Part 1 General

1.1 DESCRIPTION OF WORK

.1 The work shall consist of the supply; placing; finishing; curing of concrete; and any other requirements for the construction of concrete structures

1.2 STANDARDS

.1 Canadian Standards Association (CSA International)
178 Rexdale Boulevard,
Toronto, Ontario M9W 1R3

.2 ASTM (American Society for Testing and Materials)
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959 USA

.3 CGSB (Canadian General Standards Board)
Lac Du Portage 111, 6B
11 Laurier Street
Gatineau, QC K1A 1G6

The Standards referred to shall be the most recent edition

1.3 SUBMITTALS

.1 The Contractor shall submit the concrete mix design for each category of concrete for the Engineer’s review at least 10 days before the first concrete is to be placed.

.2 Submit shop drawings for formwork and falsework.

.1 Submit drawings stamped and signed by professional engineer registered or licensed in the Province of Manitoba, Canada.

.3 The Contractor shall include the aggregate gradation test results and the calculations made to arrive at the maximum aggregate density.

.4 The concrete mix design shall be prepared by or under the supervision of a Professional Engineer registered in the Province of Manitoba whose Engineer's seal shall be affixed to the mix design submitted for review unless otherwise approved by the Engineer.

1.4 QUALITY ASSURANCE

.1 The Engineer shall carry out such tests on construction and workmanship as he considers necessary at the Owner's expense except that:

.1 The Contractor shall furnish any and all test samples free of charge.

.2 In the case of manufactured products the Engineer may require evidence that samples of the product have recently been tested and have met the requirements of the relevant specifications.

.3 Where the Contractor cannot produce evidence satisfactory to the Engineer that a manufactured product or a particular lot of a product meets the requirements of the relevant Clause, the Engineer may require the product to be tested. If the product fails to meet the requirements of the relevant Clause, the Contractor shall pay for the costs of such testing.

1.5 DELIVERY, STORAGE AND HANDLING

.1 GENERAL

.1 All materials shall be stored in a manner that shall prevent contamination or deterioration.

.2 Any material that has deteriorated or that has been contaminated shall not be used in the concrete and shall be removed from the site.

.2 CEMENT

.1 Cement shall be stored in a suitable bin or building which shall provide protection against dampness and inclement weather conditions.

.2 Access to the storage facilities shall be provided to allow proper inspection.

.3 AGGREGATE

.1 Each size of aggregate shall be separately stored in a free draining stockpile in a manner that shall prevent contamination, intermixing, and segregation.

.2 The equipment and methods of handling aggregate shall be such as to prevent breakage and contamination of the aggregate.

.4 OTHER MATERIALS

.1 All other materials such as admixtures and curing compounds shall be stored in accordance with the manufacturer's instructions.

NOTE: Some of these materials are damaged if permitted to freeze, therefore precautions should be undertaken to prevent freezing.

1.6 INSPECTION

.1 Inspection of the work described in this Section shall be performed by the Engineer

.2 Inspection shall be required before placing concrete, during the placement of concrete, before and after waterproofing and patching, and before backfilling

Part 2 Products

2.1 CEMENT

.1 Cement shall meet the requirements of the current CSA Standard A5, Portland Cement.

.2 Unless noted otherwise in Section 01001, Special Provisions, Sulphate Resistant Portland Cement (Type 50) CSA Standard Type HS A3000 shall be used for all buried underground cast-in-place concrete installation.

2.2 WATER

.1 Water for use in Portland cement concrete and for curing shall be clear and free from oil, acid, alkali, organic matter, sediment, or any other deleterious substance and water shall be similar to potable water (drinking water) in physical and chemical properties.

.2 The water shall be in accordance with CSA A23.1.

2.3 AGGREGATES

.1 FINE AGGREGATE

.1 Shall meet the requirements of Normal Density Fine Aggregate as outlined in CSA Standard A23.1, Concrete Materials and Methods of Concrete Construction Section 4.2.3.

.2 COARSE AGGREGATE

.1 Shall meet the requirements of Normal Density Coarse Aggregate as outlined in CSA Standard A23.1, Section 4.2.3.

.2 Unless noted otherwise in Section 01001, Special Provisions, either 40 mm to 50 mm or 20 mm to 50 mm nominal size aggregate shall be used.

2.4 CONCRETE MIXES

.1 Proportion normal density concrete in accordance with current CAN3-A23.1-M, Alternative 1 to give the following properties for above grade beams and suspended slabs:

.1 Cement: Type 10 (GU) Portland cement unless otherwise specified in Section 01001, Special Provisions

.2 Minimum compressive strength at 28 days: 30 MPa. Minimum cement content: 340 kg/cu m of concrete (maximum replacement with 25% Flyash)

.3 Class of exposure: F-2

.4 Maximum size of aggregate: 20mm

.5 Initial slump 20-50mm; final slump maximum 180mm (after plasticizer added)

.6 Air content: 4-7%

.7 Admixtures: Add superplasticizer for every pour

.2 Proportion concrete in accordance with current CAN3-A23.1-M. Alternative 1 to give the following properties for below grade walls, tank walls, structural slab on grade:

.1 Cement: Type 50 Sulphate resistant cement Type HS

.2 Minimum compressive strength at 28 days: 30 MPa. Minimum cement content: 340 kg/cu.m of concrete (maximum replacement with 25% Flyash)

.3 Class of exposure: S2 or S3

.4 Size of coarse aggregate: 20 mm

.5 Initial slump 20-50mm; final slum maximum 180mm (after plasticizer added)

.6 Air content: 5-8%

.7 Admixtures: Add superplasticizer for every pour

.3 Proportion normal density concrete in accordance with current CAN3-23.1-M, Alternative 1 to give the following properties for toppings, exterior pads and curbs:

.1 Cement: Type 50 Sulphate resistant cement
.2 Minimum compressive strength at 28 days: 30 MPa
.3 Class of exposure: C-1 and C-2
.4 Size of coarse aggregate: 20 mm
.1 Slump at time and points of discharge: 50-80mm
.2 Air content: 5-8%

.5 Proportion normal density concrete in accordance with current CAN3-A23.1-M, Alternative 1 to give the following properties for exterior traffic and paving slabs:
.1 Cement: Type 50 Sulphate resistant cement HS and MS
.2 Minimum compressive strength at 28 days: 30 MPa. Minimum cement content: 340 kg/cu.m of concrete (maximum replacement with 25% Flyash)
.3 Class of exposure: C-1 and C-2
.4 Size of coarse aggregate: 20 mm
.5 Slump at time and point of discharge 20-50 mm
.6 Air content: 5-8%

.6 Proportion normal density concrete in accordance with current CAN3-A23.1-M, Alternative 1 to give the following properties for below grade skin coat and concrete fill:
.1 Cement: Type 50 Sulphate resistant cement HS and MS
.2 Minimum compressive strength at 28 days: 15 MPa
.3 Class of exposure: F-1 and F-2
.4 Size of coarse aggregate: 20 mm
.5 Slump at time and point of discharge: 20-50 mm
.6 Air content: 5-8%

.7 Proportion normal density concrete in accordance with current CAN3-A23.1-M Alternative 1 to give the following properties for concrete topping on interior floor slab:
.1 Cement type 10 GU
.2 Minimum compressive strength at 28 days: 30 MPa
.3 Class of exposure C-4
.4 Maximum coarse aggregate: 12.7 mm
.5 Slump: 40 mm ± 20 mm
.6 Air Content: No entrained air

.7 Reinforcement fibre for topping of concrete

NOTE: A concrete strength test shall mean the 28 day average strength of two companion test specimens. The strength level of concrete shall be considered satisfactory if the averages of all sets of three consecutive strength tests at 28 days equals or exceeds the specified strength, and no individual strength test is more than 3.5 MPa below the specified strength.

Table 1

Definitions of C, F, N A and S classes of exposure

C-XL	Structurally reinforced concrete exposed to chlorides or other severe environments with or without freezing and thawing conditions, with higher durability performance expectations than the C-1, A-1, or S-1 classes.
C-1	Structurally reinforced concrete exposed to chlorides with or without freezing and thawing conditions. Examples: bridge decks, parking decks and ramps, portions of marine structures located within the tidal and splash zones, concrete exposed to seawater spray, and salt water pools.
C-2	Non-structurally reinforced (i.e., plain) concrete exposed to chlorides and freezing and thawing. Examples: garage floors, porches, steps, pavements, sidewalks, curbs and gutters.
C-3	Continuously submerged concrete exposed to chlorides but not to freezing and thawing. Examples: underwater portions of marine structures.
C-4	Non-structurally reinforced concrete exposed to chlorides but not to freezing and thawing. Examples: underground parking slabs on grade.
F-1	Concrete exposed to freezing and thawing in a saturated condition but not to chlorides. Examples: pool decks, patios, tennis courts, freshwater pools, and

	freshwater control structures.
F-2	Concrete in an unsaturated condition exposed to freezing and thawing but not to chlorides. Examples: exterior walls and columns.
N	Concrete not exposed to chlorides nor to freezing and thawing. Examples: footings and interior slabs, walls and columns.
A-1	Structurally reinforced concrete exposed to severe manure and/or silage gases, with or without freeze-thaw exposure. Concrete exposed to the vapour above municipal sewage or industrial effluent, where hydrogen sulphide gas may be generated. Examples: reinforced beams, slabs and columns over manure pits and silos, canals, and pig slats; and access holes, enclosed chambers, and pipes that are partially filled with effluents.
A-2	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure. Examples: reinforced walls in exterior manure tanks, silos, and feed bunkers, and exterior slabs.
A-3	Structurally reinforced concrete exposed to moderate to severe manure and/or silage gases and liquids, with or without freeze-thaw exposure in a continuously submerged condition. Concrete continuously submerged in municipal or industrial effluents. Examples: interior gutter walls, beams, slabs, and columns; sewage pipes that are continuously full (e.g., forcemains); and submerged portions of sewage treatment structures.
A-4	Non-structurally reinforced concrete exposed to moderate manure and/or silage gases and liquids, without freeze-thaw exposure. Examples: interior slabs on grade.
S-1	Concrete subjected to very severe sulphate exposures (Tables 2 and 3)
S-2	Concrete subjected to severe sulphate exposure (Tables 2 and 3)
S-3	Concrete subjected to moderate sulphate exposure (Tables 2 and 3)

Notes:

(1) *"C" classes pertain to chloride exposure.*

(2) *"F" classes pertain to freezing and thawing exposure without chlorides.*

(3) *"N" class is exposed to neither chlorides nor freezing and thawing.*

(4) *All classes of concrete exposed to sulphates shall comply with the minimum requirements of "S" class noted in Tables 2 and 3.*

Table 2

Types of Portland cement

Name	Type	Application
General use hydraulic cement	GU	For use in general concrete construction when the special properties of the other types are not required.
High-early-strength hydraulic cement	HE	For use when high-early-strength is required.
Moderate sulphate-resistant hydraulic cement	MS	For use in general concrete construction exposed to moderate sulphate action.
High sulphate-resistant hydraulic cement	HS	For use when high sulphate resistance is required.
Moderate heat of hydration hydraulic cement	MH	For use in general concrete construction when moderate heat of hydration is required.
Low heat of hydration hydraulic cement	LH	For use when low heat of hydration is required.

Table 3

Types of blended hydraulic cement

Name	Type	Application
Blended general use hydraulic cement	GUb	For use in general concrete construction when the special properties of the other types are not required.
Blended high-early-strength hydraulic cement	HEb	For use when high-early-strength is required.
Blended moderate sulphate-resistant hydraulic cement	MSb	For use in general concrete construction exposed to moderate sulphate action.
Blended high sulphate-resistant hydraulic cement	HSb	For use when high sulphate resistance is required.
Blended moderate heat of hydration hydraulic cement.	MHb	For use in general concrete construction when moderate heat of hydration is required.
Blended low heat of hydration hydraulic cement	LHb	For use when low heat of hydration is required.

2.5 FAILURE TO MEET REQUIREMENTS

If the results of the tests indicate that the concrete is not of the specified quality, or if in the opinion of the Engineer the curing and protection requirements were not met, the Engineer shall have the right to require one or more of the following:

.1 Changes in the mix proportions for the remainder of the work

.2 Additional curing on those portions of the structure represented by the test specimens which failed to meet specified requirements

.3 Non-destructive testing (see Appendix A of CSA Standard A 23.2)

.4 Such other tests as the Engineer may specify

.5 That cores be drilled from the portions of the structure in question and tested in accordance with CSA Test Method A 23.2 14C, Methods of Obtaining and Testing Drilled Cores for Compressive Strength Testing

.6 Concrete in the area represented by the core tests may be considered structurally adequate:

.1 If the average of each set of three cores from the portion of the structure in question is equal to at least 85 percent of specified strength.

.2 If no single core is less than 75% of the specified strength.

If after carrying out the appropriate requirements of this Clause the Engineer is not satisfied that the concrete in the structure is of the specified quality, he may require a strengthening or replacement of those portions which he deems to be unsatisfactory

2.6 ADMIXTURES

.1 AIR ENTRAINING AGENT

.1 Shall meet the requirements of ASTM C260 - Specification for Air-Entraining Admixtures for Concrete.

.2 WATER REDUCING AGENT

.1 Shall meet the requirements of ASTM C494 - Specification for Chemical Admixtures for Concrete Type A.

.3 RETARDERS

.1 Shall meet the requirements of ASTM C494 - Water Based Low Voc CSA Standard A 266.2-M, Type WR, Type R and RX; and/or ASTM Standard Type B and/or D.

.4 CHEMICAL ADMIXTURES

.1 Accelerating and set retarding admixtures may be used in either cold or hot weather subject to the approval of the Engineer and shall be in accordance with CAN3-A266.2-M chemical admixtures for concrete or to ASTM C494 or ASTM C1017. Use of calcium chloride shall not be permitted.

2.7 OTHER PRODUCTS

.1 EXPANSION JOINT FILLERS

.1 Shall meet the requirements of the current ASTM D1751 – Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types), and/or ASTM D1752 – Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.

.2 JOINT SEALERS FOR CONCRETE

.1 Shall meet the requirements of the current ASTM D412 – Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension, and/or ASTM D624 – Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomer.

.3 CURING COMPOUNDS

.1 Liquid membrane forming concrete curing compounds shall meet the requirements of the current ASTM C309 – Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

.4 EPOXY ADHESIVES

.1 For bonding concrete, mortar, or metal to concrete shall meet ASTM C881

.5 PATCHING MORTAR

.1 Shall consist of one part Portland cement to two parts of concrete sand (by mass) with sufficient water to produce a mortar of the required consistency.

.6 NON-SHRINK GROUT

.1 Shall be shrinkage compensating premixed non-metallic aggregate strength 38MPa at 28 days.

.7 WATERPROOFING FOR INTERIORS OF RESERVOIRS

.1 Shall be designated ANSI/NSF 61, including NSF 14, suitable for potable water use complete with approved bonding agent.

.8 DAMPROOFING FOR CONCRETE WALLS BELOW GRADE

.1 Shall be asphalt compound and shall meet the requirements of the current CAN/CGSB-37.2-M, Emulsified Asphalt, Mineral Colloid-Type, Unfilled, for Dampproofing and Waterproofing and for Roof Coatings.

.9 DRAINS

.1 Shall be pipe of the size and type designated on the plans.

2.8 WATERSTOP

PVC Waterstop: 150 wide to CGSB 41-GP-35M polyvinylchloride prefabricated elbows, tees, etc. Place as indicated on drawings or as approved by Engineer.

.1 Waterstops shall be installed where indicated on the plans. The waterstop shall extend the entire length of the joint and shall be positioned across the centre of the joint.

.2 Waterstops shall be securely fastened to reinforcing steel or formwork every 300mm on both sides of the waterstop prior to concrete placing as required to prevent displacement and ensure accurate location of the waterstop during concrete placement operations. A minimum of 50mm clearance shall be maintained between waterstop and reinforcing steel.

.3 Waterstops shall be heated and spliced with a thermal splicing unit designed for that specific purpose. Only properly miltered, straight butt splices shall be made in the field. All field splices shall be tested for a complete seal by use of a corona discharge unit

.4 Field splices shall be made outside the rebar assembly in an unobstructed area adjacent to the reinforcing steel. The galvanized wire loops in the edge of the waterstop shall be removed from the vinyl to be spliced. When the splice has cooled and passed inspections, thread the waterstop into correct position and secure it to the rebar. (Plastic coated tie wire, white or yellow in colour can be used to provide visual assurance that the waterstops have been properly secured).

.5 No holes will be permitted in the waterstop. Nail holes or other penetrations in the waterstop shall be repaired prior to concrete placing operations

2.9 CONCRETE MIX DESIGN

.1 The Contractor shall supply the concrete meeting the requirements of these specifications and shall submit to the Engineer for review of the concrete mix design, at the concrete strengths specified. The mix design shall include the weight of the stone, sand, cement, flyash, water, pozzolith as well as percent air, water cement ratio and any additional products mixed at the plant or on site with the concrete mixture. The Contractor shall also submit for review, if requested by the Engineer, a history of concrete cylinder breaks for the concrete mix design where used on previous projects.

.2 The concrete shall meet the required compressive strengths at 28 days as outlined in Clause 2.4, Concrete Mixes, as well as meeting the required exposure class, type of cement aggregate size, slump air content and admixture requirements.

.3 A water reducing agent shall be added to the mix in an amount recommended by the manufacturer.

.4 An air entraining agent shall be added to the mix to entrain between 4 and 7 percent air for concrete having 20 mm nominal size aggregate, and to entrain between 3 and 6 percent air for concrete having 40 mm nominal size aggregate.

2.10 CONCRETE TRANSPORT

.1 MIXING EQUIPMENT

.1 Mixers shall be stationary mixers or truck mixers. All mixers shall display the manufacturer's rating plate which shows the gross volume of the drum; the rated maximum mixing capacity; and the minimum and maximum mixing and agitating speeds for the drum, blades or paddles.

.2 Truck mixers and/or agitators furnished with a water tank shall also be equipped with a water measuring device that includes a sight gauge for each compartment. The gauge markings shall be visible through the entire range of the tank capacity.

.3 All mixers shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass that meets the uniformity requirements of the current CSA Standard A23.1, 5.2.3.5, Testing for Uniformity of Mixed Concrete. Failure to meet the uniformity requirements of Density of Concrete, Air Content and Slump shall result in the rejection of the mixer. The mixer shall be inspected periodically to detect wear of blades. Accumulation of hardened concrete or mortar in the drum or on the blades will not be permitted.

.2 MIXING TIME

.1 Mixers shall be rotated at the rate recommended by the manufacturer.

.2 Stationary mixers with a capacity of 1 cubic metre or less shall have a mixing time of not less than one minute. For mixers of greater capacity the minimum time shall be increased 20 seconds for each additional cubic metre or fraction thereof. Mixing time is measured from the time all solid materials are in the drum. All water should be added to the drum by the first quarter of mixing time.

.3 Transit mixers used for complete mixing shall, at rated capacity, mix the concrete for not less than 70 nor more than 100 revolutions at the mixing speed designated by the manufacturer.

.3 DELIVERY

.1 Concrete shall be transported from the mixer to the point of placement as quickly as possible.

.2 Once the mixing water is introduced, no water may be added to the batch of a transit mixer unless, at the start of discharge, the slump is less than specified and no more than 60 minutes have elapsed from the time of batching to the start of discharge. Water may only be added with the approval of the Engineer. The indiscriminate addition of water to the mix will not be allowed. The amount of water added to the mix shall not exceed the maximum allowable water to cement ratio of the mix design and shall not exceed the maximum allowable slump. If water is added the drum must be turned an additional 30 revolutions at mixing speed. The amount of additional water added at the site shall be recorded.

.3 The time between batching and complete discharge must not exceed 120 minutes without approval from the Engineer.

.4 The concrete supplier must provide the Engineer with a delivery ticket for each batch of concrete at the time of delivery. The delivery ticket must contain:

.1 Name and location of batch plant
.2 Date and serial # of ticket
.3 Amount of concrete in cubic meters
.4 Cement content in kg/m³
.5 Type of admixtures added
.6 Time of batching
.7 Design mix reference number
.8 28 day design strength
.9 Delivery destination and driver’s signature
.10 Job, Name & Location
.11 Designation of concrete
.12 Truck #, cumulative total and or Load #
.13 Time arrived

.14 Time discharge started

.15 Time discharge complete

Part 3 Execution

3.1 SLEEVES

.1 Prior to placing concrete the Contractor shall set suitable approved sleeves in the concrete for all small pressure piping (60 mm or less in diameter). The locations where such piping passes through concrete walls or floors shall be properly co-ordinated. Where it is impossible to locate exactly the position of small pipes, the Contractor shall leave openings in the concrete of sufficient size to give latitude to locate the sleeves and pipes later. After the insertion of the pipes, openings shall be filled with concrete. Non-shrink grout shall be used where the structure is subject to water pressure.

.2 Where large pipes are indicated to be built into walls without the use of wall castings, the necessary openings shall be left with sufficient clearances for later grouting. 'Link-seal' units shall be provided where indicated on the plans.

.3 Where sleeves, castings or wall pieces have puddle collars, they shall be accurately positioned and aligned in the formwork prior to the placement of concrete.

.4 Non-shrink grout in exposed walls shall be terminated 15 mm from the finished wall surface. Cement mortar shall be used to the final surface and rubbed smooth with a carborundum brick.

3.2 CABLE, CONDUIT, DUCT & PIPE OPENINGS

.1 The Contractor shall refer to all relevant sections of the specifications and plans for details associated with pipe and duct openings.

.2 All openings required for electrical ducts, conduits, cables and pipes shall be provided as detailed and/or as directed by the Engineer. Conduit, cable or pipe shall not be permitted to pass through concrete beams.

.3 All electrical conduits in concrete structures shall be provided as required by the Plans and specified elsewhere. Outlet boxes and fixtures shall be located with reference to the final floor, wall or ceiling finish. Outlet boxes and fixtures shall be secured so that they will not be displaced by concrete placing.

.4 Embedded pipes or conduits, other than those passing through, shall not be larger in outside diameter than one-third the thickness of the slab or wall in which they are embedded, unless otherwise indicated on the Plans. Pipes and conduits shall not be located closer than three diameters off centre. The proposed location of all conduits and fixtures shall be submitted to the Engineer for review prior to concrete placing.

3.3 PLACING CONCRETE

.1 GENERAL

.1 All concrete placing methods shall be subject to the approval of the Engineer. No concrete placing shall be started until forms, foundations, reinforcing steel, construction joints, all mixing, conveying, spreading, consolidation, finishing and curing methods, and protective equipment have been inspected and approved by the Engineer.

.2 HANDLING

.1 Equipment for conveying concrete such as buckets, trucks, belt conveyors, pumps, etc. shall be of such design, size and condition to ensure a continuous and adequate supply of concrete of the required consistency at the point of placing.

.3 PLACING

.1 Concrete shall be placed in the forms as close as practical to its final position. Lateral movement of concrete which can cause segregation shall be avoided. Concrete shall be placed in horizontal layers at a rate such that each successive lift can be vibrated into the previous lift for proper bonding. However, the depth of the concrete must not exceed that depth which is dictated by the design of the form. Concrete shall be confined in a suitable vertical drop pipe to within 1.5 metres (5 feet) of the concrete in place. Concrete in place which has achieved its initial set shall not be subjected to injurious vibration or shock.

3.4 CONSOLIDATING CONCRETE

.1 GENERAL

.1 When concrete is being placed it shall be compacted thoroughly and uniformly by means of hand tamping tools, vibrators, or finishing machines to obtain a dense, homogeneous surface free of cold joints, voids and honeycomb. The concrete shall be well bonded with embedded parts

.2 VIBRATION

.1 Internal vibrators shall be used where practicable. Vibrators shall be applied systematically and at spacing intervals that ensure zones of influence overlap and the depth of penetration of the vibrator enters the upper part of the previously placed lift of the fresh concrete. The vibrator shall be inserted vertically and withdrawn slowly in a vertical direction to facilitate the removal of entrapped air bubbles. The vibrator shall be applied at any one position until the concrete is consolidated but not to the extent that segregation will occur. Build in anchors, sleeves, and other inserts required to accommodate work specified in other sections.

.2 Vibrators shall be used for consolidation purposes. They shall not be used to move concrete.

.3 The type and number of internal vibrators on the job site shall be as follows:

TABLE 4
Internal Vibrators for Various Applications

Minimum Frequency while immersed in concrete, Hz	**Diameter of vibrator head, mm**	**Rate of placement per vibrator, m^3/h**
170-250	20-40	1-4
150-225	30-60	2-8
130-200	50-90	5-15
120-180†	80-150	10-30
90-140†	130-180	20-40

†*These vibrators are recommended for use with low-slump concrete containing a maximum size aggregate of more than* 40 mm.

3.5 BONDING CONCRETE

.1 BONDING CONCRETE TO ROCK

.1 Rock surfaces shall be prepared by cleaning with air-water jets, sandblasting, or stiff brooming to produce a clean surface for mechanical bond. Where required, the first layer of concrete to be placed on this surface shall be of the quality specified but shall contain an excess of mortar and shall be vibrated to achieve maximum bond, and shall have a depth of approximately 150 mm.

.2 BONDING CONCRETE TO HARDENED CONCRETE

.1 Where fresh concrete is to be bonded to hardened concrete the hardened surface shall be thoroughly cleaned of foreign matter and laitance so as to present a clean sound surface with the coarse aggregate partially exposed. The Engineer may require the Contractor to sandblast the hardened surface to provide a clean sound surface. The design and consistency of this first layer of concrete shall be in accordance with Clause 7.2.2

.3 BONDING AGENTS

.1 When called for in Section 01001, Special Provisions, bonding agents shall be applied in accordance with the manufacturer's recommendations

3.6 ADDITIONAL CONSTRUCTION JOINTS

.1 If the Contractor wishes to utilize additional construction joints he may do so only with the Engineer's written approval. Additional joints must comply with Clause 7.3 of CSA A23.1. If the Engineer requests waterstop joint material at joints other than those shown, the Contractor shall supply and install the specified materials at the Contractor's cost.

3.7 CURING

.1 Curing shall be in accordance with Clause 7.4 of CSA A23.1. All concrete shall be cured for a period of not less than 7 days by one or more of the following methods which shall be adequate to prevent excessive loss of moisture;

.1 Ponding or continuous sprinkling.

.2 Absorptive mat or fabric kept continuously wet.

.3 Curing compound – shall be in conformance with Clause 2.7.3. Membrane curing compounds are to be applied in accordance with the manufacturers' instructions. They shall not be used on surfaces to be bonded to other concrete or on surfaces which are to receive a

waterproofing treatment unless the membrane is removed with wire brushing or sandblasting after curing of the concrete.

.4 Waterproof paper or plastic film

.5 Leave form work in place in the case of vertical surfaces

.6 Other moisture-retaining methods as approved by the Engineer

3.8 HOT WEATHER REQUIREMENTS

.1 CONCRETE TEMPERATURE

.1 The temperature of the concrete during placing must not exceed that stipulated in CSA Standard A23.1, Table 14, Page 125.

.2 PROTECTION FROM DRYING

.1 During construction of exposed concrete surfaces there is a risk of shrinkage cracking when the rate of evaporation exceeds 0.5 kg/m^2/h

.2 When such conditions exist measures should be taken to reduce the evaporation of surface moisture from the concrete.

.3 At rates of evaporation exceeding 0.75 kg/m^2/hr windbreaks shall be erected around the sides of the structural element.

.4 When surface moisture evaporation exceeds 1.0 kg/m^2/h additional measures shall be taken to prevent rapid loss of moisture from the surface of the concrete. Such additional measures shall consist of one or more of the following as directed by the Engineer:

.1 Dampen the subgrade prior to placing concrete.

.2 Erect sunshades over the concrete during finishing operations

.3 Lower the concrete temperature.

.4 Apply fog spray immediately after placement and before finishing, taking care to prevent the accumulation of water on the surface.

.5 Begin curing of the concrete immediately after floating.

.6 Place and finish at night.

.5 The rate of evaporation shall be estimated by the Engineer using measurements of relative humidity, concrete temperature, air temperature and wind velocity that the Engineer shall observe.

3.9 COLD WEATHER REQUIREMENTS

.1 JOB PREPARATION

.1 When concrete is to be placed in cold weather, all materials and equipment needed for adequate protection and curing shall be on hand and ready for use before concrete placement is started. The extent of such preparation shall be in accordance with the following requirements.

.2 CONCRETE TEMPERATURE

.1 When the air temperature is at or below 5°C or when there is a probability of it falling to that limit within 24 hours of placing (as forecast by the nearest official meteorological office), the temperature of the concrete as placed shall approach the upper limits (refer to CSA Standard A23.1, Table 14, Page 125). To accomplish this, the mixing water and/or if necessary the aggregates, shall be heated. To avoid the possibility of flash set when either water or aggregate is heated to a temperature in excess of 38°C, water and aggregate shall come together first in the mixer in such a way that the temperature of the combination is reduced to below 38°C before cement is added.

.2 Aggregate shall not be heated above 82°C and all frozen lumps of aggregate shall be excluded from the mix.

.3 PLACING

.1 All snow and ice shall be removed before placing concrete on any surface.

.2 Calcium chloride shall not be used as a de-icing agent in the forms.

.3 Concrete shall not be placed on, or against, any surface which is at a temperature less than 5°C.

.4 PROTECTION REQUIREMENTS

.1 Effective means shall be provided for maintaining the temperature of the air in contact with the concrete above 10°C for a minimum of 7 days.

.2 At the end of the protection period the temperature of the concrete shall be reduced gradually in accordance with CSA Standard A23.1, Table 14, Page 125.

.5 PROTECTION METHODS

.1 When the outside air temperature during the protection period is below $0^{o}C$ a complete housing plus supplementary heat shall be provided

.2 When the outside air temperature during the protection period is below $5^{o}C$ but not below $0^{o}C$ then adequate enclosure of all concrete surfaces with raised tarpaulins or other suitable covering with supplementary heat in readiness, or adequate insulation, shall be provided.

.6 HEATING OF ENCLOSURES

.1 At the time of placing and during curing, concrete surfaces shall be protected from direct exposure to combustion gases of heaters by formwork or by an impermeable membrane.

.2 If the housing is a covered framework it shall provide sufficient clearance from the finished structure to permit free circulation of heated air and to permit removal of the forms inside the housing to expose the concrete surfaces and allow the completion of required finishing as outlined in Clause 3.10. Finishing shall be completed at least three days before discontinuance of heating inside the housing.

.3 Within the housing, and clear of forms and form braces, a sturdy horizontal wooden platform at least 1.8m square shall be constructed for use by the Engineer when testing the concrete.

NOTE: Concrete temperature at time of mixing shall not exceed the maximum shown in Table 14/CSA-A23.1 Concrete temperature at time of placing should be kept as close as possible to the minimum.

3.10 FINISHING OF CONCRETE SURFACES

.1 GENERAL

.1 The top or final surface of all unformed concrete shall receive an initial finish of screeding immediately after compaction of the concrete to give the surface its desired shape and elevation. Screeding shall be followed by bull floating if it is required, and then a final finish of hand floating shall be applied.

.2 Where specified in Section 01001, Special Provisions, mechanical or hand floating shall be followed by finishing with a steel trowel.

.2 SCREEDING

.1 Shall mean striking off the surface of the concrete to the specified grade using a straight-edge. It shall be done immediately after placing, spreading and vibrating. If a vibrating screed is used it shall be moved forward as rapidly as consolidation of the concrete permits. Prolonged use of a vibrating screed may result in a surplus of mortar at the surface.

.3 BULL FLOATING

.1 Bull floating shall mean working the concrete surface with a long handled float to remove high spots and ridges and to fill voids and hollows left in the concrete surface by screeding. Bull floating shall commence immediately after screeding.

.2 When a concrete surface of the required smoothness has been obtained by screeding, bull floating may not be necessary.

.4 FLOATING

.1 Shall commence after bleed water has disappeared and when the concrete has stiffened to prevent the working of excess mortar to the surface. Floating shall be performed with a hand float made of wood. On larger surfaces, mechanical floating using a machine fitted with float blades or a disc shall be permitted.

.5 STEEL TROWELLING

.1 When specified in Section 01001, Special Provisions, floating shall be followed by steel trowelling, hand or mechanical if space permits, to give the surface a greater density and wear resistance.

3.11 FINISHING AND TREATMENT OF CONCRETE FORMED SURFACES

.1 Formed surfaces are those which have been confined within a formwork.

.2 Immediately after the removal of forms all bolts, ties, nails or other metal, not specifically required for construction purposes, shall be removed or cut back to a depth of 25 mm from the surface of the concrete.

.3 The cut-out areas and cavities shall have their edges as nearly perpendicular to the surface as possible and shall be sufficiently deep to hold the patching mortar.

.4 All cut-out areas and cavities shall be repaired by saturating with water. After scrubbing, the surfaces shall be patched with neat cement paste and filled with a non-shrink grout or finishing cement mortar using the same sand and cement as that used in the concrete. The mortar shall be well pressed or packed into the depressions so as to completely fill the cavity, and then finished to match the texture of the adjacent surface.

.5 On exposed formed surfaces, fins, unsightly ridges, or other imperfections shall be neatly chipped off and rubbed flush with the general surface.

.6 Honeycomb areas discovered after removal of the forms shall not be repaired until inspected by the Engineer and designated as structural or non-structural. Where honeycombing has occurred in non-structural elements, the affected area shall be cut out and filled with mortar as previously described. Where honeycombing has occurred in structural elements the corrective method of treatment shall be carried out as directed by the Engineer.

.7 The Contractor shall, if directed by the Engineer, remove the concrete to expose the steel, and replace the concrete. Areas which have been repaired shall be cured in accordance with the requirements of Clause 3.7.

3.12 WATERPROOFING AND DAMPPROOFING

.1 CONCRETE WALLS BELOW GRADE

.1 All surfaces of concrete foundations and pit walls below grade and any surface to be in contact with the soil upon completion of the work shall receive two coats of an approved bituminuous dampproofing. The dampproofing shall be applied to the exact elevation of the proposed backfill line. Each application shall be at a rate of approximately 10 litres per 24 square metres. The compound shall be brushed or sprayed on in a continuous film.

.2 The surface to which the compound is applied shall be clean and free from dust, oil, grease, salt, and loose or spalled material. Surfaces shall be smooth, even and free from projecting mortar, concrete fins, honeycomb and other irregularities.

.3 Cut back asphalts shall be applied to dry surfaces while emulsified asphalts shall be applied to dampened surfaces.

.4 The first coat shall be allowed to cure before the second coat is applied. The second coat shall be cured before the surface is backfilled. Backfilling shall be done carefully to avoid damage to the damp proofing and in accordance with Section 022190, Structural Excavation, Backfill

and Compaction. Emulsions shall not be used when the air temperature is below 4.5°C.

.5 Cut back asphalts shall not be heated above 38°C or used near open flames.

.2 WATERPROOFING INTERIOR OF RESERVOIRS

.1 The floor and interior surface of the walls of water reservoirs shall be treated with an approved material applied in accordance with the manufacturer's instructions. Refer to Clause 2.7.8 of this Section.

.2 Before commencing waterproofing, the Contractor shall examine the total surface to ensure that all foreign material, laitance, and form ties are removed and that cracks, honeycombed or spalled areas are repaired. All protrusions through walls shall be complete and shall be sealed. The waterproofing shall be applied as soon as possible after removal of the forms in accordance with the manufacturer's recommendations and by an applicator approved by the manufacturer. The Contractor shall note that the manufacturer may require the use of a bonding agent with the waterproofing. Surfaces shall be free of any materials that will not bond to the waterproofing to be applied and shall be prepared in accordance with the manufacturer's recommendations. The manufacturer's recommendations shall be consulted in each case for possible special temperature requirements during the application and curing period. When the waterproofing materials are to be applied, the Contractor must provide adequate air supply and exhaust ventilation to avoid accumulation of dust, fumes, etc. A protective covering shall be provided during the application and curing period, when rain or snow is falling or anticipated. The waterproofing coatings shall be protected from damage. If damage is done, repairs shall be undertaken in accordance with the manufacturer's recommendations. Treated surfaces shall not be exposed to aggressive water, chemicals or acids until these areas have been cured for a minimum of fourteen days or as Manufacturer Recommendations.

3.13 LOADING OF FRESHLY CAST CONCRETE

The following is included as a guide with respect to the loading of freshly cast concrete during subsequent construction operations; changes may be approved by the Engineer.

.1 SLABS ON GRADE, SPREAD FOOTINGS, PILES AND PILE CAPS

.1 The Contractor shall be permitted to carry forward construction operations after 3 days have passed, providing that vehicular traffic and other heavy loads are not permitted on the slab, spread footings, piles or pile caps.

.2 STRUCTURAL SLABS, BEAMS AND JOISTS

.1 The Contractor shall be permitted to carry forward construction operations after 3 days have passed, providing that falsework is left in place (See Section 031000, Concrete Formwork, Clause 3.4, Removal of Forms).

.3 CONCRETE WALLS

.1 The Contractor shall be permitted to load concrete walls in bearing after 6 days have passed. The Contractor shall be permitted to load concrete walls laterally (i.e. backfilling) after 14 days have passed.

.4 COLUMNS AND PIERS

.1 The Contractor shall be permitted to load columns and piers after 6 days have passed

3.14 CONCRETE TOPPING

Concrete topping shall be placed over previously cast concrete slabs in accordance with latest Edition of A23.1, Clause 7.6 and shall be installed complete with bonding agent with or without fibre reinforcement or approved equal

.1 PREPARATION

.1 Concrete base slab must be clean of dirt, dust, grease, oil or other foreign matter using a shot blast to 390 heavy blast profile to texture and clean the surface.

The slab must be thoroughly cleaned by wire brooming, scraping and vacuuming and final washing with a water pressure wash. The slab must be thoroughly soaked with water before the topping is placed and "saturated surface dry" prior the topping placement. Dividers, edge strips, reinforcing fibre, expansion joint assemblies, and other cast in place items shall be placed where required.

.2 TOPPING PLACEMENT

.1 The Contractor shall brush on the concrete bonding agent and apply the topping in accordance with CSA A23.1, Clause 7.6. The topping mix shall be reinforced with fibremesh at a rate of .9 kg per cubic meter of concrete. The water cement ratio of the mix shall not exceed .45. The topping shall be placed in separate sequences with at least 24 hours curing before being placed on an adjacent area. The areas of topping placed per sequence shall not exceed 186 m^2

.3 FLOOR FINISHING

.1 The concrete floors shall be finished in accordance with CSA A23.1, Clause 7.6.4.3. There shall be no bumps or hollow spots and high sports shall be ground and smoothed with an approved levelling compound. Hollow spots shall be filled smooth with an approved levelling compound.

.4 CURING

.1 Shrinkage resulting from drying shall be kept to a minimum. The topping shall be wet cured for a minimum period of seven days. Burlap shall be applied over the topping as soon as possible after trowelling and shall remain soaked during the curing period. The topping floor area shall be protected from heat and drying by covering with non-staining tarps. Curing compounds if used are subject to the Engineer's approval and shall be compatible with the finish flooring adhesive or epoxy paint which may be required and shall be in accordance with the manufacturer's recommendations. The finish toppings shall be protected from soiling or damage using plywood or from soiling or damage using plywood or other suitable materials during work of other trades, benches, toolboxes, scaffolding, equipment, etc.

.5 INSPECTON AND TESTING

The inspection and testing of concrete materials and placement shall be carried out by an independent testing agency by the Engineer.

3.15 CONCRETE COVER

.1 Notwithstanding A23.1, Table 17, Page 127, the Contractor shall provide proper minimum concrete cover as follows:

.1	Suspended Slabs	
	10 M and 15 M bars	40 mm
	20 M and larger bars	50 mm
.2	Structural Base Slabs	
	Top Bars	50 mm
	Bottom Bars	75 mm
.3	Beams	
	Principle reinforcement	65 mm
	Stirrups and ties	50 mm
.4	Walls	50 mm