



The St. Lawrence
Seaway Management
Corporation

Corporation de Gestion
de la Voie Maritime
du Saint-Laurent

A-3 SPECIFICATIONS REINFORCED CONCRETE CONSTRUCTION

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

I N D E X

A3-1	SCOPE.....	1
A3-2	GENERAL	1
A3-3	CEMENT.....	1
A3-4	CONCRETE AGGREGATES.....	2
A3-5	AGGREGATE TESTING.....	2
A3-6	COARSE AGGREGATE.....	2
A3-7	WATER	3
A3-8	ADMIXTURES	3
A3-9	PROPORTIONING OF CONCRETE.....	4
A3-10	MANUFACTURE OF CONCRETE.....	4
A3-11	TIME BETWEEN MIXING AND PLACING	5
A3-12	TRANSPORTING AND PLACING	6
A3-13	COMPACTION	8
A3-14	FIELD TESTS.....	8
A3-15	CURING, GENERAL.....	9
A3-16	COLD WEATHER CONCRETING.....	9
A3-17	WARM WEATHER CONCRETING.....	17
A3-18	HORIZONTAL CONSTRUCTION JOINT	17
A3-19	JOINT RUSTICATION	18
A3-20	PREPARATION OF EXISTING SURFACES PRIOR TO PLACEMENT OF CONCRETE.....	19
A3-21	EMBEDMENT OF REINFORCING STEEL ANCHORS	19
A3-22	CONSTRUCTION TOLERANCES.....	21
A3-23	FORMS	21
A3-24	INSPECTION OF FORMS.....	22
A3-25	REMOVAL OF FORMS (OTHER THAN COLD WEATHER CONCRETING).....	22
A3-26	REPAIR OF NEW CONCRETE.....	23
A3-27	SURFACE FINISH, GENERAL	23
A3-28	TREATMENT OF CHIPPED CONCRETE SURFACES	26
A3-29	PRESSURE GROUTING OF VOIDS	26
A3-30	REINFORCING STEEL	27
A3-31	BITUMINOUS CEMENT	29
A3-32	PREMOLDED JOINT FILLER.....	29
A3-33	JOINT SEALANT	29
A3-34	WATER STOPS.....	30

A3-1 SCOPE

- 1.1 These A-3 specifications outline the general requirements for concrete construction work in projects involving either the construction of new, or the rehabilitation of old concrete structures.
- 1.2 Other requirements for concrete construction pertaining to this specific project are given in the A-1 and A-2 Specifications.
- 1.3 The work required for the completion of this project shall be performed according to the requirements of the A-1, A-2 and A-3 Specifications, and the drawings.
 - 1.3.1 In case of an apparent conflict with respect to a particular item between the requirements of these A-3 Specifications and the A-1 Specifications for a specific project, the requirements of the A-1 Specifications shall govern.
 - 1.3.2 In case of an apparent conflict with respect to a particular item between the requirements of these A-3 Specifications and the A-2 Specifications for a specific project, the requirements of the A-2 Specifications shall govern.

A3-2 GENERAL

- 2.1 All applicable work shall be carried out in accordance with CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*, expanded by the additional requirements of these A-1, A-2 and A-3 Specifications.
- 2.2 Concrete quality will be controlled by the Engineer in accordance with CSA Standard A23.2-00, *Methods of Test for Concrete*.

A3-3 CEMENT

- 3.1 Cement shall conform to the requirements of CSA Standard A5, *Portland Cements*.
- 3.2 Cement may be sampled by the Engineer at the point of delivery.
- 3.3 The Contractor shall provide access to the storage facilities and delivery units for sampling purposes.
- 3.4 The Contractor may be asked to obtain and furnish to the Engineer certificates from the cement supplier showing the results of all tests and analyses of the cement to be used in this work.
- 3.5 The furnishing of such certificates shall not preclude the Engineer from rejecting any cement which does not comply with all requirements of CSA Standard A5, *Portland Cements*.
- 3.6 The Contractor shall supply storage facilities at batching plants for the cement as follows:
 - 3.6.1 Bulk cement shall be stored in weather-tight, properly ventilated structures, having at least 2 compartments.
 - 3.6.2 They shall have easy access for inspection and sampling of the cement by the Engineer.
 - 3.6.3 They shall have a capacity adequate to ensure continuity of the concreting operations.
 - 3.6.4 They shall be properly designated and used for only one type of cement.

- 3.6.5 Similar separate storage shall be provided for packaged cement.
- 3.6.6 The design and operation of these storage facilities shall be subject to review by the Engineer.

A3-4 CONCRETE AGGREGATES

- 4.1 All concrete aggregates shall be clean, hard, durable and free from deleterious material, and shall meet the requirements of Clause 5 of CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*, expanded by the additional specified requirements.
- 4.2 When requested, the Contractor shall submit to the Engineer for review, signed by the qualified person who performed the petrographic analysis, a statement attesting to the fact that the aggregate used in the concrete will not result in excessive expansion and cracks in the concrete through cement aggregate reaction as specified in CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*, Appendix B.
- 4.3 The aggregates shall consist of natural sand, gravel or crushed stone reviewed by the Engineer that meets the CSA requirements for gradation strength and durability.
- 4.4 Fine and coarse aggregate shall be kept separate.
- 4.5 Pit, bank, beach, or crusher run material will not be accepted unless such material is processed prior to its use to remove any undesirable properties or constituents.
- 4.6 The Contractor shall have sufficient aggregate of reviewed quality and gradation available to complete each pour before concrete placing operations are commenced.
- 4.7 The Engineer will examine the aggregates proposed for use in concrete.
- 4.8 Preliminary review will not constitute general acceptance of all material in the deposit or source of supply.
- 4.9 Any aggregates that do not meet the requirements of the specifications will be rejected.

A3-5 AGGREGATE TESTING

- 5.1 The Contractor shall notify the Engineer, at least 15 days in advance of placing concrete, of the intended source of supply for both fine and coarse aggregate and shall assist the Engineer in obtaining representative samples of the various aggregates for testing purposes.
- 5.2 The aggregate may be sampled and tested at any time by the Engineer during the processing operation and any aggregate failing to meet the CSA Standards for gradation or quality will be rejected.

A3-6 COARSE AGGREGATE

- 6.1 The coarse aggregate particles shall generally be cubical, and the proportion of flat and elongated particles in a representative sample of coarse aggregate shall not exceed 30%.
- 6.2 A flat particle is one having a ratio of width to thickness greater than 3.
- 6.3 An elongated particle is one having a ratio of length to width greater than 3.

A3-7 WATER

- 7.1 Water used in mixing and curing concrete shall be fresh, clean, potable, and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substances and shall contain less than 2,000 ppm of dissolved solids.
- 7.2 Adequate water storage facilities shall be provided by the Contractor to ensure that placing and curing operations are not interrupted by a breakdown in the main supply line.
- 7.3 Water additions to the concrete other than the required batching water shall not be made.

A3-8 ADMIXTURES

- 8.1 Admixtures for concrete shall conform to ASTM C494/C494M-99ae1 *Standard Specification for Chemical Admixtures for Concrete* ou ASTM C1017/C1017M-98 *Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete*.
- 8.2 All concrete supplied by the Contractor shall contain the admixtures as required by these specifications.
- 8.3 An air-entraining admixture reviewed by the Engineer shall be incorporated in the concrete so that the amount of entrained air will be according to the specifications and as directed by the Engineer.
- 8.4 The air-entraining admixture shall conform to the requirements of ASTM C260-01 *Standard Specification for Air-Entraining Admixtures for Concrete*.
- 8.5 A water reducing admixture or plasticizing agent shall be incorporated into the concrete mix using methods and proportions as recommended by the manufacturer.
- 8.6 Authorised retarding and non-shrink admixtures may be required by the Engineer.
- 8.7 Depending upon the nature and requirements of the work, the use of an authorised superplasticizer (high range water reducing admixture) may be required by the Engineer. Due to certain characteristics of this type of admixture, special measures shall be taken when it is used so that:
- 8.7.1 Prior to the addition of the superplasticizer, the concrete shall have a slump within the specified range.
- 8.7.2 The concrete, when incorporated into the work, shall have an air content within the specified range.
- 8.7.3 Should the concrete require more than one addition of superplasticizer to maintain the higher slump, the air content of the concrete shall be maintained within the specified range.
- 8.7.4 A representative of the concrete supplier shall administer the superplasticizer, as reviewed by the Engineer.
- 8.8 The Contractor may be required to submit samples of the admixtures proposed for use in the work at least 28 days before they are to be used.
- 8.9 All samples shall be accompanied by a certificate from the manufacturer stating that the samples are of the same composition as the admixtures, which will be supplied for the concrete work.

- 8.10 When required, admixtures will be tested for acceptance in accordance with ASTM C494/C494M-99ae1 *Standard Specification for Chemical Admixtures for Concrete* or ASTM C1017/C1017M-98 *Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete*.

A3-9 PROPORTIONING OF CONCRETE

- 9.1 Proportions of all materials used for the manufacture of concrete will be controlled by the Engineer in accordance with Clause 14, *Mix Proportions*, of CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*.
- 9.2 All materials used in the manufacture of concrete shall be measured by weight except the liquid admixtures as required which shall be measured by volume.
- 9.3 The water content of all concrete mixtures shall be the minimum necessary to adequately place the concrete with systematic and uniform internal vibration.

A3-10 MANUFACTURE OF CONCRETE

- 10.1 The concrete batch plant work shall be as follows:
- 10.1.1 The Contractor shall use a batching plant, which can produce concrete continuously at a rate that will complete the work within the required time.
 - 10.1.2 An individual weigh batcher shall be provided for water, cement and fine and coarse aggregates.
 - 10.1.3 The batch plant shall have a minimum capacity of 250 m³/10h (250 cubic meters of concrete per 10 hour) shift day.
 - 10.1.4 All equipment producing concrete shall be kept clean of hardened cement and concrete.
 - 10.1.5 The weigh batchers shall be constructed so that the sequence and timing of the discharge gates can be controlled to ensure mixing of aggregates and cement as the mixer is charged.
 - 10.1.6 The plant shall include provisions to facilitate the inspection of all operations at all times.
 - 10.1.7 Delivery from the batchers shall be within the following limits of accuracy:
 - 10.1.7.1 Cement: 1% by weight
 - 10.1.7.2 Water: 1% by weight
 - 10.1.7.3 Aggregate: 2% by weight
 - 10.1.7.4 Admixtures: 3% by volume
 - 10.1.8 The air temperature in the batching plant shall be maintained above 10°C.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 10.2 The weighing by scales shall conform to the following:
- 10.2.1 Adequate scales shall be provided by the Contractor for the accurate measurement and control of all materials for each batch of concrete.
 - 10.2.2 Periodic tests of the scales shall be made at least once every 6 months or as directed by the Engineer.
 - 10.2.3 After each check test, the Contractor shall make such adjustments, repairs or replacement as may be required.
 - 10.2.4 Proof of accurate calibration of the scales shall be given to the Engineer when requested.
 - 10.2.5 Each weighing unit shall be positioned so that it can be readily observed by the batch plant operator.
- 10.3 The admixtures shall be dispensed as follows:
- 10.3.1 The admixtures shall be dispensed by volume measurement, by automatic dispensers who shall be readily adjusted to permit varying the quantity of admixtures.
 - 10.3.2 The admixtures shall be fed to the water weighing hopper through a calibrated sight glass which allows the operator a visual check of the amount of admixture measured by the automatic dispenser.
- 10.4 The mixing shall be as follows:
- 10.4.1 The batches shall be so charged into the mixer that some water will enter in advance of the cement and aggregates.
 - 10.4.2 The balance of the materials shall follow as rapidly as possible.
 - 10.4.3 The mixers shall be capable of combining the materials into a uniform mixture and discharging the mixture without segregation.
 - 10.4.4 The time and rate of mixing shall be in accordance with Clause 18.3.4 of CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*.
- 10.5 The sampling and mix adjusting work shall be as follows:
- 10.5.1 Facilities shall be provided for readily obtaining representative samples of aggregate from each of the weigh batchers.
 - 10.5.2 Batching shall cease when directed by the Engineer to permit aggregate sampling and the setting of mix adjustments on the weigh batcher scales.

A3-11 TIME BETWEEN MIXING AND PLACING

- 11.1 The time between mixing and placing shall conform to Clause 18.4 of CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*.
- 11.2 Concrete, which has not been placed during the time specified, shall be wasted unless its use is accepted by the Engineer.

A3-12 TRANSPORTING AND PLACING

12.1 Concrete shall be placed only in the presence of the Engineer.

12.2 All regular concrete shall be transported and placed as follows:

12.2.1 All equipment for transporting and placing concrete shall be adequate to maintain a continuous supply of fresh concrete at the forms and shall be kept clean of hardened concrete.

12.2.2 Concrete shall be placed in horizontal lifts of a thickness not exceeding 450 mm.

12.2.3 In order to minimise lateral movement of the concrete in the forms, the points of deposition of the concrete shall not be greater than 2 m apart.

12.2.4 Hoppers and vertical or inclined chutes or conduits shall be provided where necessary to limit the free fall of the concrete to less than 1.5 m. For lock wall concreting, where each monolith is divided into vertical panels by dummy joints, the Contractor shall use one hopper and chute for each panel.

12.2.5 Where the total vertical drop of concrete through appropriate conduits or pipes exceeds 8 m, the initial concrete in a placement shall be immediately preceded by the placing of a 0.5 m³ grout cushion at each point of deposition. The grout shall not be vibrated and shall be according to the following:

12.2.5.1 The grout cushion shall have mix proportions according to the approximate guidelines, which follow. The batch masses given on the basis of saturated, surface-dry material, per cubic meter of grout shall be:

	<u>kg/m³</u>
.1 Cement, Type 10	565
.2 Water	265
.3 Concrete Sand	1335

12.2.5.2 No admixtures are required in the grout cushion.

12.2.5.3 The temperature of the grout shall be between 5 and 15°C.

12.2.5.4 The grout used for the grout cushion shall be paid for by the m³ as the type of concrete used for the remainder of the placement. Cement incorporated in the grout will be paid for by the 40-kg bag under the payment item for cement.

12.2.6 Unless otherwise accepted by the Engineer, wherever and whenever concrete is being placed and when the concrete is being transferred into buckets, the Contractor shall use large opening bottom dump buckets which are capable of satisfactorily discharging concrete having slumps ranging from 20 mm to 80 mm.

12.2.7 Concrete shall be delivered to site, and placed within the lower half of the specified slump range. No water shall be added after the initial introduction of the mixing water for the batch, except at the start of discharge, when the measured slump is less than the minimum of the specified range and no more than 60 minutes have elapsed from the time of batching to the start of discharge, and only on the instructions of the Owner.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 12.2.8 The use of the above mentioned procedures will also prevent joint weakening due to the accumulation of bleeding water at horizontal construction joints.
- 12.3 Pumped concrete shall be placed by pumping in accordance with recommendations contained in ACI Standard 304.2R, *Placing Concrete by Pumping Methods*.
- 12.4 All concrete underwater shall be tremie concrete and shall be placed by using the tremie method.
- 12.4.1 The equipment for placing by the tremie method shall be as follows:
- 12.4.1.1 The tremie pipe shall be a straight vertical seamless pipe of sufficient length to extend from the top to the bottom of the forms.
 - 12.4.1.2 The pipe shall be at least 150 mm inside diameter and the upper end shall be equipped with a suitable funnel to receive the concrete.
 - 12.4.1.3 The pipe and funnel shall be supported so that it can be raised as the work progresses.
 - 12.4.1.4 The bottom end of the pipe shall be closed with a plug or plastic cap, before admitting concrete at the commencement of each pour.
 - 12.4.1.5 A sounding lead shall be used to ascertain the level of the concrete in the forms as the work proceeds.
- 12.4.2 The method of placing the tremie concrete shall be as follows:
- 12.4.2.1 Concrete batching and transporting facilities shall be such as to ensure a continuous placing operation.
 - 12.4.2.2 The tremie pipe shall be positioned at one end of the forms with the bottom plug in place.
 - 12.4.2.3 Concrete shall be deposited to fill the pipe and then the pipe and funnel shall be carefully raised to force out the plug and to allow the concrete to flow out.
 - 12.4.2.4 The bottom end of the pipe shall be kept continuously under the surface of the concrete throughout the pour.
 - 12.4.2.5 Placing operations shall proceed at the original point by gradually raising the pipe and hopper until the concrete surface is above the water at the pipe end of the forms.
 - 12.4.2.6 The exposed surface of concrete shall be cleaned of all surface laitance resulting from intermixing with the water, and placing operations shall continue at the dry end of the forms, thus forcing the water and wet concrete out at the opposite end.
 - 12.4.2.7 When the concrete surface has been brought above the water line at one end of the form, regular concrete, according to the specifications, shall be placed in the dry after all of the laitance has been removed from the surface of the concrete.
 - 12.4.2.8 Internal vibration of the concrete shall not be performed until placing operations have proceeded above the water line.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 12.4.2.9 At this time the concrete shall be carefully and systematically vibrated as directed by the Engineer.
- 12.4.2.10 The compacting of the concrete by vibrating shall be performed far enough back of the advancing slope of the concrete so that the water and laitance is forced out of the forms and the concrete is consolidated without intermixing with excess water.
- 12.4.2.11 All applicable subsections in the specifications shall apply to tremie concrete such as materials, manufacture and forms.
- 12.4.2.12 If more than one pipe is required for use by the Engineer, the spacing shall be as reviewed by the Engineer.

A3-13 COMPACTION

- 13.1 Concrete shall be thoroughly and uniformly compacted by means of internal mechanical vibration with internal vibrators. For the purposes of compacting concrete with 40-mm maximum aggregate size, vibrators shall have a minimum head diameter of 50 mm and a frequency while immersed in concrete of 130-200 Hz. For other concrete, vibrators shall be according to the requirements of CSA Standard A23-1-00.
- 13.2 Applications of the vibrators shall be made systematically and at such intervals that the zones of influence overlap.
- 13.3 A vibrator shall not be applied at any point longer than necessary to effect proper compaction, in order to prevent segregation and loss of entrained air.
- 13.4 Immersion type vibrators shall be inserted vertically so as to penetrate the concrete in the upper portion of the underlying layer.
- 13.5 A vibrator shall be withdrawn slowly after each insertion to facilitate the removal of entrapped air bubbles.
- 13.6 A vibrator shall not be inserted into lower layers where the final set has occurred.
- 13.7 For lock wall concreting, where each monolith is divided into vertical panels by dummy joints, the Contractor shall use one vibrator for each panel, and shall also have a minimum of two vibrators on standby for each placement.

A3-14 FIELD TESTS

- 14.1 The Engineer will supply moulds and make test cylinders with them.
- 14.2 Standard test cylinders will be 150 mm in diameter by 300 mm high and will be made of representative concrete as it is being introduced into the forms.
- 14.3 The Contractor shall provide the necessary facilities for taking the samples.
- 14.4 In special cases, job-cured test cylinders may be used to predict the strength of concrete in place. The results from these tests shall not be used as a basis for acceptance or rejection of the concrete.
- 14.5 The job-cured test cylinders will be placed in the work area in such a manner that they will be subjected to the same conditions of curing as the concrete in the work.
- 14.6 The Contractor shall ensure that the specimens are not disturbed by the personnel working on the site during the curing period.

A3-15 CURING, GENERAL

- 15.1 Freshly placed concrete shall be protected from drying and extremes of temperature. After it has hardened sufficiently to prevent damage thereby, suitable and adequate protection shall be provided during the curing period against damage from shock and impact, exposure to undesirable weather conditions including extremes of temperature, and loss of moisture.
- 15.2 The exposed surfaces of freshly placed concrete shall be kept in a continuously moist condition for a period of at least 7 days by the use of absorbent mats or burlap which shall be wetted down as required to keep them in a continuously moist condition for the duration of the curing period. To assist in maintaining the moist conditions, adequate impervious sheets such as plastic film or its equivalent shall be used as cover.
- 15.3 Immediately upon the removal of the side forms, absorbent mats or burlap shall be draped down the sides a sufficient distance to completely cover the exposed surfaces and kept in a continuously moist condition for the required curing period.
- 15.4 In special cases where appropriate, the Engineer may authorise the use of an accepted liquid membrane-forming curing compound according to the following:
- 15.4.1 The curing compound shall contain a fugitive pigment to make the compound visible for placement and inspection purposes.
- 15.4.2 The curing compound shall not be used on surfaces, which are to receive subsequent coverage, by concrete, grout, paint and tile.
- 15.4.3 The curing compound shall be applied at the rate recommended by the manufacturer.
- 15.5 For curing requirements during cold weather see the subsection - *Cold Weather Concreting*, of these A-3 Specifications.

A3-16 COLD WEATHER CONCRETING

- 16.1 Special measures such as heating concrete materials for placing and then protecting the concrete from the adverse effects of wind, weather and low temperatures, shall be taken by the Contractor during concreting in cold weather.
- 16.2 Cold weather, for the purpose of these specifications, is when the air temperature is at or below 5°C, or when, in the opinion of the Engineer, the air temperature is likely to fall below this limit within 24 hours. Such predictions shall be made on the basis of information from the nearest Environment Canada weather station.
- 16.3 These special measures shall include the following:
- 16.3.1 The special measures regarding heating of the concrete materials shall be as follows:
- 16.3.1.1 The materials of which the concrete is composed shall be heated so as to produce concrete at the specified temperature at the time it is deposited in the work.
- 16.3.1.2 At no time shall the temperature of any of the materials exceed 60°C nor shall the resulting temperature of the concrete exceed 20°C prior to placing.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 16.3.1.3 When the air temperature is at or below 5°C, the mix water shall be heated as required to produce concrete at the specified placing temperature, however, the mix water shall not be heated to more than 60°C.
 - 16.3.1.4 When the fine or coarse aggregate contains snow or ice, or when heating the water to 60°C is not alone sufficient to produce concrete at the specified placing temperature, then the aggregates shall also be heated.
 - 16.3.1.5 The aggregates shall be heated to the temperature between 10°C and 60°C which, in conjunction with the heated mix water, is required to produce concrete at the specified placing temperature.
 - 16.3.1.6 The method of heating the aggregates shall be such as to produce uniform heat conditions without local hot spots as follows:
 - 16.3.1.6.1 Aggregates shall be indirectly heated, by live steam, steam coils or dry heat prior to placing in the mixer, while still in stockpiles and storage bins.
 - 16.3.1.6.2 Live steam, water and flame shall not be put in direct contact with the aggregates.
 - 16.3.1.6.3 Frozen lumps of aggregate shall be removed prior to batching.
 - 16.3.1.7 Those parts of the stockpiles in use, and storage bins that are not otherwise covered, shall be protected by tarpaulins or other authorised materials, against accumulations of ice and snow.
 - 16.3.1.8 The equipment for heating materials shall be of adequate capacity; available, installed and tested ready for use at least one week before it is proposed to place concrete, all as reviewed by the Engineer.
 - 16.3.1.9 Failure to have the heating equipment ready for use as specified shall be reason enough for the Engineer not to permit the batching of concrete, even if the air temperature rises above 5°C.
 - 16.3.1.10 Where the heating equipment is to be used for heating the housing and materials, « adequate capacity » means that the equipment shall have adequate capacity to heat both materials and housing at the same time.
 - 16.3.1.11 Boilers used for heating materials and housing shall meet the requirements regarding inspection and operating conditions of all applicable Provincial Acts and Regulations.
- 16.3.2 The special measures regarding mixing of the concrete materials shall be as follows:
- 16.3.2.1 Heated water over 40°C shall not be brought in direct contact with the cement but shall be added into the mixer before, with or after the aggregate, and the mixer shall be turned over a few times to distribute the heat before the cement is added.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 16.3.2.2 The specified mixing time shall start when the concreting cement is added.
- 16.3.2.3 If the hot water reduces the effectiveness of the air-entraining admixture, the admixture shall be placed in the batch after the water temperature has been reduced by mixing with the coarse aggregate.
- 16.3.2.4 The Contractor is advised that conditions may dictate that ice be used in mixing water to maintain the specified concrete temperature range. No additional payment will be made for such addition of ice.
- 16.3.3 The special measures regarding placing of the concrete shall be as follows:
 - 16.3.3.1 At the time of depositing in the work, the temperature of the concrete shall be within the range stated in the A-1 Specifications. In the event that the A-1 Specifications do not specify temperature, the temperature of the concrete shall be between 10 and 20°C, or as required by the Engineer.
 - 16.3.3.2 Where a specific temperature (rather than a range of temperatures) of the concrete as it is introduced into the forms, is required, the concrete shall be within $\pm 3^{\circ}\text{C}$ of this temperature.
 - 16.3.3.3 The concrete shall be placed rapidly and evenly as near to its final position as possible, to reduce the risk of segregation, flow lines and cold joints, and shall be immediately protected according to the specifications.
- 16.3.4 The special measures regarding formwork and other surfaces against which concrete is being placed shall be as follows:
 - 16.3.4.1 Prior to the commencement of concrete placement, the formwork into which the concrete is to be placed, any existing concrete surfaces at a construction joint, and the reinforcing steel, shall be freed of ice and snow and preheated to a temperature of not less than 10°C and so maintained to the satisfaction of the Engineer.
 - 16.3.4.2 Live steam or warm air shall be used to obtain the preheated temperatures.
 - 16.3.4.3 In the case of using warm air to obtain the preheated temperatures, all necessary precautions shall be taken to maintain sufficient moisture to the satisfaction of the Engineer so that forms and existing concrete do not become too dry.
 - 16.3.4.4 During the placing operations, adequate measures shall be taken to maintain all the surfaces and the reinforcing steel, as close as possible, to the required preheat temperatures.
 - 16.3.4.5 Concrete shall not be placed against any surface that is at a temperature of less than 5°C.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 16.3.5 The special measures regarding the cold weather protection and the classes shall be as follows:
- 16.3.5.1 The method of protection devised by the Contractor to provide the specified curing conditions shall be subject to the prior review of the Engineer.
 - 16.3.5.2 The protection shall conform to the details specified and the requirements of Table 1, *Classes of Cold Weather Protection*, depending upon ambient conditions and the nature of the work.
 - 16.3.5.3 The Contractor shall submit proposals for cold weather protection in writing, including any drawings and samples of insulating materials as required.
 - 16.3.5.4 Such submission shall be made sufficiently in advance of the need for protection to permit the proper assessment of the proposal.
 - 16.3.5.5 The Engineer's acceptance of a proposed system of protection shall not relieve the Contractor of the responsibility for the adequacy of the protection provided.
 - 16.3.5.6 Any concrete damaged by freezing, by inadequate protection or by inadequate curing shall be removed and replaced by the Contractor at no additional cost.
 - 16.3.5.7 The Engineer will classify the protection as Class A or B.
 - 16.3.5.8 The temperature to determine Cold Weather Protection shall be based on the daily low temperature recorded at the nearest Environment Canada weather station.
 - 16.3.5.9 Class A protection is to meet less severe conditions and may be ruled by the Engineer to meet temperature conditions below those specified where the work is not subject to severe exposure, or is of a massive nature, and shall include the following:
 - 16.3.5.9.1 All protective measures required to protect concrete where the air temperature is between -1°C and +5°C.
 - 16.3.5.9.2 It shall include a suitable impermeable covering and adequate insulation.
 - 16.3.5.9.3 It shall include all other protective measures which are not classified by the Engineer as Class B protection.
 - 16.3.5.10 Class B protection shall include protection by housing and heating or protection by insulated forms as detailed in Table 1, *Classes of Cold Weather Protection*.
 - 16.3.5.11 Table 1, *Classes of Cold Weather Protection*, details the minimum protective measures required for various weather conditions.
 - 16.3.5.11.1 The Table is based on average exposure conditions; and for exposure conditions other than average, the protective measures shall be altered accordingly.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

16.3.5.12 For concrete placements on the lock walls, special measures will be required in order to minimise the heat gain in the concrete and thereby minimise the time until the forms can be removed.

16.3.5.12.1 Specifically, depending upon ambient temperature conditions, the Contractor will be required to alter the protection for the concrete during the curing period by installing or removing insulation as directed by the Engineer.

16.3.5.12.2 These alterations may be required several times for each concrete placement.

TABLE 1 - CLASSES OF COLD WEATHER PROTECTION			
.1	When the outside ambient air temperature is as follows:	The concrete temperature when placing shall be as follows:	The minimum curing and protection required shall be as follows:
.2	Requirements for Class A Protection		
.1	5°C or more	As specified in A-1 Specifications	<u>Formed Surfaces and Unformed Surfaces</u> shall be moist cured according to Paragraph 16.3.5 of these specifications
.2	5°C to -1°C including -1°C	As specified in A-1 Specifications	<u>Formed Surfaces</u> where un-insulated metal forms are used shall be covered with securely tied tarpaulins to provide a dead air space adjacent to forms. <u>Unformed Surfaces and Flat Surfaces</u> shall be covered with waterproof sheeting and adequate insulation to conform to CSA A23.1-00.
.3	Requirements for Class B Protection		
.1	Lower than -1°C	As specified in A-1 Specifications	<u>Formed and Unformed Surfaces</u> - shall be covered with insulation on all surfaces in the thickness recommended in ACI Standard 306R Table 7.3.1 or provided with complete weather-tight housing and heating as required to maintain the curing conditions adjacent to the concrete surfaces at 95% relative humidity and 10-20°C.
.4	The various classes of protection shall be provided until such time as the concrete in place reaches the minimum design compressive strength.		
.5	Temperatures of the concrete in place may be used as a basis for determining the strength of the structural concrete.		

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

16.3.5.13 Table 4.3.1 - *Thermal Insulation Provided for Concrete Walls and Slabs Above Ground*, and Table 4.3.5 - *Insulation Values of Various Materials*, from ACI (American Concrete Institute) Standard 306R, shall be used according to the specifications and, for convenience, is reproduced hereunder.

TABLE 4.3.1. — THERMAL INSULATION PROVIDED FOR CONCRETE WALLS AND SLABS ABOVE GROUND										
Concrete placed and surface temperature maintained at 50° F (10° C) for 7 days										
Wall or slab thickness in. (m)	Minimum ambient air temperature, deg. F (C) allowable when insulation having these values of thermal resistance R , hour x ft ² x deg. F/Btu (m ² x deg. K/W), is used									
	$R = 2$ (0.35)		$R = 4$ (0.70)		$R = 6$ (1.06)		$R = 8$ (1.41)			
Cement content = 300 lb/yd ³ (178 kg/m ³)										
6 (0.15)	48 (9)	46 (8)	43 (6)	40 (4)						
12 (0.30)	45 (7)	39 (4)	32 (0)	25 (−4)						
18 (0.46)	41 (5)	31 (−1)	21 (−6)	11 (−12)						
24 (0.61)	38 (3)	24 (−4)	10 (−12)	−2 (−19)						
36 (0.91)	32 (0)	12 (−11)	−8 (−22)	−28 (−33)						
48 (1.2)	26 (−3)	3 (−16)	−17 (−27)	−37 (−38)						
60 (1.5)	26 (−3)	3 (−16)	−17 (−7)	−37 (−38)						
Cement content = 400 lb/yd ³ (237 kg/m ³)										
6 (0.15)	47 (8)	44 (7)	40 (4)	36 (2)						
12 (0.30)	43 (6)	35 (2)	26 (−3)	17 (−8)						
18 (0.46)	39 (4)	25 (−4)	11 (−12)	−2 (−19)						
24 (0.61)	34 (1)	16 (−8)	−2 (−19)	−20 (−29)						
36 (0.91)	25 (−4)	−1 (−18)	−27 (−31)	−53 (−47)						
48 (1.2)	18 (−8)	−10 (−23)	−38 (−39)	* *						
60 (1.5)	18 (−8)	−10 (−23)	−38 (−39)	* *						
Cement content = 500 lb/yd ³ (296 kg/m ³)										
6 (0.15)	47 (8)	43 (8)	38 (3)	33 (1)						
12 (0.30)	42 (6)	31 (4)	20 (−7)	9 (−13)						
18 (0.46)	36 (2)	19 (−1)	2 (−17)	−15 (−26)						
24 (0.61)	30 (−1)	7 (−4)	−16 (−27)	−39 (−39)						
36 (0.91)	18 (−8)	−15 (−11)	−46 (−43)	−79 (−62)						
48 (1.2)	10 (−12)	−25 (−16)	−60 (−51)	* *						
60 (1.5)	10 (−12)	−25 (−16)	* *	* *						
Cement content = 600 lb/yd ³ (356 kg/m ³)										
6 (0.15)	46 (8)	41 (5)	35 (2)	29 (−2)						
12 (0.30)	40 (4)	28 (−2)	15 (−10)	0 (−18)						
18 (0.46)	33 (1)	13 (−11)	−7 (−22)	−29 (−34)						
24 (0.61)	26 (−3)	−1 (−18)	−28 (−33)	−55 (−48)						
36 (0.91)	12 (−11)	−27 (−31)	−66 (−54)	* *						
48 (1.2)	4 (−16)	−40 (−40)	* *	* *						
60 (1.5)	4 (−16)	−40 (−40)	* *	* *						

* << 60 F (−51 C).

TABLE 4.3.5 — INSULATION VALUES OF VARIOUS MATERIALS

Insulating material	Thermal resistance <i>R</i> for these thickness of material*	
	1 in., deg F/Btu/hr ft ²	10 mm, m ² K/W
Boards and slabs		
Expanded polyurethane (<i>R</i> -11 exp.)	6.25	0.438
Expanded polystyrene extruded (<i>R</i> -12 exp.)	5.00	0.347
Expanded polystyrene extruded, plain	4.00	0.277
Glass fibre, organic bonded	4.00	0.277
Expanded polystyrene, moulded beads	3.57	0.247
Mineral fibre with resin binder	3.45	0.239
Mineral fibre board, wet felted	2.94	0.204
Sheathing, regular density	2.63	0.182
Cellular glass	2.63	0.182
Laminated paperboard	2.00	0.139
Particle board (low density)	1.85	0.128
Plywood	1.25	0.087
Blanket		
Mineral fibre, fibrous form processed from rock, slag, or glass	3.23	0.224
Loose fill		
Wood fibre, soft woods	3.33	0.231
Mineral fibre (rock, slag, or glass)	2.50	0.173
Perlite (expanded)	2.70	0.187
Vermiculite (exfoliated)	2.20	0.152
Sawdust or shavings	2.22	0.154

* Values from *ASHRAE Handbook of Fundamentals, 1977*, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, New York

16.3.6 The special measures regarding curing conditions of the concrete shall be as follows:

16.3.6.1 The freshly deposited concrete shall be protected from evaporation of water by continuous moist curing which shall be maintained for at least 7 days after placement.

16.3.6.2 « Moist » here is defined as maintaining the atmosphere adjacent to the concrete at a minimum relative humidity of 95%, or that the concrete shall retain sufficient of its original moisture for the hydration of the cement and proper hardening of the concrete while within insulated formwork or under protective covering.

16.3.6.3 If the application of heat for protection of the concrete during cold weather is required, all necessary measures shall be taken to prevent the drying of the concrete.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 16.3.6.4 The method used for curing by the Contractor shall be as reviewed by the Engineer.
- 16.3.7 The special measures regarding the withdrawal of heating and protection of the concrete, and removal of the formwork, shall be as follows:
 - 16.3.7.1 Protection and heating, where used, shall be withdrawn progressively in such a manner as not to introduce thermal shock stresses in the concrete.
 - 16.3.7.2 During the prescribed curing period after the initial temperature rise in the concrete due to heat of hydration, the temperature of the concrete adjacent to and in contact with the forms shall be reduced at a gradual rate not exceeding 5°C per day to within 4°C of ambient (outside air) temperature.
 - 16.3.7.3 To achieve this in a heated housing, the heat shall be slowly reduced, and regulated as necessary, and the whole housing shall be allowed to cool to air temperature before the housing itself or the formwork is removed.
 - 16.3.7.4 Where the work is to proceed within the same housing on the next stage of the work, the formwork may be removed as soon as the prescribed curing period is over.
 - 16.3.7.5 With insulated formwork, the forms themselves may be slackened and some insulation removed if needed.
 - 16.3.7.6 The forms shall remain in place for a minimum of 7 days to achieve satisfactory curing. In addition, to avoid thermal shock and associated cracking, the forms shall not be removed unless and until the concrete temperature has fallen to within 4°C of ambient temperature, and within 8°C of the low ambient temperature as forecast for the following 24 hours by the nearest Environment Canada weather station.
 - 16.3.7.7 Formwork shall be stripped with care to avoid damage to the concrete, and precautions shall be taken to avoid chipping of exposed edges and corners.
- 16.3.8 The special measures regarding temperature records and other information, and measures to take if specified curing requirements are not met, shall be as follows:
 - 16.3.8.1 Thermometers shall be placed at several points within the protection to show the most favourable and unfavourable temperature conditions to which the concrete is subjected.
 - 16.3.8.2 When required by the Engineer, the Contractor shall provide suitable tube inserts in the concrete for thermometers.
 - 16.3.8.3 Thermometer readings and other required information shall be taken at least 3 times per day and recorded, one time being at the start of the work in the mornings and one time being at the close of the day.
 - 16.3.8.4 Where the method of curing is by a moist atmosphere within a housing, the relative humidity shall be measured by a wet and dry bulb thermometer and recorded.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 16.3.8.5 The corresponding outside air temperature and approximate wind velocity and direction shall also be taken and all recorded.
- 16.3.8.6 The maximum and minimum air temperatures shall be noted and recorded each day.
- 16.3.8.7 The records so compiled shall establish whether the specified protection and curing conditions are being met and shall determine whether Class B protection was provided.
- 16.3.8.8 Where the required curing conditions are not met during the required period of protection, the Engineer will instruct the Contractor to take measures either at once or later as deemed necessary, to ensure that the overall final quality of the concrete is not adversely affected.
- 16.3.8.9 Should any concrete be found to be frozen or apparently damaged by low temperatures, it shall be, first of all, slowly thawed out and cured with live wet steam over a period of several days with the forms in place where possible, after which the concrete will be inspected by the Engineer who will instruct the Contractor as to required remedial measures.

A3-17 WARM WEATHER CONCRETING

- 17.1 The concrete shall be batched and delivered to the forms within a temperature range of 15 to 27°C when the air temperature is above 20°C.
- 17.2 The Contractor shall use suitable methods such as adding flaked ice to the mix in lieu of mixing water, cooling the mixing water with ice, sprinkling the aggregates, or other means to achieve the temperatures required.
- 17.3 The type of equipment used shall permit a continuous pour of concrete and shall be subject to the prior review of the Engineer.
- 17.4 When the ambient temperature exceeds 25°C, the Contractor shall make special preparations to ensure that the concrete will be transported, placed, consolidated, and finished at the fastest rate possible compatible with other requirements for good construction practice; and special means shall be taken in conveying the concrete to the forms, so that large surface areas of fresh concrete are not exposed to the sun and hot winds.
- 17.5 When the ambient temperature consistently exceeds 25°C and the concrete temperature when deposited in the forms exceeds the specified limits after the Contractor has taken precautions such as using ice in the mix water, shading or cooling aggregate supplies, and protecting conveying devices from the sun and hot winds, a set-retarding admixture shall be used on authorisation by the Engineer, the cost of which shall be included in the price tendered for the concrete.

A3-18 HORIZONTAL CONSTRUCTION JOINT

- 18.1 Construction joints, other than those shown on the drawings shall be as reviewed by the Engineer.
- 18.2 Horizontal construction joints shall be continuous throughout the structure and shall be revibrated within 1 to 3 hours after the initial placement of concrete to provide a uniform level surface.
- 18.3 The exact time of revibration will be as accepted by the Engineer.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 18.4 The showing edge of construction joints shall be brought to a neat line by the use of chamfer strips when forming.
- 18.5 The surface preparation of horizontal construction joints shall be conducted in two phases as follows:
- 18.5.1 The first phase, which shall be performed prior to forming the next lift, shall consist of sandblasting to expose and clean the coarse aggregate without undercutting the particles.
- 18.5.1.1 At least 2 m³ of dried, sized sand, passing the No. 10 Canadian Standard (2.00 mm) sieve and at least 98% retained on the No. 20 (840 micrometers) sieve, shall be provided for sandblasting each 100 m² of surface.
- 18.5.1.2 After sandblasting, all loose particles shall be washed or blown from the joint surface.
- 18.5.2 The second phase, which shall be performed immediately before the placement of the next lift shall consist of cleaning the surface by means of an air operated water jet.
- 18.5.2.1 This phase of the surface preparation shall be carried out in a thorough manner in order to remove all contaminating substances and loose material from the joint and shall be completed to the satisfaction of the Engineer before concrete is ordered for placement in the next lift.
- 18.6 Concrete shall not be deposited upon a prepared joint until all free water has been removed from the surface.
- 18.7 The first layer of concrete placed upon the joint shall be approximately 150mm thick and shall be vibrated uniformly with internal vibrators inserted at spacings of approximately 500mm.
- 18.8 Surface set retarders for construction joint preparation shall not be used.

A3-19 JOINT RUSTICATION

- 19.1 Unless otherwise directed or accepted by the Engineer, all horizontal and vertical construction joints and contraction joints shall be rusticated by the use of 20-mm chamfer strips installed on the formwork.
- 19.2 The chamfer strips shall consist of the same material as that used in the forms.
- 19.3 The chamfer strips shall be so installed as to leave a neat regular groove in the concrete at all construction joints, along the vertical showing edge of contraction joints and at all exposed corners and edges of the concrete.
- 19.4 When the chamfer strips are fabricated, care shall be taken to ensure that all strips are equal in cross-section so that the ends of the strips can be matched during installation.
- 19.5 When wooden strips are used, the forming face shall be oiled and shall be free from warps, knots or slivers that would otherwise mar the concrete surface.
- 19.6 The strips shall be carefully installed true to line and grade.
- 19.7 When used to form the showing edge of construction joints or at the top edges of pours, the concrete shall be placed even with the top of the strip to provide a formed groove with the same dimensions as that of the strip.

- 19.8 To avoid inclusion of dust and debris beneath chamfer strips located at construction joints, the strips at the bottom of the form shall not be positioned until the joint surface has been washed or blown clean of all debris and accepted by the Engineer.

A3-20 PREPARATION OF EXISTING SURFACES PRIOR TO PLACEMENT OF CONCRETE

- 20.1 Existing rock and existing concrete surfaces shall be prepared according to the following:

20.1.1 All surfaces against which new concrete is to be placed shall be clean, solid, and free from loose or unsound fragments, objectionable coatings, ice, snow and any other foreign substances or debris, and shall be sufficiently rough to ensure that a full bond is developed with the new concrete.

20.1.2 Before fresh concrete is placed, the surfaces shall be chipped or roughened if necessary, sandblasted as described in Subsection A3-18 (to expose and clean the coarse aggregate without undercutting the particles, in the case of existing concrete) and cleaned of all debris and foreign material with an air-operated water jet with air pressures in excess of 600 kPa to provide a thoroughly clean surface.

20.1.3 After the use of the air-operated water jet, free water shall be removed from the surfaces with the air jet alone.

20.1.4 Prior to placing concrete, any seepage water encountered in the area shall be controlled and all pools of water shall be removed from depressions to the satisfaction of the Engineer.

- 20.2 Demolished concrete surfaces shall be prepared according to the following:

20.2.1 After initial demolition of the existing concrete, the Contractor shall inspect the demolished surface for areas of underbreak, and shall complete the demolition to the lines shown on the drawings.

20.2.2 The demolished surfaces shall be thoroughly scaled.

20.2.3 If, during the course of the work, existing disintegrated or porous concrete is exposed, further removal of concrete shall be performed until sound concrete is exposed, as directed by the Engineer.

20.2.4 After the scaling is accepted by the Engineer, and prior to the placement of new concrete, the entire surface of the existing concrete shall be thoroughly cleaned by sandblasting, followed by an air-water jet, operating with air pressure in excess of 600 kPa, to remove all loose and adhering contaminating material (including drill dust, oil, mud, coatings, ice, snow) to ensure full bonding.

20.2.5 After the use of the air-water jet, free water shall be removed from the surface with the air jet alone.

20.2.6 Prior to placing concrete, any seepage water encountered in the area shall be controlled, and all pools of water shall be removed from depressions to the satisfaction of the Engineer.

A3-21 EMBEDMENT OF REINFORCING STEEL ANCHORS

- 21.1 General requirements shall be according to the following:

21.1.1 All reinforcing steel anchors into rock and existing concrete shall be installed at the locations shown on the drawings or as directed by the Engineer according to the specifications and drawings.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 21.1.2 Reinforcing steel anchor holes shall be drilled to the dimensions and in the locations as shown on the drawings or as directed by the Engineer.
- 21.1.3 All drill cuttings and water shall be blown out of the hole by compressed air immediately before grout is installed.
- 21.1.4 The anchors may be installed using either cementitious or resin-type grout.
- 21.2 Installation of anchors with resin grout shall be according to the following:
- 21.2.1 The grout shall be that of a polyester resin anchor system such as manufactured by Celtite Inc., or Ground Control Ltd., or other equivalent reviewed by the Engineer.
- 21.2.2 The diameters of the anchor bar, drilled hole, and the resin cartridges are to be mutually compatible as recommended by the manufacturer of the resin anchor system.
- 21.2.3 With the anchor in place, the resin shall completely fill the anchor hole.
- 21.2.4 When the ambient temperature is below 5°C or as required by the manufacturer of the resin, the resin cartridges shall be stored in a warm location to provide an installation temperature of 10° to 25°C and the anchor bars shall be thoroughly preheated immediately prior to installation.
- 21.2.5 Installation procedures for anchor installation shall be as recommended by the manufacturer.
- 21.3 Installation with cementitious grout shall be according to the following:
- 21.3.1 The grout to be used to embed the anchors shall be a cement-sand mortar of plastic consistency having time of efflux by cone method between 30 and 40 seconds, containing finely flaked aluminium powder in an amount of 0.005% by weight of the cement used and approximately 18 bags of cement/m³.
- 21.3.2 The actual field batch weights of cement, sand and water will be provided by the Engineer after the Contractor has submitted samples of the materials for testing.
- 21.3.3 The water cement ratio of the grout shall not exceed 0.50.
- 21.3.4 The grout materials shall be according to the following:
- 21.3.4.1 The cement shall be normal Type 10 Portland cement.
- 21.3.4.2 The sand shall be clean, and well-graded according to the following grading limits:
- | SIEVE SIZE | PERCENT PASSING, by weight |
|--------------------|----------------------------|
| .1 5.00 mm | 100% |
| .2 2.50 mm | 85 - 100% |
| .3 1.25 mm | 55 - 90% |
| .4 630 micrometers | 27 - 63% |
| .5 315 micrometers | 10 - 32% |
| .6 160 micrometers | |
- 21.3.4.3 The aluminium powder shall be non-leaving aluminium flake, such as CANBRO No. 806 NL.
- 21.3.4.4 The water shall be clean, potable water.

21.3.4.5 Grout mixing and anchor installation:

- 21.3.4.5.1 The grout shall be mixed for at least 10 minutes in a machine mixer reviewed by the Engineer and shall be capable of being introduced by means of a grout pump reviewed by the Engineer and through a hose to the bottom of the drilled holes.
- 21.3.4.5.2 The grout shall be installed in the holes by pumping it through a hose or pipe that shall be inserted into the hole to its full depth.
- 21.3.4.5.3 As the hole fills with grout, the hose or pipe shall be withdrawn slowly while the discharge end remains at all times below the level of the grout.
- 21.3.4.5.4 After the hole has been completely filled with grout, the reinforcing steel anchor bar shall be inserted to the required depth.
- 21.3.4.5.5 If the air temperature is below 5°C, the holes in the concrete shall be preheated by circulating hot water at 93°C for not less than 30 minutes immediately prior to introduction of grout and the reinforcing steel anchor bars.
- 21.3.4.5.6 The reinforcing steel anchor bars shall also be preheated.
- 21.3.4.5.7 The work shall be protected from freezing temperatures for 24 hours after the embedment of reinforcing steel anchors.

A3-22 CONSTRUCTION TOLERANCES

- 22.1 The concrete surfaces shall not deviate from the specified lines and grades by more than ± 5 mm in 5 m when measured with a straight edge.

A3-23 FORMS

- 23.1 Forms shall be made of steel or heavy waterproof plywood.
- 23.2 Forms shall conform to the shapes, lines and dimensions of the structure according to the drawings.
- 23.3 Forms shall be substantial, rigid and unyielding.
- 23.4 Forms shall be so designed, tied and supported by the Contractor that they will not deflect or bulge during placement and compaction of the concrete.
- 23.5 Forms shall be sufficiently tight to prevent loss of mortar.
- 23.6 Forms for successive lifts on adjacent parts of the structure shall be so arranged that a continuous, uniform and harmonious texture of the concrete surface results.
- 23.7 Wherever the formed area permits, the minimum form panel size that may be used shall be 1200 mm by 2400 mm.
- 23.8 Before concrete is placed within the forms, the accumulated dust and debris shall be removed from the form surfaces, and the inside surfaces of forms shall be coated with a form oil reviewed by the Engineer.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 23.9 The design of the formwork shall be done by a registered Professional Engineer experienced in this type of design.
- 23.10 The formwork shall conform to Clause 11 of CSA Standard A23.1-00, *Concrete Materials and Methods of Concrete Construction*.
- 23.11 Bolts and rods used for internal ties shall be so arranged that when the forms are removed there shall be no metal within 80 mm of any concrete surface.
- 23.12 Wire form ties shall not be used.
- 23.13 The Contractor shall, where wire snap ties are used, do the packing and finishing around the ties similar to that required around boltholes, after the forms are removed.
- 23.14 Inspection ports shall be provided when requested by the Engineer.
- 23.15 The inspection port closures shall be fitted in such a manner as to ensure a neat-formed surface.
- 23.16 In general, chamfer strips of 40 mm in dimension shall be provided at all exposed corners and edges unless otherwise shown on the drawings and except for joint rustication as reviewed by the Engineer.
- 23.17 When concreting under cold weather conditions, the provisions of Subsection A3-16, *Cold Weather Concreting*, shall apply.

A3-24 INSPECTION OF FORMS

- 24.1 The Contractor shall notify the Engineer in writing in sufficient time to permit a thorough inspection of the forms, form bracing, reinforcing steel and embedded parts, that they are ready for inspection.
- 24.2 No concrete shall be mixed or placed until this inspection is completed and Concrete Control, Placement Authorisation slips have been signed and given to the Contractor by the Engineer.

A3-25 REMOVAL OF FORMS (OTHER THAN COLD WEATHER CONCRETING)

- 25.1 For restrictions to form removal in cold weather concreting, see Section A3-16.3.7.
- 25.2 Forms and form supports such as shoring shall not be removed without the authorisation of the Engineer.
- 25.3 Forms and form supports shall not be removed before the expiration of the minimum time indicated below, and as specifically authorised by the Engineer.
 - 25.3.1 Bottom forms and supports shall not be removed before 7 days.
 - 25.3.2 Side forms and supports shall not be removed before 48 hours.
 - 25.3.3 These periods represent the cumulative number of consecutive days or fractions thereof during which the temperature of the concrete is above 10°C.
 - 25.3.4 For concrete temperatures above 27°C, these periods may be reduced as reviewed by the Engineer.
- 25.4 The formwork shall be stripped with care to avoid damage to the green concrete and special precautions shall be taken to avoid chipping of exposed edges and corners.

A3-26 REPAIR OF NEW CONCRETE

- 26.1 Concrete surfaces found to be defective upon the removal of the forms shall not be repaired until they have been examined and the areas that are to be repaired marked out by the Engineer.
- 26.2 Within 48 hours after the removal of the forms covering concrete which is to be repaired, and after the examination referred to above, the Contractor shall carry out all necessary repair work to the concrete as directed by, and to the satisfaction of the Engineer.
- 26.3 Repair patches or replacement concrete shall be kept continuously moist for at least 7 days after placement in the required areas.

A3-27 SURFACE FINISH, GENERAL

- 27.1 The formed surface of concrete shall be true, sound, smooth and free from defects except as otherwise noted.
- 27.2 Immediately upon the removal of forms, the surface shall be inspected, repaired and finished as specified.
- 27.3 The surface of the concrete to be finished shall be thoroughly saturated with water and maintained wet for at least one hour before finishing operations are begun which shall be as follows:
 - 27.3.1 Immediately before application of the plastic mortar, the surface shall be blown with air jets to remove free water.
 - 27.3.2 The mortar shall then be rubbed thoroughly over the concrete with clean burlap pads, or by other reviewed methods so as to fill all the voids.
 - 27.3.3 While the mortar in the voids is still plastic, the surface shall be sack rubbed with a mix of the same proportions and materials except that no water shall be used.
 - 27.3.4 The final rubbing shall be performed in a manner that assures that the voids are filled and left flush with the surface of the surrounding concrete.
- 27.4 Surfaces that have been improperly filled improperly cured or otherwise damaged due to the failure of the Contractor to observe the above procedures shall be repaired by the Contractor at no additional cost.
- 27.5 No material shall remain on the surface of the concrete except within the voids.
- 27.6 The surface shall be maintained in a damp condition by means of burlap sacking or other absorbent material for a period of 72 hours after finishing.
- 27.7 The mortar used for finishing shall consist of 1 part by volume of cement to 2 parts by volume of clean sand that passes a 630-micrometer sieve, and enough water so that the consistency of the mortar is equivalent to that of thick cream.
- 27.8 The mortar shall be pre-shrunk by mixing it at least one hour before it is used and then it shall be remixed and applied to the surface without adding water to the mixture.
- 27.9 The sand and cement used in the mortar shall be the same as that used in the concrete.
- 27.10 It may be necessary to blend white cement with the job cement to obtain a colour that will match the surrounding concrete surface.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 27.11 To determine the exact proportions, trial batches in which the percentage of replacement is varied shall be made, allowed to set, and compared with the surface of the concrete to be sack rubbed.
- 27.12 Exposed unformed surfaces shall be screeded and floated to an even dense surface, free from projecting stone, high spots and depression.
- 27.13 In the event that finishes are not specified or given on the drawings, the finish to be used shall be that specified for similar adjacent surfaces as determined by the Engineer.
- 27.14 The finishes to be given to the various surfaces shall be as follows:
- 27.14.1 Formed surfaces shall be given the following finishes unless otherwise specified or indicated on the drawings:
- 27.14.1.1 Type A Finish shall be as follows:
- 27.14.1.1.1 This finish shall apply to formed surfaces that are not exposed to view and where roughness is not objectionable, such as surfaces in contact with backfill or below ground.
- 27.14.1.1.2 These surfaces will, in general, require no treatment after the removal of forms other than repair of form boltholes, defective concrete and specified curing.
- 27.14.1.1.3 Fins and offsets not exceeding 10 mm will be permitted.
- 27.14.1.2 Type B finish shall be as follows:
- 27.14.1.2.1 This finish shall apply to all permanently exposed-formed surfaces.
- 27.14.1.2.2 Form sheathing or lining shall be placed so that joint marks on the concrete surface will, in general, align horizontally and vertically and will conform to a standard pattern.
- 27.14.1.2.3 This finish shall be a smooth, dense finish of uniform texture, free from pits, voids and blemishes and shall be mortar finished as specified above.
- 27.14.1.2.4 Abrupt irregularities shall not exceed 5 mm.
- 27.14.1.3 Type C finish shall be as follows:
- 27.14.1.3.1 This finish shall apply to all formed surfaces prominently exposed to view or in contact with fast flowing water and to finishes which the Engineer considers to be of special importance, such as the outside exposed surfaces of walls, the walls of culverts, galleries, ports, conduits and their accesses, and the interior and exterior surfaces of all buildings.
- 27.14.1.3.2 Special care shall be taken to ensure that all forms are true and are erected accurately so that a smooth dense finish of uniform texture, free from surface imperfections is obtained.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

27.14.1.3.3 Joints in form lining shall conform to a regular pattern and shall be kept to a minimum.

27.14.1.3.4 The concrete surface shall be mortar finished as specified above after all required patching, cleaning and correction of major imperfections have been completed.

27.14.2 Unformed surfaces shall be given the following finishes unless otherwise specified or indicated on the drawings:

27.14.2.1 Type D finish shall be as follows:

27.14.2.1.1 This finish, which is a screeded finish, shall apply to unformed surfaces that will be covered by fill material.

27.14.2.1.2 Finish D shall also be used as the first stage of Finishes E and F.

27.14.2.1.3 Finishing operations shall consist of sufficient levelling and screeding to produce even uniform surfaces.

27.14.2.2 Type E finish shall be as follows:

27.14.2.2.1 This finish, which is a floated finish, shall apply to unformed surfaces not permanently concealed by fill material or concrete, or not required to receive Finishes D and F.

27.14.2.2.2 Finish E shall also be used as the second stage of Finish F.

27.14.2.2.3 Floating may be performed by the use of hand or power-driven equipment.

27.14.2.2.4 Floating shall be started as soon as the screeded surfaces have stiffened sufficiently to permit floating without the drawing of excess fines to the surface of the concrete.

27.14.2.2.5 Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture.

27.14.2.3 Type F finish shall be as follows:

27.14.2.3.1 This finish, which is a trowelled finish, shall be applied to unformed surfaces as given on the drawings and to surfaces where accurate alignment and evenness of surface are required.

27.14.2.3.2 When Finish F is to be applied, trowelling shall be performed as soon as the floated surface has hardened sufficiently to prevent an excess of fine material being drawn to the surface.

27.14.2.3.3 Steel trowelling shall be performed with firm pressure to produce a dense, uniform surface, free from blemishes and trowel marks.

27.14.2.3.4 Surface shall be sloped for drainage according to the drawings or as directed by the Engineer.

27.15 All finished concrete work shall be free from all defects which will impair its appearance, strength, impermeability and durability and all concrete which, in the opinion of the Engineer, is defective or inferior shall be removed and replaced or restored to the satisfaction of the Engineer.

A3-28 TREATMENT OF CHIPPED CONCRETE SURFACES

28.1 The exposed surfaces of all chipped concrete recesses and surfaces which will be left exposed after the existing concrete has been removed shall either be formed and backfilled with concrete or filled by shotcreting.

28.2 Should shotcreting be used, the method and procedures proposed by the Contractor shall be reviewed by the Engineer before any such work is carried out.

28.3 Where pargeeting of the exposed concrete surfaces to match the surrounding surface is required, according to the drawings or as directed by the Engineer, this shall be carried out as directed by the Engineer.

A3-29 PRESSURE GROUTING OF VOIDS

29.1 After the concrete has obtained sufficient strength to withstand grouting pressures, grouting to fill all voids between the newly placed concrete and the existing concrete shall be performed.

29.2 The Engineer will determine the pressures to be used and control all grouting.

29.3 All grouting shall be done in the presence of the Engineer.

29.4 No grouting shall be done until at least 21 days after the concrete has been placed.

29.5 The forms and supports used when placing the grout and concrete shall be left in place until at least 48 hours after the pressure grouting of the voids has been completed.

29.6 All equipment used for mixing and injecting grout shall be of a type and capacity reviewed by the Engineer.

29.7 The equipment shall be capable of mixing and stirring the grout and forcing it into the holes continuously and without interruption at any pressure up to a maximum of 350 kPa.

29.8 The materials used for the manufacture of the grout shall satisfy the general requirements of Sections A3-3, A3-7, and A3-8 of these specifications where applicable, and the composition and mix proportions of the grout mixture shall be as specified in the A-1 Specifications.

29.9 Dummy grout pipes shall be inserted through the forms to observe the travel of the grout.

29.10 Rubber packers equipped with a quick acting shut-off valve shall be provided for each grout hole.

29.11 The grouting of each hole shall be done until, in the opinion of the Engineer, all voids have been filled to the maximum extent practicable.

29.12 After the grouting of a hole is finished, the pressure shall be maintained by closing the packer valves.

29.13 The packers shall be left in place until the grout has hardened sufficiently so that it will remain in the hole.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 29.14 The Contractor shall install pipes that are approximately 20 mm in diameter along the top edge of the forms to observe the crown packing.
- 29.15 All pipes shall be cleared of concrete by drilling after the concreting operations and shall be used both for making grouting connections and to observe the grout travel.
- 29.16 The Contractor shall remove all grout supply connections from the grout holes and clean out the holes for a 150-mm length measured from the inside surface of the concrete.
- 29.17 The holes shall then be dry-packed with mortar consisting of 1 part by volume of normal Portland cement to 2 parts by volume of concrete sand.
- 29.18 The patching shall be done in a manner that will provide a surface smoothness at least equal to undisturbed areas of concrete.
- 29.19 During the work, the Contractor shall remove all waste grout resulting from the work by washing it away with water before it hardens on the existing surfaces.
- 29.20 Before final acceptance of the work, the surface of the concrete shall be cleaned and restored to its original condition to the satisfaction of the Engineer.
- 29.21 The Contractor shall supply tapered pipe to form the grout holes, install them in the forms, remove them after placement of concrete, maintain the holes free from obstructions until grouted, and patch the holes according to the specifications.

A3-30 REINFORCING STEEL

- 30.1 General requirements for the reinforcing steel work shall be as follows:
 - 30.1.1 The reinforcing steel shall include all bar steel, wire and accessories required for the concrete reinforcement work.
 - 30.1.2 The reinforcing steel work shall include the following:
 - 30.1.2.1 Supplying.
 - 30.1.2.2 Cutting.
 - 30.1.2.3 Bending.
 - 30.1.2.4 Welding.
 - 30.1.2.5 Storing.
 - 30.1.2.6 Cleaning.
 - 30.1.2.7 Placing.
 - 30.1.3 All reinforcing steel shall be manufactured from hard or intermediate grade new billets steel or rail steel.
 - 30.1.4 All reinforcing steel bars shall be deformed and shall conform to CAN/CSA Standard G30.18M92 (R1998), *Billet-Steel Bars for Concrete Reinforcement*, except that bars having a diameter smaller than 10M bar may be plain.
 - 30.1.5 Welded wire fabric shall conform to CSA Standards G30.3-M1983 (R1998), *Cold-Drawn Steel Wire for Concrete Reinforcement*, and G30.5-M1983 (R1998), *Welded Steel Wire Fabric for Concrete Reinforcement*.
 - 30.1.6 The finished reinforcing steel shall be free from injurious seams, flaws, cracks and other defects.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 30.1.7 The reinforcing steel shall be unpainted and shall be thoroughly cleaned of scale, grease, oil and rust before being covered with concrete.
- 30.2 Bending reinforcing steel requirements shall be as follows:
- 30.2.1 All reinforcing steel bars shall be bent, when required, to the exact shapes according to the drawings before being placed in the work.
- 30.2.2 The Contractor shall check the bending measurements and shall ensure that all reinforcing steel bars are bent to the required clearances.
- 30.3 Placing reinforcing steel requirements shall be as follows:
- 30.3.1 Annealed iron wire for tying reinforcing steel shall be not less than 1.5 mm in diameter (16 gauge).
- 30.3.2 Spacers shall be installed at not more than 1-m centres, or according to the drawings.
- 30.3.3 All vertical reinforcing steel shall be secured at the top while concrete is being placed.
- 30.3.4 All reinforcing steel shall be secured in such a manner so that it does not move during concrete placement operations.
- 30.3.5 Wooden blocks, bricks and stones shall not be used for spacing or supporting reinforcing steel.
- 30.3.6 Concrete blocks, of the same design and strength as the concrete to be placed under this contract and cured as specified, specifically constructed for this purpose and which have been reviewed by the Engineer, may be used for supporting reinforcing steel.
- 30.3.7 Plastic chairs for supporting reinforcing steel shall only be permitted with the prior written acceptance of the Engineer.
- 30.3.8 Plastic supports shall be of a type, quality and strength that will support the weight of the reinforcing steel and the fresh concrete placed on them, as well as the shock of the concrete placing and compacting operations, without moving, bending, deflecting, cracking or breaking.
- 30.3.9 Should concreting operations prove the plastic supports to be unsatisfactory, the Contractor shall remove all such supports already installed and replace them with supports satisfactory to the Engineer.
- 30.3.10 Welding of or to existing or new reinforcing steel bars will not be permitted unless specifically authorised in writing by the Engineer.
- 30.4 Reinforcing steel orders and mill analyses requirements shall be as follows:
- 30.4.1 The Contractor shall provide the Engineer with 4 copies of the orders for the reinforcing steel at the time such orders are placed.
- 30.4.2 The Contractor shall provide 4 certified copies of the mill analysis of each heat of steel supplied.
- 30.5 Reinforcing steel inspection requirements shall be as follows:
- 30.5.1 Reinforcing steel will be inspected and may be tested by the Engineer.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

30.5.2 This inspection shall be made at the mill where rolled, the place of fabrication and bending, or the site of the work, either or all of these places.

30.5.3 Reinforcing steel that does not comply with these specifications may be rejected at any time prior to being covered with concrete even though it may previously have been inspected and passed as being suitable.

30.6 Reinforcing steel anchor requirements shall be as follows:

30.6.1 The Contractor shall supply and install all anchors, required for anchoring new concrete to the existing concrete according to the drawings.

30.6.2 The anchors shall consist of deformed reinforcing steel as specified for which holes shall be drilled and grout shall be installed, all according to the specifications.

A3-31 BITUMINOUS CEMENT

31.1 Bituminous cement for the joints, according to the drawings, shall be applied to one face to a thickness of at least 3-mm when dry.

31.2 The bituminous cement shall have the following capabilities:

31.2.1 Applicable by spray at temperatures ranging from -15°C to +30°C.

31.2.2 Possess good adherence to uncured concrete.

31.2.3 Does not run or sag at temperatures up to 50°C.

31.2.4 Will remain unbroken under abrasive action due to concrete placing operations after a drying time of 48 hours at average fair weather humidity.

31.3 In cold or wet weather, forms shall not be removed until immediately prior to the application of the coating in order to keep the surface of the concrete as dry as possible.

A3-32 PREMOLDED JOINT FILLER

32.1 Joint filler shall be provided according to the drawings.

32.2 Joint filler shall be an asphalt impregnated material such as Flexcell as manufactured by Sternson Limited.

32.3 Joint filler shall, where possible, be nailed to the forms with the nail heads protruding from the surface to provide a bond into the concrete.

A3-33 JOINT SEALANT

33.1 The joints shall be sealed according to the drawings.

33.2 The sealant shall be a one component, permanently flexible polyurethane base elastomeric sealant, gray in colour, such as Sikaflex-1a as manufactured by Sika Canada Incorporated.

33.3 The sealant shall retain elasticity and durability over a temperature range of -40°C to +65°C.

33.4 No application of sealant shall be made until:

33.4.1 The concrete is fully cured.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

33.4.2 The surface of the concrete to which the sealant will be applied is sandblasted to remove friable material, and cleaned by means of a compressed air jet.

33.5 The sealant shall be applied in strict accordance with the manufacturer's instructions.

33.6 The application temperature for the sealant shall not be less than 5°C or the temperature according to the manufacturer's instructions.

A3-34 WATER STOPS

34.1 The Contractor shall supply and install water stops according to the drawings.

34.2 Plastic PVC (polyvinyl chloride), water stops shall be moulded or extruded in such a manner that all cross-sections will be dense, homogeneous and free from porosity and other imperfections.

34.3 The section shall be uniform and symmetrical throughout.

34.4 PVC water stops shall have a minimum weight of 2.16 kg/m for a 150-mm width.

34.5 Water stops shall be installed in their locations prior to concrete being placed.

34.6 All intersections of water stops of all types shall be field welded before concrete is placed in the forms.

34.7 The Contractor shall have an authorised, electric, water stop splicer and welding equipment available to make the necessary welds.

34.8 Where a number of short pieces of water stop are to be joined together, they shall be shop-welded before the completed section is placed in the forms.

34.9 The water stops shall be undamaged and shall be capable of fulfilling the following requirements.

34.9.1 Withstanding indefinitely, when elongated by a 20-mm gap between monoliths, hydrostatic heads of up to 20 m.

34.9.2 Retain essential plasticity and elasticity under temperatures to -32°C.

34.9.3 Have high durability under conditions of moisture, temperature and physical environment to which they will be subjected.

34.10 If requested by the Engineer, the Contractor shall supply, for testing purposes, one 3-meter length of the type of moulded water stop for which review is requested.

34.11 The sample shall be accompanied by a certificate identifying the material and certifying that it is the same in all respects as that used in the manufacture of the proposed water stops.

34.12 The sample shall be supplied not less than 10 days prior to the delivery of the water stops to the site and without cost to the Owner.

34.13 The Contractor shall furnish the Owner with complete instructions on the manner in which it is proposed to make splices in the field.

34.14 It is essential that splices be made in such a manner as to ensure the following:

34.14.1 The material shall not be damaged by heat sealing or by the application of cementing materials.

34.14.2 The splices shall have a tensile strength of not less than 50% of the unspliced material.

A-3 SPECIFICATIONS, REINFORCED CONCRETE CONSTRUCTION

- 34.14.3 Except in the case of water stops of different sections, the ribs on the splice pieces shall match perfectly; this shall require mitre cutting at corners.
- 34.15 During concreting, special care shall be taken to keep water stops in their intended position, and to place concrete so as to fill in evenly around the water stops.