

**Part 1            General**

**1.1                DESCRIPTION**

- .1            This section specifies requirements for concrete formwork, falsework and their accessories for concrete construction.
- .2            The Work includes design, construction, erection and removal of concrete formwork, falsework and accessories.

**1.2                RELATED WORK**

- .1            Concrete Reinforcement - Section 03 20 00
- .2            Cast-In-place Concrete - Section 03 30 00

**1.3                REFERENCE STANDARDS**

- .1            Concrete Materials and Methods of Concrete Construction - CSA-A23.1
- .2            Methods of Test for Concrete - CSA-A23.2.
- .3            ACI Detailing Manual - ACI 315-80
- .4            Falsework for Construction Purposes - CSA-S269.1.

**1.4                DESIGN**

- .1            Design of concrete formwork and falsework are the responsibility of the Contractor.

**1.5                SUBMITTALS**

- .1            Submittals shall be in accordance with Section 01 33 00 Submittals.
- .2            Submit shop drawings of proposed formwork and/or falsework for review if requested.
- .3            Show material sizes and grades, and spacing of members.
- .4            Indicate rate and sequence of concrete placing used in design of formwork.
- .5            Shop drawings shall bear the stamp of a qualified Professional Contract Administrator registered in Manitoba.
- .6            Submit for review shoring and reshoring provisions, and removal schedules.
- .7            Submit for review proposed curing procedures.
- .8            Submit for review proposed hoarding and heating methods for cold weather concreting.

**Part 2 Products**

**2.1 FORMS**

- .1 Use material of suitable strength and quality to produce the specified surface finish.
- .2 Use forms which are watertight, unwarped, non-absorbent and non-staining.
- .3 Formwork lumber: Plywood and wood formwork materials to CAN/CSA-A23.1 latest edition.
- .4 False work materials: To S269.1, Table 1- Materials shall bear grade marks, or be accompanied with certificates, test reports or other proof of conformity.

**2.2 FORM TIES**

- .1 Use only ties with ends removable to a distance of not less than 38 mm from the face of the finished concrete.
- .2 Form ties with a removable cone cast in the concrete shall produce a cone hole not more than 25 mm in diameter.
- .3 Through bolts shall not be acceptable.
- .4 No form ties allowed for circular column forms. Use external clamps and internal concrete spacers.

**2.3 FORM RELEASEAGENT**

- .1 Chemically reactive release agents containing compounds that react with frelime present in condition to provide water insoluble soaps, preventing set of film of concrete in contact with form.

**Part 3 Execution**

**3.1 INSPECTION**

- .1 Notify the Contract Administrator to permit inspection of formwork at least 72 hours before concreting. Inspection by Contract Administrator of formwork shall be for conformance to project specifications, but not for structural strength and stability, which is the sole responsibility of the Contractor.

**3.2 CONSTRUCTION AND CONTRACTION JOINT LAYOUTS**

- .1 Construction and contraction joints shall be constructed where required as shown on the plans, as specified and/or according to CSA-A23.1. The Contractor shall prepare and submit for approval, a location diagram and proposed details for all planned construction joints, and for layout of construction and contraction joints in slabs on grade, sidewalks and other concrete paved areas.
- .2 Construction joints shall be approved by the Contract Administrator.
- .3 Clean all construction joint surfaces which will be inaccessible after the erection of formwork.
- .4 Construct falsework to CSA S269.1.

### **3.3 FORMS**

- .1 Assemble and erect in accordance with the formwork design.
- .2 Allow for deflection of the formwork due to the weight of concrete.
- .3 Make all form joints watertight.
- .4 Make form surfaces smooth and flat.
- .5 Clean forms properly before assembling in position, and as necessary before concreting.
- .6 Oil or coat forms before assembly in final position.
- .7 Provide 20 mm chamfer at all exposed exterior corners with interior angle of 120 degrees or less.
- .8 Provide access for cleaning prior to concreting.
- .9 Do not use temporary removable spacers or blocks to support reinforcement or other items unless approved by the Contract Administrator.
- .10 Finished concrete exhibiting evidence of excessive form displacement, and/or excessive deflection shall be cause for rejection of the work and its removal and replacement at the Contractors own expense.
- .11 Obtain Contract Administrator's approval before framing openings not indicated on drawings.

### **3.4 TOLERANCES**

- .1 Construct formwork to maintain the tolerances of concrete work in Clause 10 of CSA-A23.1.
- .2 Provide cambers to beam and slab forms as indicated on the drawings, as directed, or in accordance with the following:
- .3 Beams - 5 mm per 3000 mm of span
- .4 Slabs - 8 mm per 3000 mm of span

### **3.5 PLACING OF CONCRETE AND GROUT INJECTION**

- .1 Make a final inspection and ensure that forms are satisfactory and no deleterious materials are present inside the area to be concreted.
- .2 Observe forms during concreting or grout injection operations and correct any displacement of the form.

### **3.6 FORM REMOVAL**

- .1 Remove forms so that no damage occurs to the concrete.
- .2 Consider the location, character of the structure, weather and other conditions influencing the curing of concrete, in determining the time for removal of forms. (Refer to Section 03 30 00 - Cast-In-Place Concrete and CSA-A23.1).

- .3 Leave shores in place until concrete has attained sufficient strength to adequately support its own weight together with construction loads likely to be imposed.
- .4 In accordance with clause 3.6.3, leave formwork in place for the following minimum periods of time after placing concrete:
  - .1 3 days for walls
  - .2 3 days for columns
  - .3 14 days for beam soffits, slabs, decks and other structural members or at least until concrete has attained 2/3 of the specified 28 day strength, or to the Contract Administrators approval
- .5 Re-use of formwork and falsework subject to requirements of CSA-A23.1.

**END OF SECTION**

**Part 1            General**

**1.1                DESCRIPTION**

- .1            This section specifies requirements for the supply, fabrication and placing of reinforcing steel, including necessary supports, spacers, and related accessories.

**1.2                RELATED WORK**

- .1            Concrete Formwork and Accessories - Section 03 10 00
- .2            Cast-In-Place Concrete – Section 03 30 00

**1.3                REFERENCE STANDARDS**

- .1            Concrete Materials and Methods of Concrete Construction CSA-A23.1.
- .2            Billet-Steel Bars for Concrete Reinforcement - CSA-G30.18.
- .3            Welded Steel Wire Fabric for Concrete Reinforcement - ASTM A185 / A185M-07.
- .4            ACI Detailing Manual - ACI 315.80.
- .5            CRSI Manual of Standard Practice.

**1.4                SUBMITTALS**

- .1            Submit shop drawings in accordance with Section 01 33 00 - Submittals, at least 10 days before fabrication.
- .2            Submit bending schedules and placing drawings.
- .3            Show bar size, spacing, location and quantities to permit correct placement without reference to structural drawings.
- .4            Provide details to show placement of reinforcing where special conditions occur.
- .5            Details shall be in accordance with ACI 315.
- .6            Submit certificates and mill tests for the material supplied as requested by the Contract Administrator.
- .7            Design and detail lap lengths and bar development lengths to CSA A23.3 M94, Unless otherwise indicated.

**1.5                PRODUCT DELIVERY, STORAGE AND HANDLING**

- .1            Ship bar reinforcement in standard bundles, easily identifiable and marked in accordance with the bar lists.
- .2            Store reinforcement to prevent deterioration or contamination by dirt, detrimental rust, loose scale, paint, oil or other foreign substances that will destroy or reduce bond.

- .3 Do not straighten or rebend reinforcement in any manner.
- .4 Do not use bars kinked or bent by improper handling or storage.

**Part 2 Products**

**2.1 REINFORCING STEEL**

- .1 Reinforcing steel to meet CSA-G30.18 as shown on drawings. Steel grade to be 400 MPa.
- .2 Welded wire fabric shall be welded galvanized steel of 51mm x 51mm, MW5.5xMW5.5, and shall conform to CSA G30.5. Galvanizing shall conform to CAN/CSA G164.

**2.2 CHAIRS, BOLSTERS, BAR SUPPORTS, SPACERS**

- .1 Provide adequate support of reinforcement (according to CRSI Manual of Standard Practice).
- .2 For exposed or architectural concrete surfaces use accessories which are plastic coated, stainless steel or as indicated on the drawings.
- .3 Precast concrete block supports must be equal in strength and quality to the concrete in the structure.
- .4 Chairs, bolster bar supports and spacers shall have sufficient strength to support the reinforcing under normal construction conditions. Brick shall not be used for bar supports.

**2.3 FABRICATION**

- .1 Fabricate reinforcing steel from bar sizes and grades indicated within the following tolerances:
  - .1 Sheared length: plus or minus 25 mm.
  - .2 Stirrups, ties: plus or minus 13 mm.
  - .3 Location of bends: plus or minus 25 mm.
- .2 Unless otherwise indicated, fabricate in accordance with CSA-A23.1.
- .3 Obtain Contract Administrator's approval for location of reinforcing splices other than as shown on reinforcing steel placing drawings.

**Part 3 Execution**

**3.1 INSPECTION**

- .1 Notify Contract Administrator to permit inspection after placement is completed. Reinforcing for all concrete pours shall be inspected after placing and prior to concreting.
- .2 Provide adequate notice of scheduled pours to facilitate inspection of reinforcement (minimum of 72 hours).

**3.2 PLACING OF REINFORCEMENT**

- .1 Place reinforcement as shown on the reviewed shop drawings and in accordance with CSA-A23.1.

- .2 Support reinforcement in position as follows:
  - .1 Beams, walls, and columns - laterally support reinforcement with supports in pairs on opposite faces.
  - .2 Do not use supports which will be forced into the supporting formwork or soil by the weight of the reinforcement or other construction loads.
  - .3 Separate layers of bars by precast mortar blocks, bars or equally suitable devices. Do not use pebbles, pieces of broken stone or brick, metal pipe or wooden blocks.
  - .4 The welded steel wire fabric shall be securely fastened to the exposed reinforcing steel by ties placed at not more than a 300mm square grid.

Inserts shall be used to fastening the existing reinforcing steel to the existing concrete when the reinforcing steel is not capable of providing rigid support for the wire fabric.

Where there is no existing reinforcing steel, the wire fabric shall be anchored to the concrete with inserts placed at not more than a 300mm square grid. The minimum clearance between the wire fabric and the existing concrete shall be 20mm.

Each installed insert shall resist a pull-out force of at least 1kN.

- .5 Do not place bars on layers of fresh concrete as the work progresses or install bars during placing of concrete.
- .3 Provide concrete cover as detailed on the drawings.

### **3.3 WELDING OF REINFORCEMENT**

- .1 Welding of reinforcing bars is not permitted.

### **3.4 SPLICING OF REINFORCEMENT**

- .1 Splice bars only as shown on the drawings or approved by the Contract Administrator.
- .2 Bar splices shall conform to CSA3-A23.3, Type B, unless noted.
- .3 Lap adjacent sheets of wire fabric to provide an overlap of at least one cross wire spacing plus 50 mm, measured between outermost cross wires of each sheet.

### **3.5 DETAILS**

- .1 Corner Bars: Install corners bars in walls and beams to match the larger size of normal reinforcement unless otherwise noted on the drawings.
- .2 Openings in slabs or walls: Unless otherwise noted on drawings, install 2 additional 20 M bars on all sides of every opening, one near each concrete face or the number of bars intercepted, divided equally between the two sides, whichever is greater. Bars to extend one lap length past each side of the opening.

**END OF SECTION**

**Part 1            General**

**1.1                SECTION INCLUDES**

- .1            This section specifies requirements for design and preparation of the concrete mix, handling, placing, finishing and curing of cast-in-place concrete.

**1.2                RELATED WORK**

- .1            Concrete Formwork and Accessories - Section 03 10 00
- .2            Concrete Reinforcement - Section 03 20 00

**1.3                REFERENCE STANDARDS**

- .1            Concrete Materials and Methods of Concrete Construction - CSA-A23.1.
- .2            Methods of Test for Concrete - CSA-A23.2.
- .3            Portland Cement - CSA-A3000.
- .4            Supplementary Cementing Materials - CSA-A3000.
- .5            Chemical Admixtures for Concrete - CSA-A266.2.
- .6            Air-Entraining Admixtures for Concrete - CSA-A266.1.
- .7            Have available on-site one copy of CSA-A23.1 and CSA-A23.2. These shall form the basis for acceptable standards of concrete practice and methods.

**1.4                SUBMITTALS**

- .1            Mix Design Statement
  - .1            For each type of concrete used, the Contractor shall provide the Contract Administrator with a Mix Design Performance Record, certifying the constituent materials and mix proportions that will be used in the Portland Cement Concrete. The Contractor shall include, in the certification, the following information:
  - .2            List the product name and source of all proposed constituent materials of the concrete including cement, coarse aggregate, fine aggregate, water, water reducing agent, and air entraining admixture. A statement is required indicating that the constituent materials proposed for each mix design are compatible with each other, thereby providing concrete with good long-term durability capabilities.
  - .3            Supply recent records of each mix design for concrete quality control tests including slump, total air content, and 7 and 28-day compressive strengths. The Contractor shall supply reasonable evidence that the mix designs submitted will produce concrete with the specified strength, workability and yield.
  - .4            When previously satisfactory strength data on the proposed mix is not available, the Contract Administrator may request the preparation of field trial batches in order that the concrete be tested prior to construction. Such field trial batches shall be carried out in similar conditions and using similar equipment, batching, and mixing procedures as will be used in the actual construction. The number of trial batches required shall be



- determined by the Contract Administrator and shall depend on the class of concrete materials.
- .5 Supply recent test information, on coarse aggregates of water absorption and abrasion.
  - .6 Supply recent information, if available on aggregate alkali-silica reactivity.
  - .7 Supply recent information on tests performed on Portland Cement, fly ash and silica fume.
  - .8 Supply other information deemed applicable.
- .2 The Contractor shall perform the following test and submit the results to the Contract Administrator prior to the start of construction.
- .1 Determine the gradation of fine and coarse aggregates in accordance with CSA Test Method A23.2-2A. Results shall be within acceptable limits specified herein.
  - .2 The Contractor shall submit test data showing that the Contractor's proportioning and mixing equipment, procedures and concrete mix constituent materials are capable of producing a satisfactory air-void system in the hardened concrete. Prior to Site mobilization, the Contractor shall prepare and cast representative test specimens of each type of concrete using the same proportioning and mixing equipment and procedures, and the same concrete admixtures as will be employed for the supply and placement of each type of structural concrete.
  - .3 The cost for batching, casting, and testing trial batch specimens shall be incidental to the Supply and Placement of Structural Concrete. No measurement or separate payment will be made for this work.
  - .4 The Mix Design Statement shall be submitted to the Contract Administrator at least twenty-one (21) days prior to the delivery of any concrete to the Site. Once accepted by the Contract Administrator, all concrete shall be supplied in accordance with this Statement, which shall be called the Job Mix Formula.
  - .5 No changes in the job mix formula will be permitted without following the above procedure.

## **1.5 QUALITY CONTROL TESTING**

- .1 The Contractor will retain and pay for the services of an independent testing agency for testing as follows.
- .2 Allow for casual labour and expenses in conjunction with testing.
- .3 Concrete Cylinder tests:
  - .1 At least one set of 3 cylinders will be made for each days concreting or for each 50 cubic metres of concrete placed, for each type of concrete mix.
  - .2 Cylinders shall be taken at the point of deposit of the concrete.
  - .3 For each test slump and air content will be taken and 3 standard cylinders will be prepared and cured under laboratory conditions.
  - .4 One cylinder from each test will be broken at 7 days and the remaining cylinders at 28 days.
  - .5 When temperatures are below 5°C additional field cured cylinders will be prepared to verify that adequate strength is attained.
- .4 Test results shall be delivered directly from the test laboratory to the Contract Administrator and to the Contractor.
- .5 Test reports shall include:

- .1 project name
  - .2 date and time of sampling
  - .3 supplier, truck and departure time
  - .4 specified strength and admixtures
  - .5 cement type
  - .6 exact location in structure
  - .7 slump and air content
  - .8 maximum aggregate size
  - .9 test strength and age at time of test
  - .10 date cylinder received by lab
  - .11 testing technician identification
  - .12 weather and temperature information.
- .6 If any tests reveal concrete not meeting Specifications, the Contract Administrator may enforce one or more remedial procedures such as:
- .1 change in mix design
  - .2 change in concrete supplier
  - .3 additional testing by coring or impact hammer
  - .4 replacement of work
  - .5 other procedures as necessary
- .7 The costs of remedial work to bring concrete to meet specifications shall be borne by the Contractor.
- .8 Refer to Section 01 45 00 - Quality Control.

## **1.6 QUALITY ASSURANCE TESTING**

- .1 The City of Winnipeg may retain and pay for the services of an independent testing agency for testing for quality assurance for the City of Winnipeg's purposes.

## **1.7 PRODUCT DELIVERY, STORAGE AND HANDLING**

- .1 Store all material in accordance with CSA-A23.1, Storage of Materials, except as otherwise noted.
- .2 Store each shipment of cement separately to provide access to identification and inspection of each shipment.
- .3 Clean stockpile areas of foreign materials.
- .4 Do not use stockpiled material within 150 mm of the ground surface if the stockpile is placed directly on the ground.

## **Part 2 Products**

### **2.1 CEMENT**

- .1 Conform to CSA-A3000 Portland Cement.
- .2 Type to be as specified on the drawings.

**2.2 WATER**

- .1 Potable.

**2.3 FINE AND COARSE AGGREGATES**

- .1 Conforming to CSA-A23.1.

**2.4 AIR-ENTRAINING ADMIXTURES**

- .1 Air entrainment to CSA-A266.1.
- .2 No other air entraining mixture shall be used regardless of the type of cement selected, unless approved by the Contract Administrator.

**2.5 CHEMICAL ADMIXTURES**

- .1 Conforming to CSA-A266.2.
- .2 Use only as approved by the Contract Administrator.

**2.6 VAPOUR BARRIER**

- .1 0.15 mm polyethylene with 150 mm laps taped and sealed, where shown on the drawings.

**2.7 POZZOLANIC MINERAL ADMIXTURES**

- .1 Conforming to CSA-A3000.
- .2 Use only as approved by the Contract Administrator.

**2.8 FLY ASH**

- .1 Fly ash may be used as detailed on the drawings.

**2.9 CONCRETE CURING COMPOUND**

- .1 Chlorinated rubber type compound conforming to CSA-A23.1, Type 1.
- .2 On coloured floors, wax-free curing and sealing compound "Floor Coat" as manufactured by Master Builders Co. Ltd., or approved equivalent alternate.
- .3 Where topping or waterproofing is to be applied, ensure adequate surface preparation of the concrete for proper bonding. (Clause 21, CSA-A23.1)

**2.10 SELF COMPACTING CONCRETE (SCC)**

- .1 Sikacrete~08SCC as manufactured by Sika Canada. Add Sika Ferrogard 901 corrosion inhibitor into SCC mix.
- .2 Use self-compaction concrete for column restoration work.

## **2.11 CONCRETE MIX REQUIREMENTS**

- .1 Concrete mix requirements shall be as shown on the drawings.

## **2.12 SLURRY COAT**

- .1 Slurry coat mix to be 2 parts sand, 1 part cement and 1 part water.

## **2.13 MIXING**

- .1 Ready-mixed concrete:
  - .1 Mix premixed or Transit-mixed concrete according to CSA-A23.1 and to ASTM-C94.
  - .2 Ensure that the concrete supplier has sufficient plant capacity and transporting apparatus to provide delivery so that the interval between successive loads does not exceed 15 minutes.
- .2 Site-Mixed Concrete shall be in accordance with CSA-A23.1-M77.

## **Part 3 Execution**

### **3.1 INSPECTION**

- .1 The Contract Administrator will inspect forms, foundations, reinforcing steel, construction joints, mixing, conveying and placing equipment before concreting.

### **3.2 PREPARATION**

- .1 Do not place concrete on soil that has been softened by mechanical disturbance or moisture.
- .2 Retighten forms at construction joints.
- .3 Roughen, thoroughly remove foreign matter and laitance, and saturate the hardened concrete at construction joints with water prior to concreting.
- .4 Make suitable arrangements to prevent damage to fresh concrete by adverse weather conditions, such as rain, wind or extreme temperatures.
- .5 Concrete shall not be poured against frozen ground, frozen concrete or into frosted formwork.
- .6 Prepare all sleeves and ducts to be cast into concrete at the same time as the concrete formwork to ensure that correct assembly and fit is obtained.
- .7 Check architectural, mechanical and electrical drawings for sleeves, inserts, etc.
- .8 Set sleeves, ties, anchor bolts, pipe hangers and other inserts and openings in concrete floors and walls as required.

### **3.3 INSERTS**

- .1 Set hatch and sump frames, pipe, sleeves, ties, anchor bolts, pipe hangers and other inserts, openings and sleeves, in concrete floors and walls as required by other trades. Sleeves, openings, etc., greater than 100 x 100 mm not indicated on structural drawings must be approved by the Contract Administrator.

- .2 No sleeves, ducts, pipes or other openings shall pass through beams except where expressly detailed on structural drawings or approved by the Contract Administrator.
- .3 Do not eliminate or displace reinforcement to accommodate hardware. If inserts cannot be located as specified, obtain approval of all modifications from the Contract Administrator before placing of concrete.
- .4 Check locations and sizes of sleeves, openings, etc., shown on structural drawings with architectural miscellaneous, mechanical and electrical drawings.

### **3.4 PLACING OF CONCRETE**

- .1 According to CSA-A23.1, and as specified herein.
- .2 All formwork shall be cleaned of all debris, loose material, snow and ice immediately prior to pouring.
- .3 Ensure proper placement and support of reinforcement and embedded material immediately ahead of a pour.
- .4 Do not temporarily displace reinforcement for convenience in placing concrete.
- .5 Do not use wood or other temporary spreaders or spacers.
- .6 Do not insert reinforcement into fresh concrete.
- .7 Confine concrete in a suitable vertical drop pipe to within 1.0 m or less of the concrete in place.
- .8 Set screeds accurately for level surfaces or to maintain cambers as required.
- .9 Ensure that concrete is adequately consolidated in the forms.
- .10 Place concrete in such a manner that the concrete in the form is still plastic and can be integrated with fresh concrete.
- .11 To prevent segregation, deposit concrete in approximately horizontal layers of 300 to 450 mm thickness, as near as possible to its final position.
- .12 Pump self-compacting concrete into column forms.

### **3.5 COLD WEATHER REQUIREMENTS**

- .1 When the air temperature is at or below 5°C, or when there is a possibility of it falling to that limit within 24 hours of placing, the requirements according to CSA-A23.1 shall be met.
- .2 Withdraw protection and heating gradually so that air temperature around the concrete does not drop more than 15 Celsius degrees per day.
- .3 Concrete shall be protected from alternate freezing and thawing for 14 days.
- .4 Provide enclosures for heating such that air circulation is maintained.
- .5 Frozen concrete will be rejected.
- .6 Fresh concrete should not be exposed to any combustion gases.

### **3.6 HOT WEATHER CONCRETE WORK**

- .1 Hot weather shall be considered to be an air temperature in the shade, of 23°C or greater.
- .2 Hot weather methods shall conform to CSA-A23.1.
- .3 The concrete temperature at the time of placing in hot weather shall not exceed those specified in CSA-A23.1. In the event that this limit is exceeded the concrete operations shall be suspended until the constituent materials of concrete are cooled.
- .4 Retarding admixtures shall be used only if approved by the Contract Administrator prior to use in the concrete.
- .5 The use of ice may be required to lower the temperature of concrete for large pours.

### **3.7 JOINTS**

- .1 Construction, and/or control joints shall be provided where required and as shown on the plans or according to CSA-A23.1.
- .2 Carefully finish all face edges exposed to view true to line and elevation. Apply a neat cement paste or approved bonding agent to the hardened concrete immediately in advance of the fresh concrete.
- .3 At water tight horizontal joints, apply the first layer of new concrete above the joint with an excess of mortar, obtained by omitting 20 to 50 percent of coarse aggregate from the normal mix.
- .4 Make all construction, or control joints in accordance with details shown on the drawings, layout to be submitted by Contractor for approval by Contract Administrator.
- .5 Allow at least 2 hours after placing concrete in supporting columns or walls before placing in beams, girders or slabs above.
- .6 Place beams monolithically with the floor system, unless otherwise approved by the Contract Administrator.
- .7 See typical details on the drawings for isolation joints at columns, and other locations.
- .8 Construction joint layouts shown on the drawings take precedence over above requirements.

### **3.8 FINISHING**

- .1 To CSA-A23.1 and as specified herein:
- .2 Tank wall and base slab finish
  - .1 Use on concrete surfaces not exposed to view in the completed structure.
  - .2 Chip off fins and irregular projections.
  - .3 Patch honeycomb and fill tie holes with mortar containing approved bonding agent. Mix according to manufacturer's directions.
- .3 Floated surface finish.
  - .1 Strike off the compacted concrete to the cross section and elevation shown on the drawings. Keep a slight excess of concrete in front of the screed at all times.

- .2 Obtain a uniform surface by floating as necessary. If floating is not completed before excess water appears at the surface, remove this water before continuing with floating.
- .3 Add or remove concrete during floating as required to obtain a surface with no more than 3 mm deviation from the required surface in any 3 metre length.
- .4 Do not overwork the concrete surface. Float only enough to obtain a dense uniform surface.
- .4 Broomed finish. (Exterior slabs on grade)
  - .1 After completion of Article 3.8.3 (d), broom to produce a non-slip surface with regular corrugations not more than 3 mm deep.
- .5 Troweled finish. (Main floor finish)
  - .1 After completion of Article 3.8.3 (d), trowel to produce a dense smooth finish.
  - .2 Steel trowel in accordance with CAN / CSA A23.1-M94 Class A.
  - .3 Follow with second steel troweling to produce smooth burnished surface.
  - .4 Do not sprinkle dry cement and sand mixture over concrete surfaces.
  - .5 Apply curing compound to manufacturer's instructions except on concrete to receive protective coating.
- .6 Workmanship for Floor Slabs
  - .1 Steel trowel concrete slabs to be left exposed.
  - .2 Where floor drains occur, floors shall be level around walls and have a minimum 1% uniform pitch to drains, unless indicated otherwise on drawings.
  - .3 Concrete which is to receive protective coating shall be cleaned free of dirt, oil, loose material and laitance.
  - .4 Concrete slabs to receive protective coating to be screeded off to true lines and levels shown and left ready to receive finish.
- .7 Areas which are exterior walkways, driveways or landings, shall receive a broomed non-slip surface.

### **3.9 CURING**

- .1 Curing shall be according to CSA-A23.1 and as specified herein.
- .2 Prevent loss of moisture from concrete surfaces for at least seven days after concreting.
- .3 Protect formed surfaces as follows, subject to approval by the Contract Administrator.
  - .1 Leave forms in place and keep concrete wet by pouring water between concrete and forms.
- .4 Maintain concrete temperatures as recommended according to CSA-A23.1.

### **3.10 FORM REMOVAL**

- .1 Forms shall not be removed until removal operations will cause no damage to concrete surfaces.
- .2 Beam and slab soffit forms shall not be removed until sufficient strength has been attained for support of the applied dead and live loads and to minimize deflections.
- .3 See Clause 11 CSA-A23.1 for specific requirements.

**3.11 PATCHING AND FINISHING OF HARDENED CONCRETE**

- .1 Patching, if required and if allowed, shall be done immediately after stripping.
- .2 Methods of patching and repair shall be submitted to the Contract Administrator and accepted before repair work is started.
- .3 All form ties shall be cut back a minimum of 25 mm and all tie holes shall be neatly patched and rubbed down.

**3.12 DAMP PROOFING AND WATERPROOFING**

- .1 Preparation of concrete surfaces for damp proofing and waterproofing shall conform to CSA-A23.1.
- .2 Application shall conform to manufacturer's recommendations.

**3.13 CONCRETE SPECIALTIES**

- .1 Provide and install all concrete specialties as shown on the drawing and/or as necessary to complete the concrete work.
- .2 Included are fibreboard expansion joint covers, water stop and bond breakers.

**END OF SECTION**



**Part 1            General**

**1.1                DESCRIPTION**

- .1        Requirements for supply and installation of shotcrete inside the Sludge Holding Tanks No.5 and 7 or other areas as directed by the Contract Administrator.
- .2        Include all equipment protections, ventilation system, conveying facilities and air monitoring equipment as required for a proper application inside a confined space.
- .3        Comply with the requirements of the Occupational Health and Safety Act and Regulations for Construction Projects.

**1.2                RELATED WORK**

- .1        Cast-in-Place Concrete - Section 03 30 00
- .2        Concrete Restoration - Section 03 70 00
- .3        Tank Lining - Section 09 77 33

**1.3                REFERENCE STANDARDS**

- .1        CSA-A23.1, "Concrete Materials and Methods of Concrete Construction".
- .2        CSA-A23.2, "Methods of Test for Concrete".

**1.4                SUBMITTALS**

- .1        Submit shotcrete mix design and aggregate analyses to Contract Administrator for review.
- .2        Submit product data sheets for all proposed pre-package materials for review.

**1.5                QUALIFICATIONS**

- .1        Contractor must have a minimum of 5 years experience in shotcrete application.
- .2        Submit project experience and qualifications of nozzle operators and project supervisor for approval.
- .3        Trial shotcrete mix and demonstration of shotcreting technique must be performed to the satisfaction of the Contract Administrator prior to the actual work. Each nozzle operator must demonstrate, using the specified material and the anticipated equipment, acceptable proficiency in applying shotcrete uniformly in both the vertical and overhead orientation. Proficiency shall be demonstrated through the use of vertical and overhead test panels that reflect the actual jobsite conditions. The test panels should be finished with a wood float as described in the specification. Cores will be taken from the test panel for quality assessment and compression testing. Notwithstanding the acceptance of the nozzle operator, the nozzle operator shall be replaced when, in the opinion of the Contract Administrator, the quality of the work is not maintained.

## **1.6 TESTING**

- .1 Shotcrete materials are subjected to quality control testing requirements as per CSA Standards.
- .2 In-place shotcrete not meeting the strength requirements shall be removed and re-applied to the satisfaction of the Contract Administrator and at no cost to the City of Winnipeg.

## **Part 2 Products**

### **2.1 MATERIALS**

- .1 Cement:
  - .1 Silica fume enhanced cement (Min. 8%) as manufactured by St. Mary's Cement Company, St. Lawrence Cement or approved suppliers. The ratio of water to cement-silica fume mixture shall not be greater than 0.35.
  - .2 "Spray-Con WS ST Concentrate" as supplied by Gemite Products Inc. and mixed with concrete sand and CSA Type GU cement as per Gemite Products Inc. supplied mix design.
- .2 Aggregates - Max. size : No.4 (4.75 mm).
- .3 Air Content - 5 to 8%
- .4 Compressive Strength - Minimum 40 MPa at 28 days.
- .5 Superplasticizer - As required to suit pumping and handling requirements.
- .6 Pre-package Materials:
  - .1 "Spray-Con WS ST" wet shotcrete as supplied by Gemite Products Inc.
  - .2 "SikaRepair 225" as supplied by Sika Canada Inc.
  - .3 "Microsil Shotcrete" as supplied by King Packaged Materials Company

### **2.2 ACCESSORIES**

- .1 Use Type 316 stainless steel concrete anchors for Shotcrete thickness control.

## **Part 3 Execution**

### **3.1 PROJECT CONDITIONS**

- .1 Shotcrete shall not be applied to any surface whose temperature is less than 48° F (9° C) or greater than 85° F (30° C). The Contractor may use appropriate radiant and space heating to establish required conditions, subject to strict safety requirements. All such heaters shall be electrically powered and no braziers or open flame shall be permitted inside any enclosure. Shotcrete shall not be exposed to temperature below 48° F (9° C) for a minimum of 96 hours after the application of the shotcrete.
- .2 Areas receiving shotcrete shall have floodlights and exhaust ducts to provide adequate lighting and local ventilation.
- .3 Safe and adequate access shall be provided to facilitate the performance of the work and any inspection or measurement of the work by the Contract Administrator.

### **3.2 EQUIPMENT**

- .1 Placement equipment for dry mix or wet mix shotcrete shall be capable of introducing materials to the delivery hose at a uniform rate with material exiting from the nozzle at a velocity that will ensure adhesion to the surface with minimum rebound and maximum density of the shotcrete.
- .2 If dry mix is used, the water supply system shall be capable of supplying the necessary amount of water through a manually operated liquid injection system (water ring) so that
- .3 The water can be easily controlled by the nozzleman. If variations in water pressure cause wet/dry fluctuations at the nozzle, shotcrete application should be terminated until situation is resolved.
- .4 Shotcrete equipment shall be capable of “pre-dampening” the shotcrete mix either through the use of a continuous feed pre-dampener or through the use of a hydro nozzle.
- .5 The air supply system shall be capable of supplying clean air to the delivery machine and hose at the volumes and pressures recommended by the manufacturer of the equipment. The air compressor shall have a minimum capacity of 3.5 cu.m/min. The compressed air shall be free from oil when tested in conformance with ASTM D4285.
- .6 Equipment shall be maintained in clean and proper operating condition throughout the duration of the project. Sufficient equipment wear parts shall be stored at the jobsite in order to minimize disruptions to the shotcreting process due to equipment breakdown.

### **3.3 SURFACE PREPARATION**

- .1 Concrete surfaces to receive a shotcrete overlay shall be either sandblasted or high pressure water cleaned to remove all loose and foreign materials and to ensure that an adequate bond is achieved. Any excess water remaining on the receiving surface shall be removed using compressed air. The receiving surface should be saturated, surface dry before the application of shotcrete.
- .2 Install steel reinforcement, anchors and corrosion protection anodes as per drawing details.

### **3.4 PLACEMENT OF SHOTCRETE**

- .1 The Contract Administrator shall be notified at least three working days prior to the time the shotcrete is scheduled to commence and the shotcreting shall not proceed until the Contract Administrator or his/her representative has inspected and approved the surface preparation work.
- .2 Uniform Materials:
  - .1 The same shotcrete mix that was used during the trial mix and approval process shall be used for the permanent shotcrete application. The same shotcrete equipment that was used during the approval process shall also be used for the permanent shotcrete application. Strength requirements specified shall be applicable to test panels and test cores obtained during production work.
  - .2 The supply of shotcrete materials and the air pressure at the nozzle shall be uniform so that there is a steady, continuous flow of shotcrete with no surging or pulsing. The velocity of the shotcrete as it leaves the nozzle shall be maintained at a uniform rate determined for the given job conditions which ensures that the shotcrete bonds to the existing surface with proper compaction and minimum rebound.
- .3 Nozzle Technique:
  - .1 The nozzle shall be held approximately 3 feet (1 metre) from the receiving surface in such a position that material impacts at right angles to the receiving surface. Shotcrete shall be

applied using a circular motion of the nozzle while building up the required thickness. The optimum balance of nozzle velocity and distance from the end of the nozzle to the receiving surface shall be maintained in order to maintain a uniform dense layer. Shotcrete shall be free from sags, drips, tears or runs. Rebound or waste material shall not be salvaged and reused.

.4 Thickness:

- .1 Shotcrete thickness may vary from 25 mm (1") to 65 mm (2.5").

**3.5 FINISH**

- .1 After the shotcrete has reached initial set, excess material should be sliced off using a sharp edge cutting tool. The surface of the shotcrete should then be finished with a wood float. The final finish should be representative of the finish that was approved by the Contract Administrator after shooting test panels.

**3.6 CURING**

- .1 Curing is essential to optimize physical properties of the shotcrete and minimize plastic shrinkage. Shotcrete should be cured immediately after material has reached initial set. Continuously moist cure for a minimum period of 5 days.

**3.7 FIELD QUALITY CONTROL**

.1 Inspection:

- .1 The Contract Administrator will make a visual inspection of each shotcrete layer, supplemented by sounding with a hammer. Areas with voids, rebound pockets, aggregate pockets or unbonded areas shall be rejected, removed and replaced.

.2 Core Sampling:

- .1 Cores shall be taken in accordance with the requirements of CSA and ASTM Standards at locations randomly selected and at a frequency determined by the Contract Administrator or his testing agency. Cores shall have a length to diameter ratio of 1.0 or greater and shall be taken when the shotcrete is a minimum of 4 days old. If any cores taken show inadequate bond with the existing surface, or between layers, show obvious defects or fail to meet specified compressive strength, two additional cores shall be taken within approximately 5 feet (1.5 metres) of the unacceptable core. If either of these cores show similar defects, the Contract Administrator shall direct the Contractor to remove the shotcrete in the surrounding area and replace it at no extra cost to the City of Winnipeg.

.3 Defective Shotcrete:

- .1 Shotcrete which lacks uniformity, exhibits segregation, honeycombing, delamination or cracking, poor bond between layers or with the rock surface or which fails to meet the specified compressive strength shall be regarded as defective shotcrete. The Contract Administrator reserves the right to order the removal of the defective shotcrete and its replacement with acceptable shotcrete or the placement of additional shotcrete layers to compensate for the inadequacy of the insitu shotcrete material. The additional shotcrete shall be placed at the Contractor's expense.

**3.8 CLEANING AND FLUSHING**

- .1 All areas receiving the shotcrete overlay shall be cleaned and flushed.
- .2 Remove all debris off-site.

**END OF SECTION**

**Part 1            General**

**1.1                DESCRIPTION**

- .1        Requirements for repair and restoration of concrete surfaces where permitted by the Contract Administrator.
- .2        Supply and installation of corrosion mitigation anodes.

**1.2                RELATED WORK**

- .1        Concrete Reinforcement - Section 03 20 00
- .2        Concrete Framework – Section 03 10 00
- .3        Cast-In-Place Concrete - Section 03 30 00
- .4        Shotcrete - Section 03 37 13

**Part 2            Products**

**2.1                MATERIALS**

- .1        Repair and Patching Materials:
  - .1        SikaTop 122 Plus and 123 Plus repair mortar for horizontal, vertical and overhead repairs. Sika Canada Ltd.
  - .2        Meadow-Crete H2 and GPs repair mortar for horizontal, vertical and overhead repairs. W.R. Meadows Inc.
  - .3        Fibre-Patch ST and OV concrete patching mortar for horizontal, vertical and overhead repairs. Gemite Products Inc.
- .2        Bonding Agents:
  - .1        Sikadur 32 Hi-Mod epoxy bonding agent, (Sika Canada) or Rez-Weld 1000 multi-purpose construction (W.R Meadows Inc.) for bonding hardened and fresh concrete.
- .3        Anti-corrosion Coating for Reinforcement:
  - .1        SikaTop Armatec 110 EpoCem (Sika Canada) or Fibre-Prime Rustproofing Primer (Gemite Products Inc.)
- .4        Chemical Anchors:
  - .1        Use Hilti "HVA" adhesive anchor or Powers Rawl "Chem-Stud" at locations as indicated on Drawings. Use Type 304 Stainless Steel threaded bar in conjunction with adhesive anchor application.
- .5        Corrosion Mitigation Anodes:
  - .1        Sika Galvashield XP embedded galvanic anodes as supplied by Sika Canada.

**Part 3 Execution**

**3.1 INSTALLATION AND WORKMANSHIP**

- .1 Bonding of Concrete Components:
  - .1 Clean hardened concrete surfaces to be in contact with new concrete by combination of scarifying, acid wash and fresh water cleaning.
  - .2 Drill holes and insert dowels or rebars including bonding adhesive as specified in Clause 2.1.4. Blow clean drilled holes using compressed air and further wipe clean with damp cloth.
  - .3 Apply bonding agent to concrete surface immediately prior to concreting.
  - .4 Cure concrete with dampened burlap for a minimum of three days.
- .2 Repair of Concrete Surfaces:
  - .1 Clean concrete surfaces to remove all loose and foreign materials.
  - .2 Apply repair mortar in accordance with manufacturer's written instructions.
  - .3 Install additional anchors and apply bonding agent as required for bonding requirement.
  - .4 Cure all repaired areas.
- .3 Corrosion Prevention using Anodes
  - .1 Install corrosion mitigation anodes on existing concrete surfaces as directed by the Contract Administrator and/or as detailed on Drawings.
  - .2 Tie anodes to existing reinforcing bars in accordance with manufacturer's written specification. Maximum spacing between anodes is 750 mm (30 in.) .
  - .3 Cover anodes with shotcrete
- .4 Crack Injections
  - .1 Use cleaning equipment suitable to clean crack surfaces in order to provide proper adhesion.
  - .2 Dry out cracks if required.
  - .3 Drill holes at an angle of approximately 45 degrees to the surface and on alternate sides of a crack, where possible, to intercept cracks. Space holes as close as required.
  - .4 Install injectors into drilled holes.
  - .5 Apply surface sealer along crack surface as required.
  - .6 Flush crack with clean water.
  - .7 Inject resin into cracks in accordance with manufacturer's written instructions.
  - .8 Commence injection at the lowest injector on a vertical face and at one end on a horizontal surface. Continue injection until pure uncontaminated material flows out from adjacent injectors. Cap the injectors and proceed to adjacent injectors until all injectors have been filled.
  - .9 On completion, re injectors and surface sealer. Thoroughly clean the concrete surfaces of excess resin material. Finish surface to match surrounding concrete.
  - .10 Patch injection holes with repair mortar.
- .5 The Contract Administrator reserves the right to accept or reject any repaired components or surfaces. All unacceptable repairs shall be reworked to the satisfaction of the Contract Administrator.

**END OF SECTION**

**Part 1            General**

**1.1                DESCRIPTION**

- .1            This section specifies requirements for air pressure testing of concrete tank structures and vacuum testing of joints, connections and seals that are not accessible when the roof is in its final position.
- .2            Supply of all calibrated test equipment for measuring atmospheric pressure, internal tank pressure, outdoor temperature, supply air temperature and internal tank temperature.

**1.2                TEST REFERENCE**

- .1            Canadian Standards Association (CSA) B149.6-11 "Code for the digester gas and landfill gas installations."

**Part 2            Products**

**2.1                EQUIPMENT SUPPLIED BY THE CONTRACTOR**

- .1            All test equipment and material required to perform the testing of the concrete structures, joints connections and seal shall be supplied by the contractor.
- .2            Test media: air or inert gas

**2.2                TESTING EQUIPMENT**

- .1            Testing equipment used for measuring the parameters of the test shall have calibration documents to certify accuracy of the instrument. Accuracy of instruments shall be in accordance with CSA B149.6-11.
- .2            Test pressure of concrete structures =  $3.55\text{kPa} \times 1.5 = 5.32\text{kPa}$
- .3            Measuring equipment shall have a scale that is readable. The upper limit of the measuring device shall have a scale that no more than twice the expected reading.
- .4            Test instruments shall suit the environment to which they are exposed.
- .5            Prior to testing, provide a list the instrument specification and calibration documents to the Contract Administrator

**Part 3            Execution**

**3.1                AIR PRESSURE TEST OF CONCRETE TANKS**

- .1            Hydraulic concrete structures shall be subjected to an air pressure test upon completion of the repair.
- .2            The Contractor shall, prior to testing, finish the structures and shall repair areas which appear to be inadequate.



- .3 Prior to testing, provide specification documentation for the test measuring instruments along with calibration documents to the Contract Administrator for review.
- .4 Testing of the concrete structure shall be done after completion of concrete repairs and after the concrete repairs have adequately cured but before application of painting, gas tightness coating, cover roof materials, and exterior wall covering materials.
- .5 The percentage loss of air per volume shall be expressed as a loss over a 24 hour period in accordance with the formulas in the Canadian Standards Association B149.6-11 "Code for the digester gas and landfill gas installations" clause 11.2.1.
- .6 In the case of inadequacies, repair the deficiencies and repeat the air pressure test. Repair methods shall be approved by the Contract Administrator.
- .7 All testing is to be witnessed by the Contract Administrator.

### **3.2 PARAMETERS MEASURED**

- .1 The following parameters are to be measured: atmospheric pressure, atmospheric air temperature, internal tank pressure and internal tank air temperature.

### **3.3 REPORT DOCUMENTS**

- .1 Instrument information is to be recorded onto a field test document.
- .2 Provide a copy of the field test document to Contract Administrator for review.
- .3 After completion of the test, submit a copy of field test document to the Contract Administrator.

**END OF SECTION**