pipes and prevent damage to the air network.

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

6.33.5.3.3 No adjustment to the mixes to obtain a mix with higher cement content, a high sand-stone ratio or a higher slump than the requirements indicated on the plans and in the specifications is permitted to meet the requirements of specific models and brands of pumps.

6.33.5.4 HOPPER

6.33.5.4.1 The hopper shall be watertight and of sufficient diameter to allow the free flow of concrete.

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

6.33.5.4.3 The inside diameter of the hopper’s down pipe or “elephant trunk” 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 can flow freely without having to be vibrated.

6.33.5.4.4 The maximum length for 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.

6.33.5.5 SELF-PROPELLED FINISHER

6.33.5.5.1 The slab concrete finishing shall be carried out by means of a *Gomaco* model C-450 commercial self-propelled concrete finisher or equivalent authorized by the Engineer.

6.33.5.5.2 The use of a vibrating screed is prohibited.

6.33.5.5.3 The self-propelled finisher shall be equipped with a mobile unit comprising two (2) feeder screws, two (2) smooth rollers, one (1) vibrating box and a camber device for adjusting the slope of the unit rails. This device shall also be intended to compensate for the camber loss of the finisher bridge when the width to be concreted exceeds 6 m and that the transversal profile is banked. When the distance between the roller rails exceeds 18 m, a stabilisation trellis installed on the top of the finisher, or a finisher with an overhead bridge crane height increased according to the finisher manufacturer’s instructions shall be used. The adjustments to the self-propelled finisher and the operation thereof during the dry run and the concreting shall be performed by a qualified operator reporting to the owner of the finisher.

6.33.5.5.4 Two (2) working platforms shall be used:

6.33.5.5.4.1 one platform to carry out the manual concrete finishing and;

6.33.5.5.4.2 one platform for the curing of the concrete and, where applicable, to install protection in cold weather;

6.33.5.5.4.3 these platforms shall be equipped with metal wheels and shall move on the roller rails used by the self-propelled finisher. The rigidity of the platforms shall be sufficient to withstand a 200 kg load while maintaining a clearance varying from 100 to 150 mm between the platform and the intended profile of the top of the slab.

6.33.5.5.5 Roller rails

6.33.5.5.5.1 The self-propelled finisher shall move on roller rails. These rails shall be parallel to each other, except when the area to be concreted is of variable width. Each rail section shall be fabricated from a steel tube having a minimum diameter of 50 mm and a wall thickness that is sufficient to prevent the deflection of the rail under the weight of the self-propelled finisher. The continuity of rails shall be ensured by a male-female assembly between the rail sections. The roller rails shall rest on height-adjustable steel supports, spaced by a maximum distance of 900 mm. For a slab on girders, the supports installed on a girder shall be welded to steel girder dowel heads or to a concrete girder clamps.

6.33.5.5.5.2 The roller rails shall exceed the extremities of the area to be concreted enough to allow the self-propelled finisher to cover the entire area. The formwork at the end of the slab shall not prevent the free passage of the self-propelled finisher.

6.33.5.5.5.3 The rail located on the outer side of the slab shall be located behind the intended location of the concrete barrier. The rail located on the side of the slab adjacent to another work area shall be located just outside of the surface area of the slab to be concreted. In the latter case, it is prohibited to locate the rail on an existing slab without a structural link with the slab section to be concreted.

6.33.5.5.5.4 The roller rails shall extend over a minimum distance of 3 m on the approaches to the slab so that before and after concreting, the concrete finishing equipment is located outside of the area to be concreted. The formwork at the end of the slab and the backwall reinforcing steel shall not prevent the free passage of the self-propelled finisher.

6.33.6 EXECUTION OF WORK

6.33.6.1 PRE-CONCRETING MEETING

6.33.6.1.1 For each type of concrete, the Contractor shall hold a pre-concreting meeting at least fourteen (14) days prior to the commencement of concreting. The Contractor shall at that time have the Engineer validate the following:

6.33.6.1.1.1 the concrete placement method proposed for each type of element to be casted or repaired as indicated on the plans and in the specifications;

6.33.6.1.1.2 the concrete mixes proposed on the basis of the requirements of these specifications including, if required, any adjustments made as part of the suitability tests;

6.33.6.1.1.3 the quality control measures implemented by the Contractor to ensure the proper performance of the work.

6.33.6.1.2 The Contractor shall ensure that all workers and subcontractors involved in the manufacturing, transportation and placement of the concrete attend the pre-concreting meeting.

6.33.6.2 CONCRETE MIX

6.33.6.2.1 The Contractor is responsible for proportioning the proposed concrete mix and shall, at least fourteen (14) days prior to the commencement of concreting, provide the Engineer with the proposed mix formulas and placement methods.

6.33.6.2.2 The Contractor shall provide a technical data sheet on the cement concrete mix dated and signed by the manufacturer's person in charge of quality control. This data sheet is valid for one (1) calendar year.

6.33.6.2.3 The technical data sheet on the mix shall include the following information:

6.33.6.2.3.1 a mix designation, number or code;

6.33.6.2.3.2 the fresh concrete density in kg/m³ for the specified air content and slump;

6.33.6.2.3.3 the cement mass in kg/m³;

6.33.6.2.3.4 the quantity of water in L/m³;

6.33.6.2.3.5 the mass of fine and coarse aggregate in kg/m³ SSD condition;

6.33.6.2.3.6 the water/binder ratio, considering that the aggregate is in a saturated surface dry (SSD) condition;

6.33.6.2.3.7 the compressive strength;

6.33.6.2.3.8 the air content and slump limits;

6.33.6.2.3.9 the types of admixtures, product names, respective manufacturers thereof and recommended quantities;

6.33.6.2.3.10 the type of cement, origin thereof and name of the cement plant;

6.33.6.2.3.11 a report from a laboratory member of the *Association des firmes de genie-conseils – Québec* (*AFG*), issued within the last (3) years and establishing the characteristics of the air-entrained bubble network in the supplied mix: the air content, air bubble spacing factor and specific surface area;

6.33.6.2.3.12 the intrinsic manufacturing and complementary properties of the fine and coarse aggregate as well as the origin thereof for each calendar year;

6.33.6.2.3.13 the grading, the dry-rodded density, the gross relative density (saturated surface dry (SSD) condition), the percentage of absorption of the fine and coarse aggregate as well as the fineness modulus and colour indicator of the fine aggregate;

6.33.6.2.3.14 a report from a laboratory, member of the AFG, issued within the last three (3) years and establishing the potential for alkali-aggregate reactivity;

6.33.6.2.3.15 the name of the latex and of the manufacturer thereof;

6.33.6.2.3.16 a report from a laboratory member of AFG, issued within the last three (3) years and establishing the chloride ion content;

6.33.6.2.3.17 a report from a laboratory member of AFG, issued within the last three (3) years and establishing the chloride ion permeability of the mix;

6.33.6.2.3.18 a certificate, issued by the manufacturer, of the chemical and physical analysis of the binder used, indicating the percentages of cement additives used in the manufacturing thereof;

6.33.6.2.3.19 a certificate, issued by the manufacturer within the last three (3) months, of the chemical and physical analysis of each cement additive used in the manufacturing of the binder.

6.33.6.2.4 The mix formulas are subject to review by the Owner's Laboratory and acceptance thereby. The Owner reserves the right to request changes to the formula in order for it to comply with the indications on the plans and in the specifications.

6.33.6.2.5 At the request of the Engineer, the Contractor shall submit samples of the admixtures it intends to use.

6.33.6.2.6 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 implementation.

6.33.6.3 PROPORTIONING AND MANUFACTURING OF CONCRETE

6.33.6.3.1 The Contractor shall obtain its supply from a manufacturer capable of guaranteeing that the facilities, equipment and materials used in the manufacturing of concrete as well as all operations related thereto comply with standard CAN/CSA-A23.1.

6.33.6.3.2 The concrete manufacturer's plant shall hold a compliance certificate issued by the BNQ in accordance with certification protocol BNQ-2621-905.

6.33.6.4 WAYBILL

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

6.33.6.4.1.1 the corporate name of the concrete manufacturer and the identification of the batching plant;

6.33.6.4.1.2 the date and identification number of the waybill;

6.33.6.4.1.3 the manufacturer's code number identifying the mix delivered;

6.33.6.4.1.4 the name of the Contractor to which the concrete is to be delivered;

6.33.6.4.1.5 the identification of the structure or structural element;

6.33.6.4.1.6 the grade of the concrete;

6.33.6.4.1.7 the number of the dosage formula, including the quantities of cement, water, coarse aggregate, fine aggregate and admixtures actually incorporated into the mix;

6.33.6.4.1.8 the admixtures used;

6.33.6.4.1.9 the temperature limits specified for fresh concrete;

6.33.6.4.1.10 the air content limits;

6.33.6.4.1.11 the slump limits;

6.33.6.4.1.12 the quantity of concrete in cubic metres;

6.33.6.4.1.13 the truck number, cumulative total for the pour and load number;

6.33.6.4.1.14 the loading time;

6.33.6.4.1.15 the time of arrival on worksite;

6.33.6.4.1.16 the start time of unloading;

6.33.6.4.1.17 the quantity of water added after the proportioning and the signature of the engineer who authorized that addition.

6.33.6.5 PREPARATION OF EXISTING SURFACES PRIOR TO CONCRETING

6.33.6.5.1 All surface preparation work shall be reviewed by the Engineer prior to concrete placement.

6.33.6.5.2 Existing surfaces (concrete, steel or rock)

6.33.6.5.2.1 All surfaces shall be clean, solid and free of loose or broken fragments, sawdust, ice, snow and any other foreign materials and debris.

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

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

6.33.6.5.2.4 The surfaces shall be rough enough to ensure obtaining a complete bond with the new concrete. The roughness of the treated surface shall have a minimum amplitude of 5 mm in accordance with the CSP 8 profile of ICRI's Technical Guideline Nº 03732.

6.33.6.5.2.5 The Contractor shall subsequently remove any excess water from the surfaces using air blasting alone.

6.33.6.5.2.6 The Contractor shall monitor and eliminate any water that may have infiltrated as well as any puddles that have formed in hollows, to the satisfaction of the Engineer.

6.33.6.5.2.7 In the event that the presence of the formwork would prevent the saturation of the surfaces, the Contractor shall, less than thirty (30) minutes prior to concreting, inject water vapour into the formwork during at least twenty (20) minutes.

6.33.6.5.2.8 The injection of water vapour into the formwork shall be carried out so as to create free circulation of vapour by injecting it from one point and evacuating it from another without creating any pressure increase in the formwork. The Contractor shall submit to the Engineer, for information, the type of equipment used and the procedure for injecting water vapour into the formwork.

6.33.6.5.3 Demolished concrete surfaces

6.33.6.5.3.1 The Contractor shall demolish any deteriorated concrete and prepare the surfaces in accordance with the requirements of subsection 6.21 *Demolition and Removal*.

6.33.6.5.3.2 After having been cleaned by means of water blasting, any excess water shall be removed from the surfaces using air blasting alone.

6.33.6.5.3.3 Prior to placing the concrete or the repair product, any water infiltration in the work area shall be controlled and any accumulation of water in hollows shall be removed to the satisfaction of the Engineer.

6.33.6.5.3.4 At least three (3) hours prior to the placement of the new concrete, the Contractor shall moisten the surfaces to be repaired so that they are in SSD condition. Any excess water shall be removed by means of air blasting fifteen (15) minutes prior to the placement of the concrete so that the concrete is in saturated surface dry (SSD) condition at the time of placement.

6.33.6.5.3.5 For the surface repair of the slab, the Contractor shall, prior to placing the concrete, apply to the concrete surfaces and reinforcing steel a bonding agent containing a corrosion inhibitor shall be the product *SikaTop Armatec 110 Epocem* manufactured by Sika Canada Inc. or equivalent authorized by the Engineer. The Contractor shall comply with the maximum waiting period recommended by the manufacturer.

6.33.6.6 TRANSPORTATION OF CONCRETE

6.33.6.6.1 All concrete shall be delivered to the worksite by mixer truck or agitating truck or by mobile concrete mixer in accordance with Article 6.33.5.1 *Mobile Concrete Mixer*.

6.33.6.6.2 The concrete shall be transported so as to ensure that the materials do not segregate and the consistency is not altered.

6.33.6.7 SPECIFIED TIME BETWEEN DOSING AND PLACEMENT

6.33.6.7.1 The time between the start of dosing and complete unloading shall meet the requirements of standard CAN/CSA-A23.1

6.33.6.7.2 At no time shall the time elapsed between dosing and unloading exceed one hundred and twenty (120) minutes. Any departure from this requirement shall be approved by the Engineer prior to concrete placement.

6.33.6.7.3 If ninety (90) minutes have elapsed since dosing, the air content and temperature of the concrete shall be rechecked by the Contractor.

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

6.33.6.8 TEMPERATURE CONTROL

6.33.6.8.1 The temperature of the concrete delivered to the worksite shall comply with standard CAN/CSA-A23.1 and be measured at the outlet of the mixer truck in accordance with standard ASTM C1064/C1064M.

6.33.6.8.2 The temperature shall be as low as possible in order to limit the temperature increase caused by the heat of hydration and shall in no case be higher than the temperature prescribed in the following table:

Thickness of the Smallest Dimension of the Portion to Pour (mm)	**Temperature of Concrete, °C**	
	Minimum	**Maximum**
< 1,000	10	30(1)
1,000 to 2,000	5	25(1)
> 2,000	5	20(1)

(1) The temperature of Type XIII concrete shall at no time exceed 22°C. Between May 15 and October 15, this maximum requirement of 22°C also applies to the concrete of certain major structure elements, namely:

- Thick slabs;
- Rigid-frame structures (crutch, gussets and slab);
- Safety barriers;
- Curbs;
- Sidewalks;
- Bicycle paths;
- Median strips.

During that same period, the temperature of the slab on girder concrete shall not exceed 25°C. This requirement does not apply to Types XIV-S and XVI-15 concretes.

6.33.6.8.3 Concreting in hot weather

6.33.6.8.3.1 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 and Climate Change Canada weather station closest to the worksite), appropriate measures shall be taken to ensure the protection of the placed concrete from the effects of hot or dry weather.

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

6.33.6.8.3.3 In severe drying conditions, the formwork, reinforcing steel and concreting equipment shall be protected from direct sunlight or cooled by means of misting and evaporation.

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

6.33.6.8.3.5 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 the evaporation rate exceeds or could exceed that limit:

6.33.6.8.3.5.1 erect wind screens around the concrete surfaces;

6.33.6.8.3.5.2 wet the support prior to concrete placement;

6.33.6.8.3.5.3 erect sunshades over the concrete during finishing;

6.33.6.8.3.5.4 lower the concrete temperature;

6.33.6.8.3.5.5 cover the concrete surface with a polyethylene film between finishing the phases;

6.33.6.8.3.5.6 undertake curing immediately after towel finishing;

6.33.6.8.3.5.7 place and finish the concrete at night.

6.33.6.8.4 Concreting in cold weather

6.33.6.8.4.1 When the minimum plastic concrete temperatures indicated in paragraph 6.33.6.8.2 cannot be reached, the concrete materials shall be heated according to the following requirements:

6.33.6.8.4.1.1 the temperature of the water that comes into contact with the cement shall be below 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;

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

6.33.6.8.4.1.3 the use of hot mixing water to dissolve frozen clumps and snow in the aggregate is prohibited.

6.33.6.8.4.2 When the air temperature is at or below 5°C or when there is a possibility of it falling below 5°C within twenty-four (24) hours of placement (according to the forecasts from the Environment and Climate Change Canada weather station closest to the worksite), all equipment and materials needed to ensure the protection and curing of the concrete shall be available and ready for use prior to the start of concreting.

6.33.6.8.4.3 Snow and ice shall be removed before concrete is placed on any surface whatsoever. Concrete shall not be placed on or against any surface whose temperature would contribute to lowering that of the concrete.

6.33.6.8.4.4 The concrete shall be maintained at a minimum temperature of 10ºC during the curing period. Type XVI-15 concrete shall be maintained at that temperature for a period of seven (7) consecutive days following concreting. These concrete protection periods shall be extended until the concrete has reached 70 % of the specified strength at twenty-eight (28) days checked by tests on control test specimens cured in the same conditions as the structure.

6.33.6.8.4.5 For the prestressed concrete in place, the concrete protection period shall continue for ten (10) days after the grout injection.

6.33.6.8.4.6 Following the protection period, the concrete temperature shall be gradually lowered during first the twenty-four (24) hours. The rate of decrease shall not exceed 10^0C/h. The concrete shall not be exposed to the outdoor air if the difference between the concrete temperature and that of the outdoor air is greater than 20^0C.

6.33.6.8.4.7 The use of sodium chloride or calcium as a de-icing agent is prohibited.

6.33.6.8.4.8 For outdoor concreting, all surfaces (existing concrete, formwork, reinforcement, etc.) with which the plastic concrete comes into contact shall be pre-heated to a minimum temperature 5^0C until concreting begins.

6.33.6.8.4.9 In cold weather, the Contractor shall provide the appropriate protection for the concrete throughout the duration of placement and curing. Such protection shall be provided by means of heated shelters, tarpaulins, insulation or a combination thereof, according to the following types:

6.33.6.8.4.9.1 Type 1 protection consists in completely covering all plastic concrete surfaces with insulating material. Each layer of insulating material shall be of the waterproof cover type manufactured from closed cell foam plates and shall have an ISR thermal resistance of 0.40. The day before concreting, the Contractor shall obtain approval from the Engineer on the number of layers of insulating material to install. According to the evolution of the concrete temperature during the Type 1 protection period, the Engineer may require a reduction or an increase in the number of layers. The removal or addition of a layer shall be carried out within three (3) hours from the request from the Engineer. The insulation shall be installed in such a way as to prevent any exposure of the concrete surfaces to the outdoor air throughout the duration of the protection. The insulation blanket joints shall overlap by at least 75 mm.

6.33.6.8.4.9.2 Type 2 protection consists in building a shelter enveloping the structure. The shelter shall be constructed so as to cover the surfaces of the structure to be concreted with canvas or tarpaulins. These canvas or tarpaulins shall be watertight, resistant and secured so as not to be displaced during the protection period. The shelter shall be high enough and large enough to allow for the concrete to be placed, finished and cured inside. In the case of a structure supported by shoring resting on the ground, the shelter and heating method shall be designed so as to avoid thawing of the ground. Heating devices such as kettles and heaters shall be of sufficient capacity and in sufficient numbers to maintain the concrete at the required temperature. A stream of hot air shall circulate inside the shelter. The heat shall reach all surfaces, whether formed or unformed. If devices emit carbon dioxide, these gases shall be discharged outside of the shelter. Carbon dioxide shall never come into contact with the concrete.

6.33.6.8.4.9.3 Type 3 protection consists in building a shelter enveloping a deck underside with canvas or tarpaulins and covering the top of the slab with insulating material. In the case of a slab on girders, the shelter shall encompass the girders. These canvas or tarpaulins shall be watertight, resistant and secured so as not to be displaced during the protection period. The protection shall extend vertically on the outer sides of the deck up to a minimum height of 1200 mm above the slab. This extension shall be located within 1000 mm on each side of the slab to be concreted. Sufficient clearance shall be provided between the deck underside and the canvas or tarpaulins in order to allow the flow of a stream of hot air so as to reach all the surfaces to protect. Heating devices such as kettles and heaters shall be of sufficient capacity and in sufficient numbers to maintain the concrete at the required temperature. If devices emit carbon dioxide, these gases shall be discharged outside of the shelter. Carbon dioxide shall never come into contact with the concrete.

6.33.6.8.4.10 For concreting carried out under a Type 2 and 3 protection shelter, the contact surfaces shall be pre-heated and maintained at a temperature ranging between 5^0C and 20^0C for a minimum period of twenty-four (24) hours prior to concreting. The forms shall be kept in place throughout the duration of protection and the formwork surfaces shall be maintained at a temperature ranging between 10^0C and 20^0C.

6.33.6.8.4.11 The heating devices shall be located outside of the protection and a heat distribution system shall be provided inside the protection. The Contractor shall provide the Engineer, for review, at least fourteen (14) days before concreting requiring a Type 3 protection, with the plan of the heating device it intends to use. During the twenty-four (24) hour heating period that precedes the concreting, the Contractor shall cover the surfaces to be concreted with insulating material. Each layer of insulating material shall be of type waterproof cover manufactured from closed cell foam plates and shall have a thermal resistance of ISR 0.40. The Contractor shall have the Engineer approve the number of layers of insulating material to install.

6.33.6.8.4.12 After concreting, the plastic concrete surfaces shall be covered with the same insulating material as soon as it is possible to do so without damaging the surfaces. The insulation shall be installed so as to prevent any exposure of the concrete surfaces to the outdoor air throughout the protection period. The insulating blanket joints shall overlap by 75 mm. Depending on the evolution of the concrete temperature during the protection period, the Engineer may require a reduction or an increase in the number of layers. The removal or addition of a layer shall be carried out within three (3) hours of the request from the Engineer.

6.33.6.8.4.13 In cold weather, the Contractor shall replace the humidification of the surfaces and the wet curing by a membrane-forming curing compound on the horizontal surfaces. These surfaces include slabs on girders and the top of barriers, as well as the top of deck joint shoulders. The curing compound shall be applied immediately after the concrete finishing.

6.33.6.8.4.14 The use of ternary cement after October 15 is prohibited. Ternary cement shall be replaced by binary cement.

6.33.6.8.4.15 The Contractor shall avoid spreading of ice melters on any freshly concreted concrete surface, regardless of the type of concrete used, during a period of twenty-eight (28) days following concreting.

6.33.6.8.4.16 The shelter shall be constructed so as to be capable of withstanding wind loads and snow loads and shall be airtight.

6.33.6.8.4.17 The shelter may be heated with live steam, forced-air, or with stationary heaters or other types of heaters.

6.33.6.8.4.18 The requirements of Article 6.33.6.18 *Curing of Concrete* relating to the curing of concrete apply regardless of the type of protection installed.

6.33.6.8.4.19 Any concrete that has frozen will not be payable and will be rejected. The part of the structure constructed with that concrete will be considered defective and shall be redone at the Contractor's expense as directed by the Engineer.

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

6.33.6.9 CONTROL OF SLUMP AND AIR CONTENT

6.33.6.9.1 All adjustments to slump and air content shall be authorized by the Engineer and made in accordance with Article 5.2.5.3 *Control of Slump, Spread and Air Content* of standard CAN/CSA-A23.1.

6.33.6.9.2 Unless otherwise specified by the Engineer, water may not be added to the water contained in the concrete mix, whether while the mix is in transit or after arrival thereof at the worksite.

6.33.6.9.3 If authorized by the Engineer, the concrete slump 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 dosed.

6.33.6.9.4 The quantity of water added shall not exceed 12 L/m³ or 8 % of the prescribed mixing water and this addition shall be accepted by and carried out under the supervision of the Engineer.

6.33.6.9.5 The use of set retarders to extend the unloading time shall be authorized by the Engineer.

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

6.33.6.9.7 The sampling to test the uniformity of the mixed concrete shall be done in accordance with Article 7.4 *Sampling to determine the Homogeneity of Mixed Concrete* of standard CAN/CSA-A23.2-1C.

6.33.6.10 CONCRETE PLACEMENT

6.33.6.10.1 The concrete shall be placed in accordance with Article 7.4.3 *Discharging Concrete* of standard CAN/CSA-A23.1 and with the following requirements.

6.33.6.10.2 No concreting shall begin before the Contractor has obtained written authorization from the Engineer.

6.33.6.10.3 The slump and air content shall meet the requirements of Articles 6.33.4.8 *Standard Concrete*, 6.33.4.9 *Self-Consolidating Concrete* or 6.33.4.10 *Anti-Washout Concrete* according to the type of concrete to be placed.

6.33.6.10.4 All equipment used to transport and pour the concrete shall allow the fresh concrete to be discharged continuously into the formwork and shall, prior to use, be cleaned of any hardened concrete.

6.33.6.10.5 The concrete shall be placed within 1.5 m of its final position, except for self-consolidating concrete, which may be placed within 10 m of its final position.

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

6.33.6.10.7 The concrete shall be poured in horizontal layers, and the placement rate shall be such that each successive layer can be vibrated in order to ensure a bond with the preceding layer.

6.33.6.10.8 The concrete shall be placed in horizontal layers of a maximum thickness of 500 mm.

6.33.6.10.9 In order to minimize the lateral movement of concrete in the formwork that could lead to segregation, the distance between discharge points shall not exceed 5 m.

6.33.6.10.10 Collector hoppers and chutes or vertical or inclined pipes shall be used as needed in such a way as to maintain the freefall height of the concrete under 1.2 m.

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

6.33.6.10.12 In cases where concreting is interrupted unexpectedly, the exposed surface of the plastic concrete shall be kept moist at all times. Concreting can be resumed if less than one hundred twenty (120) minutes have elapsed since that concrete was mixed. Once that period expired, a vibrator shall be driven into the concrete every fifteen (15) minutes and should sink under its own weight. At the slightest sign of hardening, a construction joint shall immediately be executed, as directed by the Engineer, and concreting shall be interrupted for a minimum period of twenty-four (24) hours.

6.33.6.10.13 The Contractor shall ensure that the reinforcing steel and other embedded elements are not displaced during the concrete placement.

6.33.6.11 PUMPED CONCRETE

6.33.6.11.1 Pumped concrete shall be placed in accordance with standard ACI 304.2R.

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

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

6.33.6.11.4 When the pump starts to be used, the first 0.5 m^3 of pumped concrete or mortar shall be rejected.

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

6.33.6.12 CONCRETING OF DECK SLABS

6.33.6.12.1 Adjustment of formwork, rails and finisher

6.33.6.12.1.1 The formwork shall be adjusted so as to obtain the slab thickness and final longitudinal profile indicated on the plans. The Contractor shall provide for gussets of variable heights above the girders; these heights shall be evaluated every tenth of span by the Contractor, taking into account the level of the top of the girders in place, the loss of camber of the girders under the dead load including, without however being limited to, the slab, barriers and asphalt, the final longitudinal profile, final transversal profile and slopes as well as other geometric characteristics of the deck indicated on the plans. The loss of camber of girders to be used for the assessment of gussets is indicated on the plans.

6.33.6.12.1.2 The Contractor shall add reinforcing bars to connect the slab to the girders when the distance between the top of the transversal reinforcing bar of the slab lower layer of reinforcement and the underside of the dowel heads or girder clamps is less than 25 mm, once the installation of the formwork is complete. These bars shall be positioned less than 30° relative to the vertical. The upper part of the bars shall be located between the two (2) rows of the slab longitudinal reinforcement and the lower part of the bars shall be at least 25 mm above the girders. The quantity of added reinforcement corresponds to the section of the girder dowels or clamps. The added bars shall be galvanized when the slab reinforcing bars are galvanized.

6.33.6.12.1.3 To allow for the vertical movement of the slab formwork with height adjustable saddles, the diaphragm formwork shall not be fixed to the slab formwork. In addition, the slab reinforcing bars shall not be fastened to the girder dowels or clamps or to the diaphragm vertical and horizontal reinforcing bars.

6.33.6.12.1.4 The roller rails shall be adjusted, using a survey level, each tenth of a span in order to obtain the final longitudinal profile of the top of the slab. The roller rail longitudinal profile shall be calculated by the Contractor from the final planned longitudinal profile and loss of camber of the girders or deck under dead load. However, in the case of slab replacement work carried out in phases, the profile of the rail resting on the concrete of a phase that has already been completed shall be the same as that of that concrete.

6.33.6.12.1.5 At least seven (7) days prior to concreting the slab, the Contractor shall submit to the Engineer, for review, the calculated profile of the roller rails. The Contractor shall subsequently adjust the intermediate supports using a rope. Prior to concreting a slab, the Contractor shall, in the presence of the Engineer, adjust the self-propelled finisher so that the level of the finished concrete fits the planned transversal profile perfectly. This adjustment shall be made from a rope installed using a survey level. The slope of the rope shall be that specified on the plans, at the chaining where the rope is installed. In the case of slab replacement work carried out in phases, the slope of the rope shall be equal to that indicated on the plans, corrected by the difference of loss of camber of the girders that support the roller rails.

6.33.6.12.1.6 The Contractor shall subsequently perform, in the presence of the Engineer, a dry run when all the slab reinforcement is installed. The top of the reinforcement shall be located, relative to the formwork, at a height corresponding to the slab thickness less 60 mm. The coating of the slab upper layer of reinforcement shall be 60 mm at any point, with a tolerance of 5 mm.

6.33.6.12.1.7 The slab thickness and the coating of the upper layer of reinforcement shall be checked during the dry run by installing a 55 mm high gauge under the finishing equipment. The slab thickness shall be measured between the top of the gauge and the top of the formwork, with a tolerance of minus 5 mm and plus 10 mm. As for the coating of the upper layer of reinforcement, it is deemed compliant when the gauge can remain in place during the dry run.

6.33.6.12.1.8 In the case of a multiple-span bridge, the dry run shall be carried out on the spans to be concreted and, as a minimum, on the next two (2) spans, whether or not there are deck joints indicated on the plans. The dry run shall be carried out near the outer sides of the slab to be concreted and on both sides of the beams for a structure built on shoring, the distance between the two (2) longitudinal lines of verification is 2 m. The dry run of a curved bridge with a transition on the bridge of the transversal profile, from a camber towards a slope, shall be carried out transversely to the slab, every meter of the slab length, adjusting the height of the finisher transversal high point to obtain the transversal profile indicated on the plans.

6.33.6.12.1.9 Corrections shall be made, as necessary, to the reinforcement, formwork and self-propelled finisher. After these corrections, a new dry run of the self-propelled finisher shall be carried out. Once the dry run on the slab finished, the Contractor shall adjust the level of the top of the end formwork to allow the passage of the finishing equipment. The Contractor shall further adjust the level of the top of the drains with the finishing equipment, using the gauge as a guide.

6.33.6.12.1.10 The adjustment of the self-propelled finisher, including the dry run, shall be completed at least twenty-four (24) hours before beginning concreting the slab.

6.33.6.12.1.11 In the case of a slab on girders and when the roller rails are located on the cantilever formwork, the Contractor shall measure the deflection of the formwork under the weight of the concrete and raise the level of the self-propelled finisher by a value equivalent to that deflection.

6.33.6.12.2 Concreting

6.33.6.12.2.1 At least fourteen (14) days prior to concreting, the Contractor shall submit to the Engineer, for approval, the concreting sequence it intends to use. The concreting sequence shall specify the minimum concrete placement rate that the Contractor intends to use. This placement rate shall be sufficient to allow the placement of at least 75 % of the volume of concrete of the longest span of the bridge during a maximum period of two (2) hours and shall not be less than 20 m^3/h. The Contractor shall take the necessary steps to ensure that the supply of concrete and the equipment needed for the placement make it possible for the minimum placement rate to be respected at all times. These provisions shall include, without however being limited thereto:

6.33.6.12.2.1.1 planning the main routes for the transportation of the concrete as well as the alternate routes considered in case of traffic congestion;

6.33.6.12.2.1.2 providing for a second manufacturing plant compliant with paragraph 6.33.6.3.2 in case of supply problems;

6.33.6.12.2.1.3 conducting a comprehensive inspection of self-propelled finisher prior to the start of concreting to ensure that no mechanical failure will occur during concreting.

6.33.6.12.2.2 The concreting sequence indicated on the plans shall not be changed. The concreting shall be carried out from the lowest point of the area to be concreted. In the case of a bridge having a convex longitudinal profile with a longitudinal slope at any point less than 2 %, concreting may be carried out from either one of the two (2) ends of the bridge. If, however, the longitudinal slope in any point of the slab is greater than 2 %, concreting shall be carried out from the low point corresponding to each end of the bridge.

6.33.6.12.2.3 The concreting of the slab of a curved bridge with a transition on the transversal profile bridge, from a camber towards a slope, shall be carried out adjusting, every meter of the slab length, the height of the transversal high point of the self-propelled finisher or vibrating screed to obtain the transversal profile indicated on the plans.

6.33.6.12.2.4 The front of the self-propelled finisher shall be lowered in order to establish the angle of attack of the smooth rollers prior to the start of concreting.

6.33.6.12.2.5 The area of plastic concrete placed in front of the self-propelled finisher shall not exceed a distance of 3 m. It is prohibited to circulate on the fresh concrete and on the reinforcement partially cast into fresh concrete behind the self-propelled finisher. The Contractor shall ensure that, before the concrete has hardened, the drain holes located at the top of the slab remain free of any concrete.

6.33.6.12.2.6 The Contractor shall place the concrete between the girder supporting cantilever formwork and the next girder before placing concrete on that formwork.

6.33.6.12.2.7 If the Contractor must suspend concreting for some unforeseen reason, the Contractor shall execute a construction joint. This joint shall be executed in a straight line by means of polyethylene foam support rods installed under the lower row of reinforcement and between the two rows of reinforcement. A piece of wood shall also be installed on the upper row of reinforcement. The materials required to execute an unexpected construction joint shall be on worksite prior to the start of concreting.

6.33.6.12.2.8 In the case of a slab on girders and when the roller rails are located on a girder, the rail sections and upper portion of the supports shall be removed after the concrete has hardened. The holes left by the removal of supports shall be filled with concrete at the time of concreting of the barriers.

6.33.6.12.2.9 The self-propelled finisher shall not be moved on cantilever formwork supporting concrete having between one (1) and forty-eight (48) hours of age, notably at the end of concreting of a slab or at the end of a concreting phase planned in the concreting sequence thereof. In the case of concreting by phases of a slab with cantilever formwork supporting concrete, the self-propelled finisher shall not approach within 5 m of concrete having less than forty-eight (48) hours of age.

6.33.6.12.3 Protective bridging

6.33.6.12.3.1 The Contractor shall carry out the protective bridging structure in accordance with subsection 6.15 *Temporary Structures* and with the following paragraphs:

6.33.6.12.3.1.1 Throughout the work period, when the traffic lanes of the roadway under the structure are open, the Contractor shall ensure that there are no spills or potential fall of materials, tools, water, debris, equipment or other on the roadway under, including on barriers and shoulders.

6.33.6.12.3.1.2 Once the installation of the girders completed and prior to undertaking any other operation in connection with the implementation of the slab formwork, the Contractor shall install a protective bringing structure between the girders above the traffic lanes to be maintained open to traffic under the structure, including shoulders thereof, during the installation of the formwork and the concreting of the slab;

6.33.6.12.3.1.3 For all deck slab construction work, regardless of the method used, a protective bridging structure must be installed under the slab and barriers, and in all other locations required to meet the requirement of paragraph 6.33.6.12.3.1.2. The protective bridging structure shall allow the maintenance of a minimum clearance height of 5 m between the high point of the roadway and the soffit of the viaduct, or the protective bridging structure, if the latter is at an elevation lower than that of the soffit. The protective bridging structure shall in no case restrict traffic on the lanes.

6.33.6.12.3.1.4 At least fourteen (14) days prior to commencing protective bridging structure work, the Contractor shall submit to the Engineer the protective bridging structure plans sealed and signed by an engineer member of the *Ordre des ingénieurs du Québec* (*OIQ*).

6.33.6.12.3.1.5 After the protective bridging structure has been constructed, the Contractor shall provide the Engineer with a written notice, signed by an engineer member of the OIQ, indicating that the protective bridging structure constructed complies with the plans submitted. In addition, the Contractor's engineer in charge of the protective bridging structure shall check, during the installation, that the protective bridging structure is compliant and safe.

6.33.6.12.3.1.6 The methods for securing the protective bridging structure shall in no case alter the structural strength or durability of the elements of the viaduct or of the bridge.

6.33.6.12.3.1.7 A waterproof barricade at least 1200 mm high shall be installed at the outer edges of the formwork. This barricade shall remain in place until the removal of the outer barrier formwork is completed.

6.33.6.12.3.1.8 For the protective bridging structure and barricade, the stress to consider is that which occur at the different stages of construction in accordance with standard CAN/CSA S269.1, including the stress due to wind, set in function of a return period of ten (10) years, a gust factor coefficient Cg of 2 and exterior horizontal pressure coefficient CP of 2. To take into account the local overloads due to traffic under the viaduct, the wind design pressures shall be increased by 0.24 kPa perpendicularly to the structure;

6.33.6.12.3.1.9 The protective bridging structure shall remain in place as long as the Engineer so requires and shall not be removed until authorized by the Engineer.

6.33.6.13 UNDERWATER CONCRETING

6.33.6.13.1 The requirements of Article 7.4.5 *Underwater Concreting* of standard CAN/CSA-A23.1 apply, in addition to the following requirements:

6.33.6.13.1.1 the loss of mass due to washout established according to standard CRD-C 61-89A shall be less than 5 % measured in accordance with the standard;

6.33.6.13.1.2 the concrete pump hopper or pipe shall be equipped with a valve or equivalent device to prevent water from entering the hopper pipe or pump;

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

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

6.33.6.13.1.5 the concrete pump hopper or pipe shall be watertight and of sufficient diameter to ensure the free flow of concrete;

6.33.6.13.1.6 the concrete shall be discharged and spread by moving the concrete pump hopper or pipe in such a way as to ensure as even a flow rate as possible. If the concrete pump hopper or pipe loses its load during concreting, the Contractor shall remove and reload it;

6.33.6.13.1.7 the watertightness of the concrete pump hopper and pipe shall be maintained even while sinking the end thereof at least 0.3 m into the placed concrete and while lifting the concrete pump hopper or pipe tube as the level of concrete rises;

6.33.6.13.1.8 the concrete surface emerging from the water shall be cleared of any laitance that could have formed by washout, and the Contractor shall continue placement at the dry end of the formwork in such a way as to push the water and fresh concrete towards the other end surface;

6.33.6.13.1.9 for any part of a structure whose final concrete level is located under water, the formwork shall extend high enough above the water so that at all times, the water is prevented from overflowing the formwork;

6.33.6.13.1.10 in order to prevent washout and segregation, the concrete shall be deposited in a compact mass at its final location. It shall not be handled after placement.

6.33.6.14 LATEX CONCRETE OVERLAY

6.33.6.14.1 Preparation of existing surfaces prior to concreting

6.33.6.14.1.1 Within a maximum of three (3) days following the concreting, once the corrections are completed, the Contractor shall clean the surfaces by means of water blasting at a pressure of 15 MPa;

6.33.6.14.1.2 Wet abrasive blasting is prohibited for the concrete formed with formwork lining. Cleaning shall be carried out by means of water blasting;

6.33.6.14.1.3 At least twelve (12) hours prior to moving the new concrete of the latex concrete overlay, the Contractor shall moisten the surfaces to be repaired in order for it to be in SSD. The excess water shall be removed by means of air blasting fifteen (15) minutes prior to concrete placement so that the concrete is in SSD at the time of placement.

6.33.6.14.2 Temperature control

6.33.6.14.2.1 It is prohibited to pour the overlay concrete when the ambient air or deck temperature is below 10°C, and exceptionally 5°C if the appropriate protective measures are implemented in accordance with Articles 6.33.6.8.3 *Concreting in Hot Weather* and 6.33.6.8.4 *Concreting in Cold Weather* of this subsection are used, or above 25°C.

6.33.6.14.3 Latex emulsion flow rate control

6.33.6.14.3.1 The latex emulsion flow regime shall be determined as follows:

6.33.6.14.3.1.1 the latex flow rate meter shall be adjusted to produce a latex flow regime of 15 % of solid mass per cement mass;

6.33.6.14.3.1.2 the latex shall be discharged over a two-minute period in a cylindrical container, free of contaminants and supplied by the Contractor solely for that purpose;

6.33.6.14.3.1.3 the container shall be weighed on a balance with an accuracy of 1 kg for a 200 kg load;

6.33.6.14.3.1.4 the container weight is subsequently subtracted from the weight indicated;

6.33.6.14.3.1.5 the operation shall be repeated and the latex flow regime will be calculated as the average of the two (2) tests.

6.33.6.14.3.2 The calibration process shall be repeated as needed until the flow regime is set to produce the prescribed quantity of latex. The latex flow regime test shall be conducted immediately prior to each pour of overlay concrete and at other times when deemed necessary by the Engineer.

6.33.6.14.3.3 This control shall be performed after the mixer has been charged with the required amount of aggregate, cement, water, admixtures and latex. Once the cement meter is set to zero, the mixing element set at an inclination of 20^{o} and all controls set at the prescribed dosage, the concrete having entrapped air and plasticity meeting the requirements indicated on the plans shall be discharged in a 0.20 m^3 container supplied by the Contractor. When the container is full, the cement meter shall indicate a cement unloading equal to 78 kg ±2 kg.

6.33.6.14.3.4 When the performance specifications of Article 6.33.6.14.3.1.1 are not reached, adjustments shall be made in the proportions of aggregate and the test resumed until the performance reaches the required amount within 1 %.

6.33.6.14.4 Concreting of the concrete overlay

6.33.6.14.4.1 The implementation operations of the self-propelled finisher for concreting the overlay shall be carried out as required by Article 6.33.6.12 *Concreting* of this subsection.

6.33.6.14.4.2 Immediately before placing the overlay concrete, the adhesion grout shall be applied on the slab and brushed vigorously with a stiff-bristled broom. The adhesion grout shall not be applied more than five (5) minutes before the placement of the latex concrete and shall not have dried. Otherwise, it shall be removed and replaced at the Contractor's expense. The slab surfaces covered with grout shall be located within 3 m of the surfaces where the overlay concrete is already placed.

6.33.6.14.4.3 The transversal and longitudinal profiles of the concrete and the overlay concrete finishing shall be carried out by means of the self-propelled concrete finishing equipment *Gomaco Bid-Well* or equivalent authorized by the Engineer. The maximum width between the end of the finishing equipment and the barrier, that is to say the width where the concrete shall be finished manually, is set at 300 mm. It is prohibited to circulate on the fresh concrete behind the finishing equipment.

6.33.6.14.4.4 The surface profile shall not vary by more than 6 mm from the profile indicated on the plans. No irregularities or unevenness of the surface shall exceed 5 mm within 3 m. Any irregularity noted shall be corrected at the Contractor's expense and at the satisfaction of the Engineer.

6.33.6.14.4.5 If the concreting work is carried out in phases, such as one lane at a time, the profile of the finishing equipment roller rail adjacent to a lane already concreted shall be the same as that of the top of the concrete already placed, unless otherwise indicated by the Engineer. The profile shall also align with the concrete shoulders of joints.

6.33.6.14.4.6 The concreting shall be carried out using a bucket or a mobile concrete mixer. Only the passage of the mobile concrete mixers is permitted in the adjacent lanes on both sides, which shall be closed to traffic. The lanes adjacent to the pour shall remain closed during the pour of the latex concrete overlay and for a minimum period of twelve (12) hours following placement or until the concrete has reached a compressive strength of 10 MPa. Only the concrete mixer is allowed to circulate on these buffer lanes.

6.33.6.14.4.7 The Contractor shall submit to the Engineer, for approval, at least fourteen (14) days prior to concreting the overlay, the concreting work sequence it intends to use, including concrete placement rate, if it is different from that indicated on the plans. This placement rate shall be sufficient to allow the placement of at least 8 m^{3}/h of concrete and to cover the entire upper slab of a substructure, namely between two (2) deck joints.

6.33.6.14.4.8 Concreting may be carried out from the low point to the high point or from the high point to the low point. The concreting direction shall be planned in function of the access and maintenance of traffic constraints.

6.33.6.14.4.9 Traffic is prohibited on the finished surface of the concrete overlay as long as the concrete has not reached a compressive strength of 25 MPa.

6.33.6.14.4.10 All full-depth repairs shall be carried out before the placement of the concrete overlay. The openings in the upper slab shall also be concreted before the placement of the concrete overlay. Unless otherwise indicated on the plans, the surface repairs shall be poured with the concrete overlay.

6.33.6.14.5 Construction joints

6.33.6.14.5.1 If the Contractor must suspend the concreting of the overlay for some unforeseen reason, the Contractor shall execute a construction joint as directed by the Engineer.

6.33.6.14.5.2 This joint shall be executed in a straight line by means of polyethylene foam support rods resting on a piece of wood. The materials required to execute an unexpected construction joint shall be on worksite prior to the start of concreting.

6.33.6.14.6 Surface finishing

6.33.6.14.6.1 The finishing for the concrete overlay shall be rough and grooves of a minimum depth of 3 mm shall be made perpendicular to traffic so as to make the surface slip-resistant. The center to center spacing between grooves shall be 19 mm and the width of the groove teeth shall be 3 mm. A longitudinal distance of 200 mm shall be maintained without grooves along the barriers in order to allow the water to drain. Prior to concreting the overlay, the Contractor shall conduct a test to determine the appropriate method to make the grooves.

6.33.6.14.6.2 The use of water or any other product to facilitate the concrete overlay finishing is prohibited.

6.33.6.14.7 Repair of concreting defects

6.33.6.14.7.1 For latex concrete overlay work, all cracks shall be repaired at the Contractor's expense with the sealant used for joints between pours, at least three (3) months after the last pour of the overlay concrete in accordance with subsection 6.37 *Miscellaneous Products for Concrete Work*.

6.33.6.14.8 Joint sealing

6.33.6.14.8.1 The longitudinal joints between pours and the joints between the overlay and the shoulders, drains or barriers shall be sealed in accordance with subsection 6.37 *Miscellaneous Products for Concrete Work*.

6.33.6.15 CONSOLIDATION OF CONCRETE

6.33.6.15.1 The requirements of Article 7.4.4 *Consolidation* of standard CAN/CSA-A23.1 apply, in addition to the following requirements:

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

6.33.6.15.1.2 the vibrators shall meet the requirements of standard CAN/CSA-A23.1 and the characteristics listed in the table contained in Article 6.33.5.2 *Vibrators*;

6.33.6.15.1.3 there shall always be at least one vibrator more than the number prescribed in standard CAN/CSA A23.1 at the concreting location at all times;

6.33.6.15.1.4 in general, the distance between the vibrator immersion points shall be approximately 1.5 times their observed radius of vibration, which corresponds to approximately six (6) times the diameter of the internal vibrator;

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

6.33.6.15.1.6 the vibrator shall subsequently be slowly withdrawn on a vertical plane at a speed of less than 100 mm/s (approximately four (4) seconds for a 400 mm layer);

6.33.6.15.1.7 at no time shall the vibrator touch the embedded elements, reinforcing steel and formwork;

6.33.6.15.1.8 the vibrator shall be introduced, in any point whatsoever, until the concrete is fully consolidated, but not enough to cause segregation of the concrete;

6.33.6.15.1.9 the vibrator shall not be used to move the concrete;

6.33.6.15.1.10 to eliminate air bubbles trapped at the surface of the formwork where there is flow at high speed or with architectural treatment, the layer thickness shall be reduced and greater attention shall be paid to the vibration procedure. The Contractor shall then reduce the immersion distance, increase the vibration time and reduce the speed at which the vibrator is withdrawn;

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

6.33.6.15.1.12 the number of vibrators depends on the diameter of the vibrator head and of the concrete placement rate. In the specific case of repairs, a small-diameter vibrator shall be used if there is little space in the formwork. External vibration is prohibited.

6.33.6.16 CONSTRUCTION JOINTS

6.33.6.16.1 Construction joints represent breaks in the construction work or in a concrete pour and are permitted only in the locations indicated on the plans.

6.33.6.16.2 Construction joints that are not indicated on the plans shall be authorized 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.

6.33.6.16.3 Where a construction joint must be executed, the surface of the set concrete shall be suitably roughened, thoroughly cleaned of foreign materials and laitance, saturated with water and kept moist, with no excess water on the surface, until concreting resumes, in accordance with Article 6.33.6.5.2 *Existing Surfaces (Concrete, Steel or Rock)*.

6.33.6.16.4 When the formwork is being installed, chamfer strips shall be placed at the construction joints so that the exposed edge has a flawless finish, to the satisfaction of the Engineer.

6.33.6.16.5 The first layer of concrete poured on the hardened concrete that was previously poured shall be approximately 150 mm thick. The fresh concrete shall be evenly vibrated with internal vibrators introduced into the mass thereof approximately every 500 mm.

6.33.6.16.6 Tightness of construction joints

6.33.6.16.6.1 All construction joints indicated on the plans to be watertight shall have a waterstop.

6.33.6.16.6.2 The waterstops shall meet the requirements of Article 6.37.8 *Waterstops* of subsection 6.37 *Miscellaneous Products for Concrete Work.*

6.33.6.16.6.3 The concreting shall be carried out in such a way as to prevent any loss of laitance where the seal and formwork come into contact (caulking or elastomeric joint) and to prevent warping of the waterstop. The half of the seal protruding through a form shall be protected, if necessary, by a wooden board or support on each side in such a way as to prevent the seal from bending or being damaged.

6.33.6.16.7 Contraction joints

6.33.6.16.7.1 The requirements of Article 7.2.2 *Contraction Joints* of standard CAN/CSA A23.1 apply, in addition to the following requirements:

6.33.6.16.7.1.1 the contraction joints, also called “control joints”, may be executed by sawing, manual shaping or by inserting pre-formed crack-inducing strips into the concrete surface;

6.33.6.16.7.1.2 the contraction joints are indicated on the plans;

6.33.6.16.7.1.3 unless otherwise indicated, the contraction joints shall be spaced according to a grid whose axes shall be no farther than 4.5 m apart;

6.33.6.16.7.1.4 the shaped joints and pre-formed strips shall sink into the concrete to a minimum depth of 25 mm.

6.33.6.16.8 Joint Rustication

6.33.6.16.8.1 Unless otherwise indicated on the plans, all horizontal and vertical construction joints and contraction joints shall be rusticated by means of 20 mm chamfer strips placed in the formwork.

6.33.6.16.8.2 The chamfer strips shall consist of the same material as that of the formwork.

6.33.6.16.8.3 The chamfer strips shall be placed in such a way as to leave a neat regular groove in the concrete at all construction joints, along the exposed vertical edges of the contraction joints and at all exposed corners and edges of the concrete.

6.33.6.16.8.4 The chamfer strips shall all be of equal section, level and aligned correctly.

6.33.6.17 SURFACE FINISHING

6.33.6.17.1 The concrete finishing shall be carried out while the concrete is still sufficiently plastic to produce the required texture, slopes and levels.

6.33.6.17.2 No excessive bleeding of water and fine particles shall appear on the concrete surface.

6.33.6.17.3 The surfaces shall not deviate from the prescribed limits by more than 5 mm when measured with a 3 m straight edge.

6.33.6.17.4 For all unformed surfaces, with the exception of slabs whose finishing is carried out by means of the self-propelled concrete finishing equipment *Gomaco Bid-Well* or equivalent authorized by the Engineer, the surface shall be leveled with a straight edge and subsequently finished with a leveling tool so as to eliminate the projections and ridges and fill the voids and hollows left on the concrete surface by the leveling. The tool used to level the concrete shall be made of a magnesium alloy. The texture of the finishing shall be the same as that of the adjacent concrete, or as directed by the Engineer.

6.33.6.17.5 The unformed surfaces shall be finished with a magnesium trowel in order to obtain a texture similar to that of the adjacent concrete.

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

6.33.6.17.7 The holes left by the tie rods, the hollows and the cavities shall be sufficiently deep and the edges thereof shall be sufficiently perpendicular to retain the leveling mortar.

6.33.6.17.8 The hollows and cavities shall be saturated with water and repaired after the surface to be leveled has been brushed with a pure cement paste and filled with a mortar containing the same sand and cement as those used for the concrete.

6.33.6.17.9 The surfaces shall be kept moist for a continuous period of three (3) successive hours preceding the filling with concrete or mortar.

6.33.6.17.10 The mortar shall be pressed or packed firmly into the cavity so as to fill it completely, then finished so as to give it the same texture as that of the adjacent surface or as directed by the Engineer.

6.33.6.17.11 For finishing subject to freeze-thaw cycles, the action of de-icing salts or both, the Contractor shall use a pre-bagged material containing latex that can withstand freeze-thaw cycles and is resistant to de-icing salts.

6.33.6.17.12 All asperities, rough edges, unevenness of the surfaces due to misalignment of the formwork and concrete burrs on the surface perimeter shall be carefully grinded.

6.33.6.17.13 For slabs, the concrete finishing shall be carried out from a working platform. The platform shall be equipped with metal wheels and shall move on the roller rails used by the self-propelled finisher or vibrating screed. From the working platform, final polishing by means of a float shall be carried out transversally to the slab over the entire concreted surface area. The float shall be made of an aluminum or magnesium alloy. This polishing shall be carried out as work progresses and within 6 m behind the self-propelled finisher. In case of work stoppage, polishing shall be carried out within forty-five (45) minutes after concrete placement.

6.33.6.17.14 The finishing of the concrete located near the outer sides of the slab shall be carried out manually as the forward movement of the self-propelled finisher or vibrating screed progresses, and so as to extend the established transversal slope. The Contractor shall ensure that the height between the top of the roller rails and the top of the adjacent slab is constant in any point. The quality of the slab concrete finishing shall meet the requirements relating to the placement of a waterproofing membrane in accordance with subsection 6.64 *Deck Waterproofing Membrane*.

6.33.6.17.15 Within forty-eight (48) hours from the application of the tack coat, all concrete surfaces of a new slab shall be thoroughly cleaned by means of steel shotblasting mounted on wheeled equipment. The equipment shall be adjusted to have a maximum intensity jet. The slab surfaces shall be dry at the time of cleaning. The cleaning of the surface shall not create a vertical drop between two (2) consecutive passages of the equipment. The surfaces located along, and on the first 65 mm at the base of the curb, if any, barriers and deck joints shall be cleaned by means of dry abrasive blasting. The use of water blasting or wet abrasive blasting is prohibited. The quality of that cleaning shall be at least equivalent to that obtained by the steel shotblasting.

6.33.6.17.16 The surface of the top of the bridge bearing seat blocks shall be perfectly flat and horizontal.

6.33.6.17.17 The use of water or any other product to facilitate the concrete finishing is prohibited.

6.33.6.17.18 In the case where the beams to be repaired are reinforced with carbon fiber, the finishing of the repair or reprofiling mortar of the beam surfaces shall meet the requirements for carbon fiber reinforcement work in accordance with subsection 6.38 *Reinforcement of Structural Elements by Addition of Carbon Fiber Reinforced Polymer (CFRP).*

6.33.6.18 CURING OF CONCRETE

6.33.6.18.1 The Contractor shall the take necessary precautions to eliminate the causes of concrete deterioration resulting from shock or vibration, in accordance with the following requirements:

6.33.6.18.1.1 the demolition of continuous concrete elements using hammers is prohibited within 30 m of fresh concrete, from the time of placement until it reaches a compressive strength of at least 70 % of f'_c checked by tests on control test specimens cured in the same conditions as the concrete of the structure;

6.33.6.18.1.2 the driving or vibro-sinking of piles, vibro-compaction or vibro-replacement of soils are prohibited within 30 m of fresh concrete, from the time of placement until it reaches a compressive strength of at least 70 % of f'_c checked by tests on control test specimens cured in the same conditions as the concrete of the structure;

6.33.6.18.1.3 the compaction of materials (soil, granular material, asphalt) is prohibited within 30 m of fresh concrete, from the time of placement until it reaches a compressive strength of at least 70 % of f'_c checked by tests on control test specimens cured in the same conditions as the concrete of the structure;

6.33.6.18.1.4 the vehicular movement on recently concreted surfaces, including that on worksite, is prohibited as long as the concrete has not reached a compressive strength of at least 70 % of f'_c checked by tests on control test specimens cured in the same conditions as the concrete of the structure.

6.33.6.18.2 The curing shall be maintained for a minimum period of seven (7) days following concreting, except for Type XVI-15 type concrete where the curing shall be maintained for a minimum period of twenty-four (24) hours.

6.33.6.18.3 For new bridges, decks, retaining walls, slabs and culverts with the exception of foothings, transition slabs and single seal deck joints, the curing shall continue, for all types of concrete, after the minimum period of seven (7) days as long as the concrete has not reached 70 % of f'_c checked by tests on control test specimens cured in the same conditions as the concrete of the structure.

6.33.6.18.4 Curing method

6.33.6.18.4.1 Water-soaked absorbent fabrics

6.33.6.18.4.1.1 This method consists in placing water-saturated synthetic fiber fabrics and then covering them with waterproof sheets to keep the moisture on the concrete surface.

6.33.6.18.4.1.2 The surfaces shall be completely covered with the water-saturated fabrics. The fabrics shall be kept continuously moist so that, throughout the duration of the curing, there is thin layer of water at the concrete surface.

6.33.6.18.4.1.3 The water used for curing the concrete shall comply with Article 6.33.4.2 *Water* relating to the mixing water. The water temperature shall not be below 10°C.

6.33.6.18.4.2 Membrane-forming curing compound

6.33.6.18.4.2.1 This method consists in applying a translucent curing compound with a fugitive dye on the concrete surfaces.

6.33.6.18.4.2.2 The membrane-forming curing compound shall be applied so as to form a film that is sufficiently thick and continuous over the entire surface exposed to the ambient air, as recommended by the manufacturer, without however being less than 0.2 L/m².

6.33.6.18.4.3 Top of slabs, sidewalks and bicycle paths

6.33.6.18.4.3.1 The water-soaked absorbent fabric curing method shall be used for the surfaces of slabs, sidewalks and bicycle paths. Prior to this curing, the plastic concrete surfaces of the slab, sidewalks and bicycle paths shall be kept moist on a continuous basis. To this end, the Contractor shall use equipment that sprays fine droplets of water on the concrete surfaces so as to form a fine mist that does not damage the plastic concrete. Any excessive water supply resulting in the dripping, flow or accumulation of water on the concrete surfaces before it has initially set is prohibited. The continuous humidification of the surfaces shall be carried out as the concrete finishing is completed and, in the case of a slab, within a maximum distance of 6 m behind the equipment used for the placement of the concrete. The continuous humidification shall continue until curing using water-soaked absorbent fabrics is carried out, without damaging the concrete surfaces. The continuous humidification of the surfaces prior to curing shall be carried out even when protection in cold weather is required.

6.33.6.18.4.3.2 The water-soaked absorbent fabric curing shall be carried out immediately after the continuous humidification of the surfaces.

6.33.6.18.4.3.3 In the case of a slab, the absorbent fabrics and waterproof sheets shall be installed from a working platform other than that used for the concrete finishing.

6.33.6.18.4.4 Other elements

6.33.6.18.4.4.1 The curing of unformed concrete surfaces shall be carried out by means of water-soaked absorbent fabrics, as soon as the concrete is hard enough not to be damaged on the surface by the absorbent fabrics.

6.33.6.18.4.4.2 As soon as the forms are removed, water-soaked absorbent fabrics or a membrane-forming curing compound shall be applied on the unformed surfaces before the end of the period required for the curing of concrete.

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

6.33.6.18.4.6 Steel formwork left in place to allow the concrete to cure shall, upon authorization from the Engineer, be slightly loosened after the concrete has initially set in order to allow watering that lets the water flow between the formwork and the concrete surface.

6.33.6.18.4.7 In the case of mass concrete, the curing shall be specifically carried out by constant watering or ensured by the use of absorbent mats, burlap cloths and polyethylene fabric kept continuously moist. The water temperature shall be equal to or not less than 10°C below that of the concrete.

6.33.6.18.4.8 The concrete works whose curing is not carried out in accordance with the requirements of the specifications or as directed by the Engineer will not be payable. Furthermore, the Owner reserves the right to have concreting redone at the Contractor's expense if, in the opinion of the Engineer, the concrete work has suffered a loss of quality as a result of lack of curing.

6.33.6.18.5 Cold-weather curing

6.33.6.18.5.1 The concrete shall be maintained at a minimum temperature of 10°C during the minimum curing period of seven (7) days.

6.33.6.18.5.2 This minimum period of concrete protection shall be extended as long as the concrete has not reached 70 % of the required strength at twenty-eight (28) days or the strength indicated on the plans.

6.33.6.18.5.3 The heaters shall be of sufficient capacity and in sufficient numbers to maintain the concrete at the required temperature.

6.33.6.18.5.4 Where heaters emitting carbon dioxide are used, the Contractor shall ensure that this gas is discharged outside of the shelter. Under no circumstances shall carbon dioxide come into contact with the concrete.

6.33.6.18.5.5 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 the outdoor air if the difference between the temperature of the concrete and that of the outdoor air is greater than 20°C.

6.33.6.18.5.6 Throughout the duration of the protection period, the Contractor shall supply and install a sufficient number of thermometers that record the low and high temperatures to check the temperature of the concrete in place and a thermometer to check the temperature of the outdoor air.

6.33.6.18.5.7 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.

6.33.6.19 REPAIR OF CONCRETING DEFECTS

6.33.6.19.1 The concreting defects identified by the Engineer shall be repaired using methods approved by the Engineer.

6.33.6.19.2 All 0.3 mm or wider cracks in the new concrete shall be repaired at the Contractor‘s expense according to the criteria of subsection 6.35 *Injection.*

6.33.6.19.3 The honeycombs identified after removal of the forms shall not be repaired until they have been inspected and marked by the Engineer.

6.33.6.19.4 Where honeycombs have formed in non-structural elements, the perimeter of the area to be repaired shall be marked with 20 mm deep saw cuts perpendicular to the surface in accordance with subsection 6.21 *Demolition and Removal*.

6.33.6.19.5 After sawing and roughening but before filling, each cavity shall be cleaned with a brush and compressed air, washed and kept wet on a continuous basis for a minimum period of three (3) hours in accordance with subsection 6.21 *Demolition and Removal*.

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

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

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

6.33.6.19.9 The repaired areas shall undergo a curing treatment in accordance with Article 6.33.6.1 *Curing of Concrete*.

6.33.6.19.10 All asperities, rough edges, unevenness of the surfaces due to a misalignment of the forms, among each other or relative to the existing concrete, for a repair with formwork without overlay, and concrete and laitance burrs between two (2) panels shall be carefully grinded.

6.33.6.19.11 If temporary openings were made at the upper part of the formwork, they shall be removed the day following concreting and the concrete surplus shall be removed with a manual hammer and a manual chisel up to a distance of approximately 5 mm from the final profile of the concrete surface.

6.33.6.20 SURFACE REPAIR OF EXISTING CONCRETE

6.33.6.20.1 The identified surface repairs of the existing concrete shall be carried out according to methods approved by the Engineer.

6.33.6.20.2 Where honeycombs are identified in non-structural elements, the perimeter of the areas to be repaired shall be marked with 20 mm deep saw cuts perpendicular to the surface in accordance with subsection 6.21 *Demolition and Removal*.

6.33.6.20.3 After sawing and roughening but before filling, each cavity shall be cleaned with a brush and compressed air, washed and kept wet on a continuous basis for a minimum period of three (3) hours in accordance with subsection 6.21 *Demolition and Removal*.

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

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

6.33.6.20.6 Where honeycombs are identified in structural elements, the corrective measures shall be taken as directed by the Engineer.

6.33.6.20.7 The repaired areas shall undergo a curing treatment in accordance with Article 6.33.6.1 *Curing of Concrete*.

6.33.6.21 JOINT SEALING

6.33.6.21.1 The control joints, construction joints and contraction joints indicated on the plans or executed at the request of the Engineer as well as the cracks that have appeared in the concrete latex overlay shall be sealed in accordance with subsection 6.37 *Miscellaneous Products for Concrete Work*.

6.33.6.22 CLEANING OF SURFACES

6.33.6.22.1 The surfaces shall be treated by high-pressure water blasting or wet abrasive blasting. The cleaning shall remove all traces of laitance, coating, paint, rust, oil, curing compound or any other dirt and shall give concrete a uniform appearance. The treated surfaces shall subsequently be cleaned by means of water blasting, with a pressure of 15 MPa, a flow rate 20 L/min, a concentrated circular jet nozzle and a nozzle-concrete distance of 150 mm to 200 mm, so as to obtain a surface free of any debris. The equipment used for the wet abrasive blasting shall be equipped with a filter that removes oil. The filter efficiency shall be demonstrated before using the equipment.

6.33.7 QUALITY CONTROL

6.33.7.1 INSPECTIONS AND TESTS

6.33.7.1.1 Inspections and testing of the concrete and constituents thereof will be conducted by the Owner's Laboratory. Under no circumstances shall such inspections and testing have the effect of limiting or modifying the Contractor's obligations under this Contract.

6.33.7.1.2 The Contractor shall provide the installations and accesses needed to collect the test cylinders.

6.33.7.1.3 At least twenty-four (24) hours prior to each concrete pour, the Contractor shall send a written concreting notice to the Engineer so that the latter may notify the Owner's Laboratory. The Contractor shall ensure that a representative of the Owner's Laboratory is present during these pours, failing which the Engineer will not allow concreting to proceed. The concreting notice shall specify the date and time of concreting.

6.33.7.1.4 The Engineer will not authorize the concreting of any part of a structure before the technical data sheet on the mix, as defined in paragraph 6.33.6.2.3 is accepted, all the formwork and all the reinforcement for that part of the structure are in place, the cleaning of the formwork and saturation of the demolished concrete surfaces is carried out, the equipment and materials necessary for the placement, curing and protection of the concrete in cold weather are on site and the concrete surfaces to be preserved and reinforcing bars exposed after demolition are cleaned.

6.33.7.1.5 The temperature, slump and spread of the concrete shall be measured at the outlet of the truck mixer. Where a pump is used, the air content, air network properties and compressive strength shall be measured at the outlet of the pump line. The sampling to conduct these tests shall be carried out without interrupting the concrete pumping operation. To determine the loss in air during pumping, the air content shall be measured at the outlet of the mixer truck and at the outlet of the pump.

6.33.7.1.6 Unless otherwise indicated on the plans, the Owner's Laboratory will collect six (6) test cylinders from every pour of 50 m^3 or smaller. Four (4) additional cylinders will be collected for every additional 50 m^3 of concrete placed.

6.33.7.1.7 The Owner's Laboratory will never collect less than six (6) cylinders a day for each grade of concrete placed, and this, for each type of structural element.

6.33.7.1.8 Where concreting is carried out in cold weather, three (3) additional test cylinders will be collected by the Owner's Laboratory. The Contractor shall ensure that these cylinders are cured on worksite.

6.33.7.1.9 The cylinders kept on worksite shall be laid out so that they are subject to the same curing conditions as the concrete placed in the structure. The Contractor shall ensure that its personnel do not move the test cylinders during curing.

6.33.7.1.10 Whenever test cylinders are collected, the Owner's Laboratory will check the percentage of air, temperature and plasticity of the concrete. This work will be carried out on worksite.

6.33.7.1.11 If the quality of the concrete does not meet the requirements of these specifications, the Contractor shall redo the defective structures at its expense and bear the cost of the additional tests.

6.33.7.1.12 The non-destructive test methods used for concrete shall comply with standard CAN/CSA-A23.2.

6.33.7.2 SUITABILITY TEST

6.33.7.2.1 The Contractor shall conduct a suitability test for the concretes for which a suitability test is indicated on the plans.

6.33.7.2.2 The suitability test is not required for precast concrete elements.

6.33.7.2.3 The Contractor shall submit to the Engineer the results of the tests carried out on samples cast with the mixture indicated on the plans with resistance compression at seven (7), fourteen (14) and twenty-eight (28) days following the preparation of the specimens, at least two (2) weeks before proceeding with the suitability test.

6.33.7.2.4 A meeting bringing together the representatives of the Contractor, of the concrete manufacturer and of the Owner shall be held, at least fourteen (14) prior to the conduct of the suitability test. At least twenty-four (24) hours prior to the conduct of the suitability test, the Contractor shall give to the Engineer a written notice specifying the date and time of the meeting.

6.33.7.2.5 The Contractor shall conduct the suitability test of a concrete at least fourteen (14) days prior to the date scheduled for the first pour of that concrete.

6.33.7.2.6 The Contractor shall check the compliance of the concrete properties including, without being limited to, the air content, slump, spread, temperature, compressive strength and air network properties during the conduct of the suitability test. That test will also make it possible for the Contractor to make the adjustments thereby deemed necessary to obtain the rheological properties that are suitable for the placement mode and maintenance of the concrete physical properties.

6.33.7.2.7 The suitability test shall be conducted using the same placement mode (pump, bucket or other equipment) as the one planned for the concreting of the structure. If the pump and another equipment are used for the concrete placement, only one suitability test for the placement mode with a pump is required. When a pump is used, the air content, air network properties and compressive strength shall be measured at the outlet of the pump line. The sampling to conduct these tests shall be carried out without interrupting the concrete pumping operation. The temperature, slump and spread of the concrete shall be measured at the outlet of the truck mixer. To determine the loss in air during pumping, the air content shall be measured at the outlet of the mixer truck and at the outlet of the pump.

6.33.7.2.8 The suitability test consists in carrying out a pour using a quantity of approximately 5 m^3 of concrete. The concrete pump used during the suitability test shall be equipped with the same pumping system model as the one planned to be used during the concreting of the structure. The concrete pump used for the suitability test shall have a distribution mast of a height at least equal to that of the pump used for concreting the structure. Furthermore, the suitability test shall be conducted with the distribution mast of the pump, deployed so that the last portion of the mast is in the vertical position. This portion shall represent at least half the maximum height of the mast. The maximum height of the mast corresponds to the height reached when it is fully deployed in the vertical position. At the end of the pump line, a section that reduces by at least 33 % followed by an S-shaped section formed of two (2) 45º elbows, each of a minimum length of 275 mm, and a closing device shall be installed.

6.33.7.2.9 Unless otherwise indicated on the plans, the Contractor may use the footing or transition slab of a structure to conduct the suitability test. In the absence of these elements, the Contractor shall conduct the suitability test outside the structure to be constructed.

6.33.7.2.10 Following the suitability test, the Contractor will be allowed to proceed with an initial pour with this concrete only after the results of the tests conducted by the Owner's Laboratory on the test specimens at fourteen (14) days are known, sent to the Engineer and accepted in writing by the latter on the basis of satisfactory results. However, the Engineer reserves the right to await the results of the tests at twenty-eight (28) days. The fact that the Engineer has authorized the concreting does not relieve the Contractor of its responsibility to provide concretes comply with plans and specifications.

6.33.7.2.11 The Contractor shall conduct a new suitability test at its expense if the test results do not meet requirements of the plans and specifications.

6.33.7.3 ADHESION BETWEEN REPAIR CONCRETE AND EXISTING CONCRETE

6.33.7.3.1 The Contractor shall provide for and locate indicators inside the formwork to ensure that the adhesion tests that will subsequently be conducted by means of core sampling do not conflict with the reinforcement.

6.33.7.3.2 For the adhesion tests, the Contractor shall collect, in the presence of a representative of the Owner's Laboratory, the minimum number of core samples per concrete pour indicated on the plans.

6.33.7.3.3 The minimum requirements in terms of adhesion between the repair concrete and the existing concrete are the following:

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

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

6.33.7.3.3.3 the method to conduct the test is the direct tension test method according to standard CAN/CSA-A23.2-6B *Method of Test to Determine Adhesion by Tensile Load*.

6.33.7.3.4 If any of the criteria listed in paragraph 6.33.7.3.3 are not met, the Owner reserves the right to request that the structure be redone at the Contractor's expense.

6.33.7.3.5 As soon as curing is completed, all concrete surfaces shall be inspected and repaired. The Contractor shall provide the Engineer access to the repaired surfaces for verification purposes. After curing and in the presence of the Contractor, the Engineer will check the repaired surfaces with a hammer. The surfaces that produce a hollow sound, indicating poor adhesion, including a 150 mm surface located around the perimeter, shall be demolished and reconstructed at the Contractor's expense.

6.33.7.3.6 All repairs shall undergo a sound survey in the presence of the Contractor and the Engineer. For the repair and reprofiling of the surfaces of girders to receive CFRP strengthening, the adhesion tests shall meet the requirements of the Contractor's technical CFRP engineer who is in charge of the CFRP work control.

6.33.7.4 APPLICABLE PENALTY

6.33.7.4.1 In the event that the actual strength of the concrete at twenty-eight (28) days is below the required strength, the following penalties will be applied:

Required Strength 30 MPa		**Required Strength 35 MPa**		**Required Strength 50 MPa**	
Strength at 28 Days (MPa)	**Penalty (%)(1)**	**Strength at 28 Days (MPa)**	**Penalty (%) (1)**	**Strength at 28 Days (MPa)**	**Penalty (%) (1)**
29.0 to 29.9	4%	34.0 to 34.9	2%	49.0 to 49.9	2%
28.0 to 28.9	6%	33.0 to 33.9	4%	48.0 to 48.9	4%
27.0 to 27.9	8%	32.0 to 32.9	6%	47.0 to 47.9	6%
26.0 to 26.9	10%	31.0 to 31.9	8%	46.0 to 46.9	8%
25.0 to 25.9	25%	30.0 to 30.9	10%	45.0 to 45.9	10%
24.0 to 24.9	40%	29.0 to 29.9	25%	44.0 to 44.9	20%
23.0 to 23.9	55%	28.0 to 28.9	40%	43.0 to 43.9	40%
22.0 to 22.9	70%	27.0 to 27.9	55%	42.0 to 42.9	80%
< 22.8	Please refer to Article 6.33.7.4.3	26.0 to 26.9	70%	< 42.0	Please refer to Article 6.33.6.3.2
		25.0 to 25.9	85%		
		< 25.0	Please refer to Article 6.33.7.4.2		

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

6.33.7.4.2 Notwithstanding paragraph 6.33.7.4.1, the lower limit for the compressive strength of the cast-in-place concrete for the anchor blocks is 40 MPa at twenty-eight (28) days. Any concrete whose compressive strength is below that limit will be considered non-compliant and shall be resumed at the Contractor's expense.

6.33.7.4.3 If the compressive strength of the concrete at twenty-eight (28) days is less than the minimum strength required and indicated in the table of paragraph 6.33.7.4.1, the Owner reserves the right to have the non-compliant structures resumed at the Contractor's expense, for all types of anchors or, where applicable, the Engineer reserves the right to apply the penalties appearing in the table, without resumption of the work by the Contractor.

6.33.7.4.4 No penalty applies where the strength is greater than that required. The Owner however reserves the right to request the Contractor to change its mix or quality control measures, notably with respect to the cement dosage and water content of the aggregate if the strengths are 15 % greater than the specified strengths and that, in the opinion of the Engineer, these strength values are considered detrimental to the quality of the work, particularly in terms of excessive cracking.

END OF SUBSECTION