

CAST-IN-PLACE CONCRETE

1. GENERAL

1.1 Work Included

- .1 All cast-in-place concrete shown on the Drawings.
- .2 Setting anchors, inserts, frames, sleeves, and other items supplied by other Sections.
- .3 Repairing concrete imperfections.
- .4 Finishing formed concrete surfaces.
- .5 Watertightness testing of water retaining structures.
- .6 Curing of concrete.

1.2 Quality Assurance

- .1 Cast-in-place concrete shall conform to CSA CAN/CSA-A23.1-00.
- .2 Testing shall conform to CAN/CSA-A23.2-00.
- .3 These standards shall be available in the Contractor's Site office for the use of the Contractor, sub-trades, and Contract Administrator.
- .4 A Concrete Pour Release Form shall be completed prior to each concrete pour. The Contractor shall be responsible for completing the forms. Each form shall be signed by the Contractor and Contract Administrator prior to each pour.

1.3 Qualifications

- .1 Concrete flatwork finishing is to be done by an established firm having at least five (5) years of proven, satisfactory experience in this trade and employing skilled personnel.
- .2 Submit proof of qualifications in writing to the Contract Administrator.

1.4 Performance Requirements

- .1 Watertightness
 - .1 Provide watertight concrete structures for all Type A concrete. No visible leaks will be permitted.
- .2 28-day Concrete Compressive Strengths
 - .1 Normal-density concrete:
 - .1 Type A: 35 MPa

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- .2 Type B: 30 MPa
- .3 Type C: 15 MPa
- .3 Density
 - .1 Normal density $2350 \pm 50 \text{ kg/m}^3$.
- .4 Construction Tolerances
 - .1 Comply with Clause 10-CSA A23.1-00 unless noted otherwise.

1.5 Submittals

- .1 Drying shrinkage Test
 - .1 Drying Shrinkage Tests:
 - .1 Perform laboratory trial mixes of concrete used on project. Make two (2) sets of three (3) specimens for each shrinkage test.
 - .2 Prism Specimen Size: 100 by 100 mm by approximately 280 mm with effective gauge length of 250 mm.
 - .3 Specimens: fabricate, cure, dry, and measure as specified in ASTM C157 modified as follows:
 - .1 Remove specimens from molds aged 23 hours, ± 1 hour after trial batching.
 - .2 Place immediately in water at $22.8^\circ\text{C} \pm 2^\circ\text{C}$ for at least 30 minutes.
 - .3 Measure within 30 minutes thereafter to determine original length and then submerge in saturated limewater at $22.8^\circ\text{C}, \pm 2^\circ\text{C}$.
 - .4 Measure specimens at age seven (7) days to determine expansion expressed as percentage of original length. Length at age seven (7) days shall be base length for drying shrinkage calculations (zero days drying age).
 - .5 Store specimens immediately in humidity control room maintained at $22.8^\circ\text{C}, \pm 2^\circ\text{C}$ and 50%, $\pm 4\%$ relative humidity for remainder of test.
 - .6 Measure to determine shrinkage expressed as percentage of base length and report separately for 7, 14, 21, and 28 days of drying after seven (7) days of moist curing.
 - .4 Computing Drying Shrinkage Deformation: Deformation of Each Specimen:
 - .1 Difference between base length (at zero days-drying age) and length after drying at each test age.

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- .2 Compute average drying shrinkage deformation to nearest 0.001% at each test age.
- .3 If drying shrinkage of any specimen departs from average of that test age by more than 0.004%, disregard results obtained from that specimen.
- .2 Concrete Shrinkage at 28 Day Drying Age: 0.040% maximum for laboratory trial mixes of proposed concrete for construction. If shrinkage specimen tests for concrete exceed shrinkage limits modify concrete mix to reduce shrinkage.
- .3 Carry out shrinkage test for Type A concrete as follows:
 - .1 20 mm aggregate with or without superplasticizer (two (2) tests).
 - .4 Drying shrinkage test results will be reviewed for conformance with requirements of the Specifications and will be returned with Contract Administrator's comments.
- .2 Concrete Mix Design
 - .1 Submit proposed performance mix, and supplier's applicable standard deviations for each type of concrete to the Contract Administrator for review minimum two (2) weeks prior to commencement of the Work. Pay costs for all mix design.
 - .2 Tabulate concrete mixes. Indicate range of cementing materials content, type of cements, size of coarse aggregate, water/cementing material ratio, admixtures used, air content, slump, and locations of use for each mix.
 - .3 For high-slump flowing concrete submit a mix that will not result in segregation.
 - .4 Submit detailed plan for cold weather curing and protection of concrete placed and cured in weather below 5°C.
 - .5 Submit detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 27°C.
 - .6 Concrete mix designs will be reviewed for conformance with requirements of the Specifications and will be returned with Contract Administrator's comments.
- .3 Placement Drawings and Plans:
 - .1 Submit Drawings indicating concrete placement sequence, and identifying location of each type of construction joint.
 - .2 Submit detailed plan for cold weather curing and protection of concrete placed and cured in weather below 4°C.
 - .3 Submit detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 27°C.

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1.6 Inspection & Testing

- .1 Notify the Contract Administrator at least forty-eight (48) hours before complete formwork and concrete reinforcement are ready for review. Reinforcing in walls shall be reviewed prior to closing forms. Concrete sampling, inspection, and testing is to be performed by a CSA certified inspection and testing firm appointed and paid for by the City.
- .2 Provide unencumbered access to all portions of Work and cooperate with appointed firm.
- .3 Tests of cement and aggregates may be performed to ensure conformance with requirements stated herein.
- .4 Notify the Contract Administrator at least twenty-four (24) hours in advance of any concrete placement. Under no circumstances shall concrete be placed without notifying Contract Administrator.
- .5 At least three (3) concrete test cylinders will be taken for every seventy-five (75) or less cubic metres of each class of concrete placed.
- .6 At least three (3) test cylinders will be taken daily for each class of concrete placed.
- .7 One (1) slump test and one (1) air content test will be taken for each set of test cylinders taken.
- .8 Additional slump and air content tests may be taken as necessary (up to every truck) to verify quality of concrete at the discretion of the Contract Administrator.
- .9 Testing of concrete will be performed in accordance with CAN/CSA-A23.2-00. Test results will be issued to the Contractor, the Contract Administrator, and the City.
- .10 The Contractor shall pay costs for required retesting due to defective materials or workmanship.
- .11 If accepted by the Contract Administrator, the Contractor may arrange and pay for additional tests for use as evidence to expedite construction.
- .12 To conform to the strength requirements, the average of all tests shall exceed the specified strength. When three (3) or more tests of the same type of concrete are available, the average of any three (3) consecutive tests shall be equal to, or greater than the specified strength, and no strength test shall fall more than 3.5 MPa below the specified strength. If any of the criteria of the above clause are not met, the Contract Administrator shall have the right to require one or more of the following:
 - .1 Changes in mix proportions for the remainder of the Work.
 - .2 Cores drilled and tested from the areas in question as directed by the Contract Administrator and in accordance with CAN/CSA-A23.2-00. The test results shall be indicative of the strength of the in-place concrete.

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- .3 Load testing of the structural elements.
- .4 The changes in the mix proportions, cores drilled and tested, and load testing shall be at the Contractor's expense.
- .5 Concrete failing to meet the strength requirements of this Specification shall be strengthened or replaced at the Contractor's expense and to the satisfaction of the Contract Administrator.

2. PRODUCTS

2.1 General

- .1 All materials that will come in contact with potable water shall meet the requirements of National Sanitary Foundation (NSF) 60/61.

2.2 Materials

- .1 Portland Cements/ Blended Hydraulic Cements
 - .1 Type: MSb: CSA A 3001. No flyash permitted.
- .2 Aggregates
 - .1 Normal-density Concrete
 - .1 Coarse aggregate: CSA A23.1; rough and angular gravel or crushed stone.
 - .2 Fine aggregate: CSA A23.1; natural sand.
 - .3 Ensure that no aggregates are used that may undergo volume change due to alkali reactivity, moisture retention, or other causes. Confirm suitability of aggregate with a petrographic analysis if deemed necessary by the Contract Administrator.
- .3 Admixtures
 - .1 Compatible with each other and with other concrete materials.
 - .2 Use products that are certified for potable water in construction of potable water structures.
 - .3 Calcium chloride, thio-cyanates, or admixtures containing more than 0.05% chloride ions are not permitted.
 - .4 Air-entraining admixture: ASTM C260; non-detergent type.
 - .5 Water-reducing admixtures: ASTM C494; Type A.

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- .6 Set-retarding admixture: ASTM C494; Type B.
- .7 Superplasticizing admixture: ASTM C494; Type F 1 or G 2 ASTM C1017, Type 1 or 2.
- .8 Corrosion inhibitor: ASTM C494; Type C; DCI by:
 - .1 W.R. Grace Co. of Canada Ltd.
 - .2 Rheocrete CNI by Master Builders Technologies, Ltd..
- .4 Water: CSA A23.1; clear and free from oil, acid, alkali, organic matter, or other deleterious substances with a maximum soluble chloride ion content of 0.10% by weight.
- .5 Floor hardener
 - .1 Non-metallic floor hardener: premixed blend of mineral aggregates, wetting and densifying agents, and Portland cement, shake-on type; Diamag 7 or Durag Premium by Sika Canada Inc., Maximent or Mastercron by Master Builders Technologies, Ltd., Surfex by Euclid Admixture Canada, Inc., or Quartz Tuff by Dayton Superior Canada Limited.
- .6 Materials are to be obtained from the same source of supply or Manufacturer for the duration of the project.

2.3 Accessories

- .1 Curing Sealer: sodium silicate, Miracle Kote or accepted alternate.
- .2 Moisture Retention Film: Master Builders Confilm or accepted alternate.

2.4 Concrete Mixes

- .1 General
 - .1 Establish proportions of cementing materials, aggregates, water, and admixtures required to produce consistent workable concrete that is watertight, durable concrete with strength and other properties specified. Comply with clause 14.6-CSA A23.1-00 Volume Stability Considerations.
 - .2 Use same type and brand of cement throughout.
 - .3 Comply with and allow for the supplier's Standard Deviation as specified in CSA A23.1, Clause 17.6 – Compressive Strength Requirements. If the concrete supplier has no established Standard Deviations for concrete of the specified strengths, use a value of 4 MPa minimum.
 - .4 Provide all concrete with types of cement – subjected to moderate degree of sulphate attack.

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- .5 Use high-slump concrete by addition of superplasticizing admixture for walls and columns.
- .2 Types of Normal-density Concrete
 - .1 Type A: concrete for liquid holding/containment structures, containing reinforcing bars, unless specified otherwise.
 - .2 Type B: concrete for structures, containing reinforcing bars, unless specified otherwise.
 - .3 Type C: fill concrete unless specified otherwise.
- .3 Mixes for Normal-density Concrete
 - .1 Cementing Materials Content
 - .1 Except where higher quantities are needed to meet strength or other requirements, provide the following minimum cementing materials contents
 - .1 Type A: 370 kg/m³, for nominal 20 to 5 mm coarse aggregate
 - .2 Type B: 330 kg/m³
 - .3 Type C: 180 kg/m³
 - .2 Where higher quantity of cementing materials are provided, do not exceed the amount of cementing materials greater than 1.10 times the minimum quantity specified above.
 - .2 Coarse Aggregates
 - .1 Nominal size 20 to 5 mm, unless noted otherwise.
 - .2 Nominal size 10 to 2.5 mm, for concrete in steel pans.
 - .3 Water/Cementing Materials Ratio (W/C)
 - .1 Unless specified otherwise: 0.43 maximum
 - .2 High-slump concrete: 0.40 maximum
 - .3 Type C concrete: as required for strength and workability
 - .4 Slump
 - .1 Provide slump consistent with placement, consolidation methods equipment and site conditions. Ensure concrete do not segregate during placement. Comply with CSA A23.1-00.

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- .5 Air Content
 - .1 Comply with CSA A23.1-00, Table 10 – Requirements for the Air Content Categories Specified in Table 12 and 14.
 - .2 Provide air content category 2, unless noted otherwise.
 - .3 Provide air content category 1 for loading bays, parking areas, and liquid holding structures.
 - .4 Provide 3% maximum air content for concrete forming floors where floor hardener is used.
- .6 Admixtures
 - .1 Use water-reducing admixture as necessary.
 - .2 Use superplasticizing admixture with a retarder when requirements of CSA A23.1-00, Clause 21.1.9.1 – Hot-Weather Curing are applicable.
- .4 Concrete delivered to Site must be accompanied by a delivery slip indicating time of completion of mixing, design strength of concrete, air content, and actual water to cementitious materials ratio.
- .5 Patching Mortar:
 - .1 The patching mortar shall be made of the same material and of approximately the same proportions as used for the concrete, except that the coarse aggregate shall be omitted and the mortar shall consist of not more than one (1) part cement to two and a half (2.5) parts sand by damp loose volume.
 - .2 White Portland Cement shall be substituted for a part of the grey Portland Cement on exposed concrete in order to produce a colour matching the colour of the surrounding concrete, as determined by a trial batch.
 - .3 The quantity of mixing water shall be no more than necessary for handling or placing. Mixing water shall include one (1) part latex bonding agent to three (3) parts water. Maximum water to cement ratio shall be 0.40.
- .6 Self-compacting concrete mixes will not be permitted for use on this project.

3. EXECUTION

3.1 Examination

- .1 Before starting this Work examine Work done by others that affects this Work.

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- .2 Notify the Contract Administrator of any conditions that would jeopardize proper completion of this Work.
- .3 Commencement of Work implies acceptance of existing conditions.

3.2 Placing Concrete

- .1 Place concrete in accordance with requirements of CAN/CSA-A23.1-00 and as indicated on the Drawings. Layout of the Work and accuracy of same is the Contractor's sole responsibility.
- .2 Concrete shall be placed within one and a half (1.5) hours of mixing. The concrete shall be placed rapidly and evenly to its final position without re-handling and flowing by methods ensuring to minimize the risk of segregation, loss of ingredients, and cold joints. Under no circumstances shall the concrete, which has partially hardened, be deposited in the forms.
- .3 Ensure all anchor bolts, seats, plates, and other items to be cast into concrete are securely placed and will not interfere with concrete placement.
- .4 All equipment for transporting the concrete shall be cleaned of hardened concrete and foreign materials before placing concrete.
- .5 Immediately before concrete is placed, Contractor shall carefully inspect all forms to ensure that they are properly placed, sufficiently rigid and tight, and that all reinforcing steel and embedded parts are in the correct position and secured against movement during the placing operation. All forms shall be thoroughly cleaned and all debris removed.
- .6 Concrete shall be thoroughly compacted by mechanical vibrators during placing operations. It shall be thoroughly worked around the reinforcement, embedded fixtures, and into the corners of the forms. Vibrators shall not be used to move concrete.
- .7 Vibrate concrete using the appropriate size equipment as placing proceeds, in accordance with CAN/CSA-A23.1-00. Check frequency and amplitude of vibrations prior to use. Provide additional standby vibrators in the event of equipment failure.
- .8 Prepare set or existing concrete by removing all laitance and loose or unsound materials. Roughen concrete surfaces to an amplitude of 6 mm. Apply bonding agent in accordance with Manufacturer's recommendations.
- .9 In locations where new concrete is dowelled to existing concrete, drill holes in existing concrete, insert steel dowels, and pack solidly with non-shrink grout accepted by the Contract Administrator.
- .10 Where placing operations would involve dropping the concrete more than 1500 mm, it shall be placed through canvas hoses or galvanized iron chutes. Concrete shall not be raised at a rate greater than that for which proper vibration may be affected.

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- .11 A minimum of three (3) days shall elapse between adjacent pours separated by construction joints or expansion joints.
- .12 Do not place concrete if carbon dioxide producing equipment has been in operation in the building or in the enclosure during the twelve (12) hours preceding the pour. This equipment shall not be used during placing or for twenty-four (24) hours after placing. During placing and curing concrete, surfaces shall be protected by formwork or an impermeable membrane from direct exposure to carbon dioxide, combustion gases, or drying from heaters.
- .13 Honeycomb or embedded debris is not acceptable.
- .14 Remove and replace defective concrete.
- .15 Maintain accurate records of cast-in-place concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.3 Cold Weather Concreting

- .1 When the mean daily temperature may fall below 5°C during placing or curing concrete, a complete housing of the Work, complete with heaters, fuel, maintenance, and attendants, shall be provided.
- .2 Supplementary equipment as required below shall be at the job Site if concrete is likely to be placed in cold weather.
- .3 Formwork, reinforcing steel, and existing adjacent concrete shall be heated to at least 5°C before concrete is placed.
- .4 The temperature of the concrete shall be maintained at not less than 10°C for seven (7) days. Following that, the concrete shall be kept above freezing temperature for a period of at least seven (7) days. In no case, shall the heating be removed until the concrete has reached a minimum compressive strength which will be specified by the Contract Administrator as determined from compressive strength tests on specimens cured under the same conditions as the concrete Works in question.
- .5 Aggregates shall be heated to a temperature of not less than 20°C and not more than 65°C. Water shall be heated to a temperature between 55°C and 65°C. The temperature of the concrete at the time of placing in the forms shall be within the range specified in CAN/CSA-A23.1-00 for the thickness of the section being placed.
- .6 Combustion-type heaters may be used if their exhaust gases are vented outside the enclosures and not allowed to come into contact with concrete surfaces. Fire extinguishers must be readily at hand wherever combustion-type heaters are used.
- .7 Before depositing any of the concrete, the Contractor shall show that enough heating equipment is available to keep the air temperature surrounding the forms within the specified

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- range. This shall be accomplished by bringing the temperature inside of the housing to the specified 10°C at least twelve (12) hours prior to the start of the concrete placing.
- .8 When the ambient temperature is below -15°C, the housing shall be constructed so as to allow the concrete to be placed without the housing having to be opened. If the mixing is done outside of the housing, the concrete shall be placed by means of hoppers installed through the housing. The hoppers are to be plugged when not in use.
 - .9 When the ambient temperature is equal to or above -15°C, the Contractor will be permitted to open small portions of the housing for a limited time to facilitate the placing of the concrete.
 - .10 The Contractor shall supply all required heating apparatuses and the necessary fuel. When dry heat is used, a means of maintaining atmospheric moisture shall be provided.
 - .11 Sufficient standby heating equipment must be available to allow for any sudden drop in outside temperatures and any breakdowns which may occur in the equipment.
 - .12 The Contractor shall keep a curing record of each concrete pour. The curing record shall include date and location of the pour, mean daily temperature, temperatures above and below the concrete within the enclosures, temperatures of the concrete surface at several points, and notes regarding the type of heating, enclosure, unusual weather conditions, etc. This record shall be available for review by the Contract Administrator at all times, and shall be turned over to the Contract Administrator at the end of the concreting operations.

3.4 Hot Weather Concreting

- .1 General
 - .1 The requirements of this section shall be applied during hot weather, i.e., air temperatures above 25°C during placing.
 - .2 Concrete shall be placed at as low a temperature as possible, preferably below 15°C, but not above 27°C. Aggregate stockpiles may be cooled by water sprays and sun shades.
 - .3 Ice may be substituted for a portion of the mixing water provided the ice has melted by the time mixing is completed.
 - .4 Form and conveying equipment shall be kept as cool as possible before concreting by shading them from the sun, painting their surfaces white, and/or the use of water sprays.
 - .5 Sun shades and wind breaks shall be used as required during placing and finishing.
 - .6 Work shall be planned so that concrete can be placed as quickly as possible to avoid "cold joints".
 - .7 The Contract Administrator's acceptance is necessary before the Contractor may use admixtures such as retardants to delay setting, or water-reducing agents to maintain

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workability and strength, and these are to be included in the mix designs submitted to the Contract Administrator.

.8 Curing shall follow immediately after the finishing operation.

.2 Hot-Weather Curing

.1 When the air temperature is at or above 25°C, curing shall be accomplished by water or by using saturated absorptive fabric, in order to achieve cooling by evaporation. Mass concrete shall be water cured for the basic curing period when the air temperature is at or above 20°C, in order to minimize the temperature rise of the concrete.

.3 Job Preparation

.1 When the air temperature is at or above 25°C, or when there is the probability of its rising to 25°C during the placing period, facilities shall be provided for protection of the concrete in place from the effects of hot and/or drying weather conditions. Under severe drying conditions, as defined in Clause 3.4.5.2 of this Specification Section, the formwork, reinforcement, and concreting equipment shall be protected from the direct rays of the sun or cooled by fogging and evaporation.

.4 Concrete Temperature

.1 The temperature of the concrete as placed shall be as low as practicable and in no case greater than that shown below for the indicated size of the concrete section.

| Thickness of Section (metres) | Temperatures (°C) | |
|----------------------------------|-------------------|---------|
| | Minimum | Maximum |
| less than 0.3 | 10 | 27 |
| 0.3 – 1 | 10 | 27 |
| 1.2 | 5 | 25 |

.5 Protection from Drying

.1 Moderate Drying Conditions

.1 When surface moisture evaporation exceeds 0.75 kg per square metre per hour, windbreaks shall be erected around the sides of the structural element.

.2 Severe Drying Conditions

.1 When surface moisture evaporation exceeds 1.0 kg per square metre per hour, additional measure shall be taken to prevent rapid loss of moisture from the surface of the concrete. Such additional measures shall consist of the following:

.1 Erecting sunshades over the concrete during finishing and placing operations.

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- .2 Lowering the concrete temperature.
- .3 Increasing humidity by applying fog spray immediately after placement and before finishing.
- .4 Care shall be taken to prevent accumulation of water that may reduce the quality of the cement paste.
- .5 Beginning the concrete curing immediately after trowelling.

.3 Surface Moisture Evaporation Rate

- .1 The monograph, Figure D1, Appendix D of CAN/CSA-A23.1-00 shall be used to estimate surface moisture evaporation rates.

3.5 Concrete Protection for Reinforcement

- .1 Ensure reinforcement is placed to provide minimum concrete cover in accordance with **Section 03200 – Concrete Reinforcement**.

3.6 Construction Tolerance

- .1 The Work shall be carefully and accurately set out; true to the positioning, levels, slopes, and dimensions shown on the Drawings and conforming to **Sections 03100 – Concrete Formwork** and **03200 – Concrete Reinforcement**.
 - .1 Sizes of Member or Thickness of Slabs: +6 mm, -0 mm.
 - .2 Cover of Concrete over Reinforcement: ± 3 mm.
 - .3 Variations from Plumb: 6 mm in 3 m, 10 mm maximum.
 - .4 Variations from Flat: 3 mm in 3 m, 6 mm maximum.
- .2 If these tolerances are exceeded the Contractor may, at the discretion of the Contract Administrator, be required to remove and replace or to modify the placed concrete before acceptance. The costs incurred by the Contract Administrator for such investigation, testing, or review of reconstruction and the cost of reconstruction shall be borne by the Contractor.

3.7 Finishing Slab Surfaces

- .1 Finish all slab surfaces conforming to CAN/CSA-A23.1-00, Clause 22 and as specified below.
- .2 Bull Floating
 - .1 Flatness for suspended concrete slabs to be achieved by means of hiway straight edge (minimum 3 m width) in lieu of standard bull float. Immediately after screeding, bull float floor surfaces to remove ridges and fill voids.

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- .2 Complete bull floating before any excess moisture or bleed water is visible on surface.
- .3 Mechanical Floating
 - .1 Mechanical float floor surfaces when bleed water has disappeared and surfaces are sufficiently hard to prevent working excess mortar to surface.
 - .2 Continue floating as necessary to produce surfaces of uniform texture, free from hollows, bumps, and screed marks.
 - .3 For surfaces to be trowelled, continue floating as necessary to embed coarse aggregate particles firmly below surface mortar.
 - .4 Hand float in corners, restricted areas, and around cast-in items.
- .4 Trowelling
 - .1 Trowel floor surfaces with mechanical trowelling machines fitted with steel blades.
 - .2 Commence trowelling when surfaces are sufficiently hard to prevent working excess fine material to surface.
 - .3 Perform additional trowelling at intervals so final trowelling is done just before concrete becomes so hard that further trowelling is ineffective.
 - .4 Finish trowelled surfaces to be hard, dense, and free from blemishes and other imperfections.
 - .5 Hand trowel in corners, restricted areas, and around cast-in items.
 - .6 Cure concrete as specified.
 - .7 Protect all floors from damage during construction.

3.8 Floor Hardener

- .1 Pump Room floor and Valve Chamber floor shall receive floor hardener:
 - .1 Apply non-metallic floor hardener as a shake-on application on concrete slab during the final finishing stage of steel blade trowelling. Shake apply floor hardener at a minimum rate of 7.5 kg/m². Apply the shake mix in two separate applications using approximately two-thirds of the total amount specified for the first application and the balance for the second.
 - .2 Apply hardener evenly over the floor surface in one direction.
 - .3 Machine float just enough to bring moisture completely through the shake and to embed and compact the shake into the base concrete.

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- .4 Immediately following the floating of the first shake apply the balance of the hardener. Spread and shake evenly and in direction perpendicular to the first shake. Float as specified for the first shake.
- .5 Comply with manufacturer's printed instructions for installation and curing.

3.9 Curing and Protection

- .1 Cure and protect freshly placed concrete in accordance with Clause 21 of CAN/CSA-A23.1-00.
- .2 All concrete shall receive moist curing for a period of at least seven (7) days. One (1) of the following methods shall be used as soon as the concrete has hardened sufficiently to prevent marring:
 - .1 Surface covered with canvas or other satisfactory material and kept thoroughly and continuously wet with soaker hoses.
 - .2 A liquid membrane forming curing sealer, applied at the rate recommended by the Manufacturer. Curing sealer shall not be used on a surface where bond is required for the finishes.
 - .3 Surfaces of concrete, which are protected by formwork that is left in place for seven (7) days, shall not require any additional curing (except as specified for hot weather). If the formwork is removed in less than seven (7) days, the concrete shall receive moist curing as above.
- .3 No concreting will be allowed until all materials required for the curing phase are on Site and ready for use.
- .4 At the end of the curing and protection period, the temperature of the concrete shall be reduced gradually at a rate not exceeding 10°C per day until the outside air temperature has been reached.
- .5 Concrete that is allowed to freeze or attain insufficient curing conditions shall be subject to all necessary investigations and testing as deemed necessary by the Contract Administrator and all such concrete shall be removed and the portion reconstructed as directed by the Contract Administrator, at Contractor's cost.
- .6 The supply (both quantity and time of supply) of water for curing concrete shall be subject to control of the City and prior arrangements shall be made by the Contractor with the City for its supply. The Contractor shall be responsible for, at his own cost, to supply, install, maintain, and move extensions to water services as required for conveying water to the work Site. Water required for curing concrete will be supplied by the City, from the Deacon Booster Pumping Station (DBPS).

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3.10 Formed Concrete

- .1 Allow the Contract Administrator to review concrete surfaces immediately upon removal of the forms.
- .2 Modify or replace concrete not conforming to qualities, lines, details, and elevations specified herein or indicated on the Drawings to the acceptance of the Contract Administrator.

3.11 Finishing Formed Surfaces

- .1 Interior formed concrete surfaces.
 - .1 Columns and walls of water retaining structures to receive form liner finish as per **Section 03100 – Concrete Formwork**.
 - .2 Finish surfaces exposed to view surfaces to Smooth-Form Finish conforming to CAN/CSA-A23.1-00, Clause 24.3.6.
 - .3 Finish non-exposed surfaces to Rough-Formed Finish conforming to CAN/CSA-A23.1-00, Clause 24.3.5.
- .2 Exterior formed concrete surfaces.
 - .1 Surfaces to receive vapour barrier, insulation, waterproofing material, or roofing material are to be finished to Smooth-Formed Finish conforming to CAN/CSA-A23.1-00, Clause 24.3.6.
 - .2 Other surfaces to be finished to Rough-Formed Finish conforming to CAN/CSA-A23.1-00, Clause 24.3.5.

3.12 Equipment Pads and Cast in Metal Frames

- .1 Provide concrete pads and supports for equipment where and as indicated on Drawings. Adjust dimensions to reviewed equipment Shop Drawings.
- .2 Insert bolts and sleeves and pack solidly with non-shrink grout, in accordance with setting details and templates.
- .3 Steel trowel surface smooth. Chamfer exposed horizontal and vertical edges.
- .4 Clean excess concrete from metal frames, inserts, weld plates, etc. Clean and tool concrete around the above noted items.

3.13 Grouting

- .1 Grout all miscellaneous anchor bolts with non-ferrous or epoxy grout as specified using templates for accurate positioning.

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- .2 Grout under base plates and other items to provide continuous support over the entire contact area as required and shown on the Drawings.

3.14 Defective Concrete

- .1 Concrete not meeting the requirements of the Specifications and Drawings will be considered defective concrete.
- .2 Concrete not conforming to the lines, details, and grades specified herein or as shown on the Drawings shall be modified or replaced at the Contractor's expense and to the satisfaction of the Contract Administrator. Finished lines, dimensions, and surfaces shall be correct and true within tolerances specified herein and in **Section 03100 – Concrete Formwork**.
- .3 Concrete not properly placed resulting in honeycombing and other defects shall be repaired or replaced at the Contractor's expense and to the satisfaction of the Contract Administrator.

3.15 Patching

- .1 Allow Contract Administrator to review concrete surfaces immediately upon removal of all formwork.
- .2 Remove all exposed metal form ties, nails and wires, break off fins, and remove all loose concrete.
- .3 Any imperfect joints, voids, stone pockets, or other defective areas and tie holes, as specified, shall at once be patched before the concrete is thoroughly dry. Defective areas shall be chipped away to a depth of not less than 40 mm with the edges perpendicular to the surface. The area to be patched and a space at least 150 mm wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar.
- .4 Cure all patches thoroughly in accordance to Manufacturer's instructions.

3.16 Watertightness Testing

- .1 All water retaining structures shall be watertight and all precautions shall be taken, especially joint treatment, to construct watertight structures.
- .2 Notify the Contract Administrator at least two (2) working days before commencing the watertightness test.
- .3 The structures, when full, shall be reviewed over a forty-eight (48) hour period for leakage including monitoring of visible leaks and testing for leaks by measurement. Each compartment or cell shall be tested independently.
- .4 Filling the structures in preparation of the watertightness test shall be performed only after the wall concrete has attained 100% of the design strength and may be performed prior to roof construction. Fill the tanks with clean water forty-eight (48) hours prior to the watertightness test to allow for full saturation of the concrete.

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- .5 The supply (both quantity and time of supply) of water for the watertightness test shall be subject to control of the City and prior arrangements shall be made by the Contractor with the City for its supply. The Contractor shall be responsible for, at his own cost, to supply, install, maintain, and move extensions to water services as required for conveying water to the Work Site. Water required for the watertightness testing will be supplied by the City. Source location and handling requirements will be communicated by the Contract Administrator.
- .6 The Contractor shall measure leakage during next forty-eight (48) hour period. The measurements shall be witnessed by the Contract Administrator. With the water at maximum operating level for forty-eight (48) hours, there shall be no visible moisture or wetness on areas that will be seen or backfilled and the leakage measured over a period of twenty-four (24) hours shall not exceed 0.10% of the water volume in the test period.
- .7 Locate and repair all leaks until all leakage is remedied and repeat the forty-eight (48) hour watertightness test following each repair operation, at no additional cost to the City.
- .8 All water used for retesting shall be supplied by the City as outlined in Paragraph 5 above. Disposal of the water for the initial test and all retests shall be as directed by the Contract Administrator and shall be at the Contractor's expense.

3.17 Construction Joints

- .1 Construction joint locations shall be as shown on the Drawings.
- .2 Joints not indicated on the Drawings shall be located so as to least impair the strength of the structure. The location of these joints shall be subject to prior review and acceptance by the Contract Administrator. Joints shall be in accordance with CAN/CSA-A23.1-00, or as indicated on the Drawings.
- .3 The surface of hardened concrete shall be thoroughly cleaned of foreign matter and laitance by sand blasting, and shall be thoroughly wetted with water, but not saturated, and the forms shall be re-tightened against the face of the hardened concrete before depositing additional concrete. Any concrete splatter on reinforcing bars shall be removed by sand blasting.
- .4 PVC waterstop shall be protected with suitable 12 mm thick protection boards on both sides secured firmly together by mechanical clamps (i.e., c-clamps) or other method acceptable to the Contract Administrator during the sand blast cleaning operations.
- .5 For horizontal construction joints, the concrete shall be thoroughly compacted by hand trowel in and around the reinforcing bars and along the PVC waterstops.

3.18 Clean-Up

- .1 As Work progresses and at the completion of Work, remove from Site all debris, excess materials, and equipment.

END OF SECTION