## SECTION 11 - REINFORCED AND PLAIN CONCRETE WORKS

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11.20 **SCOPE**

.1 This specification refers to reinforced and plain concrete works for the construction of pavements, sidewalks, curbs and gutters, manholes, catchbasins, concrete works associated with the installation of watermains and sewers and other works incidental to municipal services construction.

.2 This specification shall not be used for structural facilities such as buildings, bridges or other structure requiring site specific structural design.

11.21 **CODES AND STANDARDS**

.1 Concrete work shall conform to the following codes and standards:

(a) Local codes and bylaws
(b) Workers' Compensation Board Regulations
(c) NBC
(d) CSA Specification CAN/CSA A23.1 - Concrete Materials and Methods of Concrete Construction, and CAN/CSA A23.2 - Methods of Tests for Concrete
(e) ACI Standards
(f) AASHTO *(REVISED NOVEMBER 2016)*

.2 The codes and standards shall take precedence and govern in the order shown, unless otherwise specified.

.3 The concrete supplier's plant, equipment and materials, used for production of concrete, shall comply with the requirements of CAN/CSA A23.1 and be certified by a Professional Engineer.

.4 Selected concrete mix proportions shall be certified by a Professional Engineer to produce concrete of specified quality, durability, yield and strength complying with CAN/CSA A23.1.

11.22 **FORM RELEASE AGENT**

.1 Form release agent shall be approved by the Engineer prior to use and shall be a non-staining, mineral type, with chemically active release agents containing compounds that react with free lime to produce water soluble soap.

11.23 **SUPPORTS, CHAIRS AND SPACERS**

.1 Bolsters, supports, chairs and spacers shall conform to CAN/CSA A23.1.

11.24 **REINFORCEMENT**

.1 Reinforcing steel shall be intermediate grade billet steel conforming to CSA G30.18 Grade 400 unless otherwise specified on the construction drawings.

.2 Reinforcing weldable low alloy steel deformed bars shall conform to CSA G30.18.

.3 Cold drawn annealed steel wire ties shall conform to CSA G30.3.
.4 Deformed steel wire shall conform to CSA G30.14.
.5 Welded steel wire fabric shall conform to CSA G30.5.
.6 Welded deformed steel wire fabric shall conform to CSA G30.15, and supplied in flat sheets only.
.7 Epoxy coating of non-prestressed reinforcement shall conform to ASTM A775 and A775M.
.8 Galvanizing of non-prestressed reinforcement shall conform to CSA G164 with a minimum zinc coating of 610 g/m².

11.25 FORMS
.1 All forms shall conform to CAN/CSA A23.1 and shall be free of surface defects for all concrete faces exposed to view. *(REVISED NOVEMBER 2016)*
.2 Form ties shall be metal and of the type such that no metal is left within 25mm from the concrete surface when the forms are removed.

11.26 PREMOULDED JOINT FILLER
.1 Premoulded joint fillers shall be bituminous impregnated fiber board in accordance with ASTM D1751.

11.27 CEMENT
.1 Cement shall conform to CAN/CSA A3000. *(REVISED NOVEMBER 2016)*
.2 Cement shall be Type 10 Portland cement for all concrete work.
.3 Other types of cement will only be permitted with the Engineer's approval.

11.28 AGGREGATE
.1 Aggregates shall consist of crushed stone, gravel or natural sand in conformance with CAN/CSA A23.1.

The maximum size of aggregate shall not exceed the following limits:

(a) 40mm for footings.
(b) 13mm for concrete patching and grout.
(c) 20mm for other concrete work.
11.29 MIXING AND CURING WATER

.1 Mixing and curing water shall conform to CAN/CSA A23.1.

11.30 ADMIXTURES

.1 Admixtures other than air-entraining admixtures and water-reducing admixtures shall not be added unless authorized by the Engineer.

.2 Air-entraining and water reducing admixtures shall conform to CAN/CSA A266.1 and A266.2.

11.31 CONCRETE

Concrete shall meet the following minimum requirements except for concrete used for curbs and sidewalks, and stairways which shall be as specified in Section 8.21 Curb and Sidewalk Concrete.

.1 Compressive Strength:

As specified in Tables 1 and 2 of CSA A23.1 for exterior walls and columns. Concrete shall develop a minimum compressive strength of 25 MPa at 28 days. (REVISED NOVEMBER 2016)

.2 Slump:

(a) Slump shall be maintained at the minimum possible while permitting efficient placing and providing an homogeneous mass.

(b) Maximum slumps shall be as indicated in CAN/CSA A23.1

.3 Temperature:

(a) Concrete when placed shall be at least 10°C, but shall not exceed 25°C.

.4 Entrained Air:

(a) Entrained air shall be 5% + 1% by volume. All concrete, except that used for plain, interior concrete slabs, shall contain entrained air.

.5 Grout:

(a) Grout shall be approved by the Engineer.

(b) Grout shall be used in accordance with the manufacturer's recommendations.
(c) Grout shall be prepared from the constituent materials in the following proportions:

<table>
<thead>
<tr>
<th>Material</th>
<th>Proportion</th>
</tr>
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<tbody>
<tr>
<td>Cement</td>
<td>1 part</td>
</tr>
<tr>
<td>Sand</td>
<td>2-1/2 parts</td>
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<tr>
<td>Admixture</td>
<td>0.45kg per sac</td>
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<tr>
<td></td>
<td>of cement shall</td>
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<tr>
<td></td>
<td>be used to reduce</td>
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<tr>
<td></td>
<td>grout shrinkage</td>
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<tr>
<td></td>
<td>and improve bond</td>
</tr>
<tr>
<td></td>
<td>strength.</td>
</tr>
<tr>
<td>Water</td>
<td>Minimum mixing</td>
</tr>
<tr>
<td></td>
<td>water shall be</td>
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<td></td>
<td>used to obtain</td>
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<tr>
<td></td>
<td>desired</td>
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<tr>
<td></td>
<td>workability and</td>
</tr>
<tr>
<td></td>
<td>flowability.</td>
</tr>
<tr>
<td></td>
<td>If dry pack</td>
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<tr>
<td></td>
<td>grout is desired,</td>
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<td></td>
<td>sufficient water</td>
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<tr>
<td></td>
<td>shall be used</td>
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<tr>
<td></td>
<td>to pack by ramming.</td>
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<tr>
<td></td>
<td>A minimum of 15</td>
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<td></td>
<td>litres per 40kg</td>
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<tr>
<td></td>
<td>sack of cement</td>
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<tr>
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<td>shall be used.</td>
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11.32 CONCRETE ACCESSORIES

.1 All concrete accessories shall be as indicated on the drawings or as approved in writing by the Engineer.
11.40 GENERAL

.1 Install reinforced and plain concrete works, including surface tolerances, finishing and field quality control in accordance with CAN/CSA A23.1 except where specifically stated otherwise.

11.41 NOTIFICATION TO THE ENGINEER

.1 The Engineer shall be given twenty-four (24) hours notice in advance of placing concrete by the Contractor.

11.42 CONCRETE TESTING

.1 The Engineer will arrange for a CSA certified testing firm to carry out tests to determine whether the applicable standards and specifications have been met. Where initial testing indicates non-compliance with the specifications additional testing shall be required at the contractor’s expense.

.2 The Contractor as directed by the Engineer shall supply specimens or samples for testing.

.3 Concrete samples shall be taken in conformance with CAN/CSA23.2. Cure cylinders on the job site under the same conditions as the concrete they represent.

.4 The types of tests listed below are the minimum testing requirements. The Engineer shall determine if additional testing is required.

(a) Compressive Strength Test:

(i) Compressive strength shall be determined from compression tests performed in conformance with CAN/CSA23.2.

(ii) One strength test shall consist of 3 - 150mm x 300mm cylinders; one tested at 7 days, 2 tested at 28 days.

(iii) At least one strength test shall be made from each 20 cubic metres of concrete placed, with a minimum of one test for each pour of a specified concrete strength placed each day.

(iv) The average of all 28-day strength tests shall exceed the specified strength. When 3 or more tests of the same class of concrete are available, the average of any 3 consecutive tests shall be equal to or greater than the specified strength. No strength test shall fall below 85% of the specified strength.

(b) Slump Test:

(i) Slump tests shall be made in conformance with CAN/CSA A23.2.

(ii) At least one slump test shall be made for each strength test.

(iii) The slump test is not required for machine extruded concrete using a no-slump mix design.
(c) Air Content Test:
   (i) Air content tests shall be made in conformance with CAN/CSA A23.2.
   (ii) At least one air content test shall be made for each strength test.

(d) Temperature:
   (i) Temperature measurement shall be made for each strength test.

.5 All concrete trucks shall supply a copy of the delivery slip to the Engineer containing the following information:

   (a) Minimum Compressive Strength
   (b) Maximum Slump
   (c) Air Content by Percent of Volume
   (d) Batch Time
   (e) Maximum Size of Aggregate
   (f) List of Admixtures
   (g) Date
   (h) Name of Supplier

.6 Inspection and testing by the Engineer shall not relieve the contractor of his responsibility for quality control.

.7 Concrete found to be in non-compliance with these specifications, shall be repaired or replaced by the Contractor at no additional cost to the Owner. The Contractor shall submit to the Engineer for approval, his proposed method to correct the noted deficiencies, prior to commencing the work.

11.43 FORMWORK

.1 Forms shall be so constructed that the finished concrete will conform to the shape, dimensions and finish specified.

.2 Forms shall be constructed in conformance with the WorkSafeBC regulations.

.3 Forms and falsework shall be built sufficiently strong and rigid to maintain correct alignment and elevation and retain concrete pressures without deflection. Forms shall be sufficiently tight to prevent leakage of concrete.

.4 Forms shall be treated with form release agent prior to placing of reinforcement.

.5 Forms for surfaces which are to receive a plaster finish shall not be treated with form release agent.

.6 Forms shall not be stripped until concrete has attained sufficient strength to support safely its own weight and all loads to which it may be subjected.

.7 Forms shall be removed without damaging the concrete.
11.44 HOOKS AND BENDS IN REINFORCEMENT

.1 Fabrication of hooks and bends in reinforcing steel shall be in accordance with CAN/CSA A23.1.

.2 Bars shall be cold bent, unless otherwise authorized by the Engineer. Bars that are partially embedded in concrete shall not be field bent unless shown on the drawings or authorized by the Engineer.

.3 Replace bars which develop cracks or splits.

11.45 CLEANING REINFORCEMENT

.1 Bars shall be free from loose rust, mud, oil or other bond-reducing coating.

.2 Bars shall, if necessary, be recleaned prior to resumption of pouring if concrete placing is delayed during the course of a pour.

.3 Touch up damaged parts and cut ends of epoxy coated or galvanized reinforcing steel with compatible finish to provide continuous coating.

11.46 PLACING REINFORCEMENT

.1 Fabricate reinforcing steel in accordance with CAN/CSA A23.1, ANSI/ACI 315 and 315R. Upon approval by the Engineer weld reinforcement in accordance with CSA W186.

.2 Reinforcement shall be placed accurately and securely supported by chairs, spacers and ties in accordance with the construction drawings.

11.47 SPLICES

.1 Bars shall be spliced only where shown on the construction drawings or as authorized by the Engineer. Splicing shall be carried out in conformance with CAN/CSAA23.1.

.2 Welding of reinforcement, where authorized by the Engineer, shall conform to CSA W186.

11.48 COVER FOR REINFORCEMENT

.1 Supports, chairs and spacers shall be provided to ensure the specified cover.

.2 A minimum of 75mm of cover for reinforcement shall be provided for concrete placed against the ground.

.3 For surfaces to be exposed to the weather or in contact with the ground after removal of forms, the concrete cover shall be at least 50mm.

.4 A minimum of 20mm concrete cover shall be provided for surfaces not exposed to earth or weather:
11.50 CONSTRUCTION JOINTS

.1 Construction joints not shown on the drawings shall be approved by the Engineer prior to construction of formwork and placement of reinforcement. The interface between concrete pours is classified as a construction joint if fresh concrete cannot be incorporated integrally by vibration with that previously placed.

.2 Joints shall be perpendicular to main steel.

.3 Reinforcing steel and/or welded wire fabric shall be continuous across joints.

.4 Before placing new concrete on hardened concrete, forms shall be re-tightened, the surface of concrete adequately roughened, laitance removed and the surface saturated with water in advance of concreting.

.5 Joint preparation and installation of jointing materials shall be in accordance with the manufacturer's instructions.

.6 Furnish filler for each joint in a single piece for the depth and width required for the joint, unless authorized by the Engineer. When more than one piece is authorized for a joint, fasten abutting ends and hold securely to shape by stapling or other positive fastening methods.

11.51 SLEEVES AND OPENINGS

.1 Pipes, castings or conduits passing through walls or floors shall, wherever possible, be placed in forms before pouring concrete. Boxes may be built into forms to make form openings for subsequent insertion of such items only with the Engineer's approval.

.2 Continuous keyways shall be provided throughout the perimeter of the opening and shall be flared slightly to facilitate the escape of entrapped air during grouting.

11.52 EMBEDDED ITEMS

.1 Items that are to be embedded in concrete shall be properly set, held, leveled and aligned in forms.

.2 Anchor bolts or other inserts shall be accurately set, held, leveled and aligned using templates.

.3 Suitable nailing blocks, plugs, strips and other items required for attachment of architectural trim and finish shall be placed such that there is no visible distortion or defacement of the completed installation.
11.53 COLD WEATHER REQUIREMENTS

.1 Procedures used for the protection of concrete and concreting operations during cold weather shall conform to the requirements specified in CAN/CSAA23.1.

11.54 HOT WEATHER REQUIREMENTS

.1 Procedures used for the protection of concrete and concreting operations during hot weather shall conform to the requirements specified in CAN/CSAA23.1.

11.55 MIXING, PLACING AND COMPACTING

.1 Prior to placing concrete, obtain Engineer's approval of reinforcing material and placement.

.2 Mixing, placing and compacting of concrete shall conform to CAN/CSA A23.1 and to the approval of the Engineer.

.3 Pumping of concrete shall require approval by the Engineer.

.4 Placement and compacting of concrete shall not disturb reinforcement and inserts.

.5 The Engineer, shall maintain accurate records of poured concrete to indicate date, location of pour, quality, air temperature and test samples taken.

11.56 SCREEDING

.1 Suitable wood or metal screed strips shall be placed and aligned to the contours of the slab. The slab shall be screeded with compacting type screeds or strike-off templates with a sawing motion on screed strips. Power screeds shall be used wherever possible.

11.57 TYPES OF FINISHES AND TOLERANCES

.1 Float Finish:

Surfaces receiving a wood float finish shall be screeded in conformance with CAN/CSA A23.1 and then the concrete surface shall be worked with a long-handled darby or float to remove high spots and ridges and to fill voids and hollows left in the concrete surface by screeding.

.2 Broom Finish:

After float finishing, surfaces to be broom-finished shall be slightly roughed by light brooming with a stiff brush or broom to a uniform non-skid surface to the satisfaction of the Engineer. Finished surfaces shall be true in all planes within 8mm in 3.0m as determined by a 3.0m straightedge placed anywhere on the concrete.
.3 Trowel Finish:

After float finishing, surfaces to be trowel-finished shall be power-trowelled and finally hand-trowelled once the surface has hardened sufficiently. Finished surfaces shall be true in all planes within 5mm in 3.0m as determined by a 3.0m straightedge placed anywhere on the slab. The surface shall have a smooth, even, dense texture free from blemishes.

.4 Common Finish:

For a common finish formed surfaces shall have fins and protrusions exceeding 5mm ground off. Honeycombed or defective concrete shall be removed to sound concrete, an approved bonding agent applied and patched with mortar of cement and sand mixed in the same proportions as the concrete patches. Damp burlap curing shall be applied. Tieholes shall be cut back 25mm from the face and filled.

.5 Rubbed Finish:

(a) Forms shall be removed and any necessary patching completed as soon as possible after placement of the concrete without damage to the structure. The rubbed finish shall be undertaken when the surfaces are completed and accessible.

(b) The concrete surfaces shall be thoroughly saturated with water and maintained wet for at least one hour before finishing operations are begun. All free water on the surface shall be removed prior to the application of the finishing mortar.

(c) The mortar shall consist of one part cement and two parts sand (passing a 1.18mm sieve) by volume. The mortar shall be preshrunk by mixing at least one hour before it is used and then remixed without the addition of water prior to its use.

(d) The sand and cement shall be the same materials as those used in the concrete.

(e) The mortar shall be rubbed thoroughly over sections of the prepared concrete surfaces with clean burlap pads or other suitable materials so that all surface voids are filled. While the application mortar is still plastic, the surfaces shall be rubbed with the sack pads using a mixture of mortar of the same proportions as previously specified, except that no mixing water shall be used. The final rubbing shall be performed in such a manner that the filled voids are left flush with the surface of the surrounding concrete.

(f) On exposed form surfaces, it may be necessary to blend white cement with the job cement in order to obtain a finish colour that will match the surrounding concrete surfaces. Trial batches of mortar should be made prior to application on the job surface to determine the correct mix proportions to be used.

(g) The finished surface shall be cured continuously in accordance with CAN/CSA A23.1.
11.58 **SURFACE FINISHING**

.1 Unformed surfaces not exposed to view shall receive a float finish.

.2 Unformed surfaces exposed to view, or receiving a floor covering, shall receive a trowel finish.

.3 Sidewalks shall receive a uniform broom finish in accordance with Section 8.51 – Curb and Sidewalk Edging and Finishing.

.4 Formed surfaces not exposed to view shall receive a common finish.

.5 Formed surfaces exposed to view shall receive a rubbed finish.

.6 Surface finishing may be noted on the drawings or, if not clear, shall be as directed by the Engineer.

11.59 **PROTECTION**

.1 Freshly placed concrete shall be protected from damage caused by weather, construction operations and vandalism.

11.60 **CURING**

.1 Concrete curing procedures shall take into account weather and temperature conditions.

.2 Concrete surfaces shall be kept moist by continuous light sprinkling, ponding, a wet absorptive cover such as sand, sawdust, or fabric or by sealing the surface with a waterproof barrier, adequately lapped and sealed with waterproof tape.

.3 Moist curing shall commence immediately following the final set and shall continue uninterrupted for at least 7 days.

.4 Curing compounds shall not be used unless expressly authorized by the Engineer.

.5 Do not place load on the new concrete until authorized by the Engineer.