

Wharf Construction**Port Bickerton East****Guysborough County, Nova Scotia****Project No. R.082082.001**

Concrete Forming and Falsework

PART 1 – GENERAL1.1 Related Work

- .1 Refer to other Specification Sections for related information.
- .2 Refer to Section 01 33 00 for Shop Drawing/Submissions requirements.
- .3 Section 03 20 00 – Concrete Reinforcing.
- .4 Section 03 30 00 – Cast-in-Place Concrete.
- .5 Section 03 37 26 – Underwater Concreting.
- .6 Section 03 41 00 – Precast Structural Concrete.

1.2 Reference Standards

- .1 Do concrete formwork and falsework in accordance with CSA standard A23.1-14, Concrete Materials and Methods of Concrete Construction, except where more stringent standards specify otherwise.
- .2 CSA S269.1-16, Falsework and formwork.

1.3 Submissions

- .1 Shop Drawings:
 - .1 Upon request, submit to *Departmental Representative* for review four (4) sets of formwork and falsework shop drawings, in accordance with Section 01 33 00, at least four (4) weeks prior to erection. All such drawings to be stamped and signed by a Professional Engineer registered in the Province of Nova Scotia.
 - .2 Clearly indicate method and schedule of construction, materials, arrangement of joints, ties, shores, liners, and locations of temporary embedded parts. Comply with CSA S269.1 for falsework drawings.
- .2 Product Data/Samples:
 - .1 Provide product data and samples for form ties.
- .3 Provide submissions in accordance with Section 01 33 00.

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PART 2 – PRODUCTS2.1 Materials

- .1 Formwork lumber: plywood and wood formwork materials to CSA A23.1.
- .2 Falsework materials: to CSA S269.1.
- .3 Form stripping agent: colourless mineral oil, free of kerosene, with viscosity between 70s and 110s Saybolt Universal, 15 to 14 mm²/s at 40 degrees Celsius, flash-point minimum 150 degrees Celsius, open cup.
- .4 Form ties: removable or snap-off metal ties, fixed or adjustable length, free of devices leaving holes larger than 25 mm diameter in concrete surface. When forms are removed, no metal shall be embedded less than 75 mm from the surface of the concrete.

PART 3 – EXECUTION3.1 Erection

- .1 Verify lines and levels before proceeding with formwork and ensure dimensions agree with drawings.
 - .2 Construct forms to produce finished concrete conforming to shape, dimensions, locations and levels indicated within tolerances required by CSA A23.1
 - .3 Line forms with material only as approved by *Departmental Representative*.
 - .4 Construct falsework in accordance with CSA S269.1.
 - .5 Align form joints and make watertight. Keep form joints to minimum.
 - .6 Use 25 mm chamfer strips on external corners.
 - .7 Clean formwork in accordance with CSA A23.1, before placing concrete.
 - .8 Leave formwork in place for at least seven (7) days, exclusive for days when temperature falls below 5 degrees Celsius, unless otherwise directed by *Departmental Representative*.
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- .9 Re-use of formwork and falsework subject to requirements of CSA A23.1.
 - .10 All holes from form ties and rods to be plugged with mortar to requirements of CSA A23.1. When forms are removed, no metal will be less than 25 mm from the surface of the concrete.
- 3.2 Falsework
- .1 Contractor to design and construct formwork and falsework to resist severe exposed wave conditions.
 - .2 Submit formwork and falsework design to *Departmental Representative* for review prior to construction.
 - .3 Formwork and falsework design to be approved by an Engineer registered in the Province of Nova Scotia.

END OF SECTION

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Concrete Reinforcement

PART 1 – GENERAL

- 1.1 Related Work
- .1 Refer to other Specification Sections for related information.
 - .2 Refer to Section 01 33 00 for Shop Drawing/ Submission requirements.
 - .3 Section 03 10 00 – Concrete Forming and Falsework.
 - .4 Section 03 30 00 – Cast-in-Place Concrete.
 - .5 Section 03 37 26 – Underwater Concreting.
 - .6 Section 03 41 00 – Precast Structural Concrete.
- 1.2 Reference Standards
- .1 CSA A23.1-14, Concrete Materials and Methods of Concrete Construction.
 - .2 Reinforcing Steel Manual of Standard Practice (latest edition) by Reinforcing Steel Institute of Ontario.
 - .3 CSA G30.18-09 (R2014), Carbon Steel Bars for Concrete Reinforcement.
 - .4 ASTM A1064/A1064M-16b, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
- 1.3 Source Sampling
- .1 Provide *Departmental Representative* with certified copy of mill test of steel supplied showing physical and chemical analysis not less than two (2) weeks prior to commencement of work.
- 1.4 Submissions
- .1 Shop Drawings:
 - .1 Clearly indicate bar sizes, spacing, location and quantities of reinforcement and mesh with identifying code marks to permit correct placement without reference to structural drawings; to Reinforcing Steel Manual of Standard Practice.
 - .2 Detail placement of reinforcing where special conditions occur.
 - .3 Design and detail lap lengths and bar development lengths

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to CSA standard A23.1, unless otherwise specified on drawings.

- .2 Product Data/Samples:
 - .1 Provide product data for supports and spacers.
- .3 Test Results:
 - .1 Provide Mill Test Certificates cross referenced to the product supplied to the site.
- .4 Provide submissions in accordance with Section 01 33 00.

1.5 Storage

- .1 Store reinforcing steel on racks or sills that will permit easy access for identification and handling and prevent it from becoming coated with material which would adversely affect bond.
- .2 Do not store reinforcing steel in direct contact with the ground.

1.6 Measurement
For Payment

- .1 This item will not be measured separately.
- .2 Wire ties and spacers to be considered incidental to supply and placing of reinforcement.

PART 2 – PRODUCTS2.1 Materials

- .1 Reinforcing steel: to CSA G30.18; billet steel grade 400 deformed bars.
- .2 Wire ties: to ASTM A1064 plain, cold drawn annealed steel wire.
- .3 Spacers: PVC, Fabricated to suit site dimensions.

2.2 Reinforcing
Steel Fabrication

- .1 Fabricate reinforcing to CSA standard A23.1
- .2 Fabrication tolerances for reinforcing steel to Reinforcing Steel Manual of standard Practice.
- .3 Obtain *Departmental Representative's* acceptance for locations of reinforcement splices other than those shown on reinforcing shop drawings.

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- .4 Ship bundles of bar reinforcement, clearly identified in accordance with bar list.
- .5 Do not weld reinforcing steel.

PART 3 - EXECUTION

3.1 Placing

- .1 Accurately place reinforcing in positions indicated and hold firmly during placing, compacting and setting of concrete.
- .2 Tie reinforcement where spacing in each direction is:
 - .1 Less than 300 mm: - tie at alternate intersections.
 - .2 300 mm or more: - tie at each intersection.

3.2 Field Bending

- .1 Do not field bend reinforcement except where indicated or authorized by *Departmental Representative*.
- .2 When authorized, bend reinforcement without heat, by applying slow and steady pressure.
- .3 Replace bars which develop cracks or splits.

3.3 Cleaning

- .1 Clean reinforcing before placing concrete.

3.4 Inspection

- .1 Do not place concrete until *Departmental Representative* has inspected and accepted reinforcement work in place.

3.5 Surface Conditions

- .1 Reinforcement, at time concrete is placed, to be free from mud, oil or other nonmetallic coatings that adversely affect bonding capacity.
- .2 Reinforcement, with rust, mill scale, or combination of both may be considered as satisfactory provided the minimum nominal dimensions, nominal weight, and average height of deformations of a hand wire brushed test specimen are not less than specified requirements in applicable CSA Standards.

END OF SECTION

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Cast-in-Place Concrete

PART 1 – GENERAL1.1 Related Work

- .1 Refer to other Specification Sections for related information on aggregates, form work and false work, concrete reinforcement, miscellaneous items.
- .2 Refer to Section 01 33 00 for Shop Drawing/ Submissions requirements.
- .3 Section 03 10 00 – Concrete Forming and Falsework.
- .4 Section 03 20 00 – Concrete Reinforcing.
- .5 Section 03 37 26 – Underwater Concreting.
- .6 Section 03 41 00 – Precast Structural Concrete.

1.2 Reference Standards

- .1 Do structural concrete work in accordance with CSA A23.1-14, Concrete Materials and Methods of Concrete Construction, except where more stringent standards specify otherwise.
- .2 Do testing for concrete in accordance with CSA standard A23.2-14, Methods of Test for Concrete, except where stricter standards specify otherwise.
- .3 CSA A3000-13, Cementitious Materials Compendium.
- .4 ASTM C494/C494M-16, Standard Specification for Chemical Admixtures for Concrete.
- .5 ASTM C1116/C1116M-10a (2015) Standard Specification for Fiber-Reinforced Concrete.
- .6 ASTM C309-11, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
- .7 ASTM C881/C881M-15, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
- .8 ASTM D1751-04 (2013 e1), Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural

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- .9 ASTM D412-16, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension.
- .10 ASTM C260/C260M-10a (2016), Standard Specification for Air-Entraining Admixtures for Concrete.
- .11 ASTM C920-14a, Standard Specification for Elastomeric Joint Sealants.
- .12 ASTM C719-14, Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle).

1.3 Submissions

- .1 Shop Drawings:
 - .1 Submit shop drawings and erection drawings for formwork and falsework. All such drawings to be stamped and signed by a Professional Engineer registered in the Province of Nova Scotia.
 - .2 Submit placement drawings for reinforcing steel.
 - .3 Submit placement drawings for miscellaneous items.
- .2 Product Data/Samples:
 - .1 Provide technical data and/or samples for curing compounds (winter/summer/green/white/red), evaporation retardant and finishing aids, expansion joint materials/sealants, grouts.
- .3 Certificates:
 - .1 Minimum four (4) weeks prior to starting concrete work submit to *Departmental Representative* manufacturer's test data and certification by qualified independent inspection and testing laboratory that the following materials will meet specified requirements:
 - .1 Portland cement.
 - .2 Admixtures.
 - .2 Provide certification that plant, equipment, and materials to be used in concrete work comply with requirements of CSA A23.1.
 - .3 Provide certification that mix proportions selected will produce concrete of specified quality, yield, and strength

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and will comply with CSA A23.1.

.4 Provide certification that concrete will not include alkali - reactivity aggregates.

.4 Methodology and Quality Control:

.1 Submit for review methodology and quality control procedures for the following:

.1 Cold weather concreting.

.2 Hot weather concreting.

.3 Concrete placement operations. Provide details of pour sequence and proposed layout of construction joints. Unless otherwise approved, the spacing of deck construction joints shall not exceed 13.5m.

.4 Concrete deck finishing operations.

.5 Supporting reinforcing steel.

.6 Protection and curing of concrete in cold and hot weather.

.7 Submit methodology for curing and crack control. To be stamped and signed by a Professional Engineer registered to practice in the province of Nova Scotia. All concrete deck pours to be wet-cured for 7 days. Concrete deck to be sprayed with fogging machine until wet curing can begin.

.5 Test Results:

.1 Provide design mix tests results.

.2 Provide mill test certificates for reinforcing steel.

1.4 Measurement
For Payment

.1 Cast-in-place concrete will be measured in accordance with Section 01 29 00.

.2 Heating of water and aggregates, and providing cold weather protection will not be measured but considered incidental to the Work.

.3 Supply of anchor bolts, washers and nuts will not be measured but considered incidental to the Work. Bolt grouting will be considered incidental to the Work.

.4 Supply and installation of ridged PVC sleeves, and curing compounds required will be considered incidental to the Work.

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- 1.5 Storage of Materials
- .1 Store all materials to prevent contamination or deterioration, whether at the plant or at the job site.
 - .2 Store cement in watertight bins or silos that provide protection from dampness and easy access for inspection and identification of each shipment whether at the plant or at the job site.
 - .3 Prevent stored liquid admixtures and compounds from freezing and powdered admixtures and compounds from absorbing moisture.
 - .4 Use storage methods which prevent damage and straining of pre-cast concrete elements.
- 1.6 Source Sampling
- .1 At least four (4) weeks prior to commencing work, inform *Departmental Representative* of proposed source of aggregates and provide access for sampling.
- 1.7 Ready-Mix Concrete Supply
- .1 Provide, with each load of concrete delivered to site, duplicate delivery slips containing following:
 - .1 Name of ready-mix batch plant.
 - .2 Serial number of ticket.
 - .3 Date and truck number.
 - .4 Project identification.
 - .5 Class of concrete or mix.
 - .6 Amount of concrete in cubic metres.
 - .7 Time of loading or first mixing of aggregate, cement and water.
 - .8 Time of discharge of concrete.
 - .9 Admixtures added at plant.
 - .10 Amount of water added at plant.

PART 2 – PRODUCTS

- 2.1 Materials
- .1 Aggregates: to CSA A23.1, for Class "C-1" exposure.
 - .2 Portland Cement: to CSA A3000, moderate type 20.
 - .3 Water: to CSA A23.1.

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- .4 Admixtures:
 - .1 Air entraining admixtures: to ASTM C494.
 - .2 Chemical admixtures: to CSA A3000 and ASTM C494.
 - .3 Pozzolanic mineral admixtures: to CSA A3000.
- .5 Non-shrink grout: premixed compound consisting of non-metallic aggregate, Portland cement, water reducing and plasticizing agents, of pouring and/or pumping consistency, capable of developing compressive strength of 50 MPa at 28 days.
- .6 Curing compound: To ASTM C309 and CSA A23.1 type 1, I-D, or 2.
- .7 Adhesive Anchors: high strength epoxy to ASTM C881, Type IV, Grade 3. Acceptable material: Epcom Ceramic 6, Hilti HIT HY-200 or approved equal.
- .8 Premoulded joint fillers:
 - .1 Bituminous impregnated fibre board: to ASTM D1751 (latest edition), non-extruding resilient type.
- .9 Joint sealer: two component self-levelling, low odour, moisture cure, petroleum resistant, high modulus, low VOC sealant to ASTM C920, type M, Grade NS, Class 35.
 - .1 ASTM C719: +/- 23%
 - .2 Ultimate elongation: 30%
 - .3 Shore A hardness: 25-35
 - .4 Max VOC: <18 g/L
 - .5 Recovery (ASTM D412): >90%

2.2 Concrete Mixes

- .1 Prior to starting concrete work, submit to the *Departmental Representative* the proposed mix design(s) for approval. Mix design (s) to be in accordance with Alternative 1 of Table 5 in CSA A23.1. Comply with additional requirements of CSA A23.1, clause 4.1.1.5 for concrete exposed to sea water or sea water spray.
 - .1 Use concrete mix designed to produce air entrained concrete meeting the following requirements:
 - .1 Cement to be moderate Portland cement, Type 20.
 - .2 Minimum compressive strength at 28 days: 35 MPa.
 - .3 Exposure: Class C-1.
 - .4 Maximum aggregate size to CSA A23.1 table 11, Group 1, 20 mm size.
 - .5 Minimum cement content 390 kg/m³.

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- .6 Air content: 6 to 8%.
 - .7 Maximum water/cement ratio to be 0.40.
 - .8 Slump at time and point of discharge 80 mm \pm 20 mm. Where the nature of the work requires larger slumps, they are to be obtained by the use of admixtures rather than increasing the water content. Use of such admixtures and the increase in slump to be approved by the *Departmental Representative* prior to implementation in the work.
 - .2 Modify concrete mix to the approval of the *Departmental Representative* to accommodate pumping.
 - .3 Admixtures to the approval of the *Departmental Representative* and the recommendation of the manufacturer. Admixtures must be dispersed separately into mixing water.
 - .4 Do not use calcium chloride or compounds containing calcium chloride.
 - .5 Weigh aggregates, cement, water and admixtures separately when batching. Inspect and test scales for accuracy as directed. Accuracy to be such that successive quantities can be measured to within one percent of desired amounts. Test certificates to be submitted to *Departmental Representative* upon request.
 - .6 Where seven day strength is less than 70% of specified 28 day strength, provide additional protection and curing, and make changes to mix proportions to the satisfaction of the *Departmental Representative*.
 - .7 Provide certification that plant, equipment and all materials to be used in concrete comply with the requirements of CSA A23.1.
 - .8 Provide certification from independent testing and inspection company that selected mix proportions will produce concrete of specified quality and can be effectively placed and finished for all work under this contract.
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- .9 Add micro fibers to concrete according to manufacturer's recommendations.
- .10 Use plasticizer to increase slump and workability.
- .11 *Departmental Representative* to review fiber mixing procedures and mix design.

2.3 Synthetic Fiber Reinforcement

- .1 Fibermesh 150, 100 percent homopolymer polypropylene multifilament fibers, or approved equal.
- .2 Conformance to ASTM C1116, Type 3.
- .3 Single cut Fiber lengths.
- .4 Alkali proof.
- .5 Absorption: nil.
- .6 Specific gravity: 0.91.
- .7 Melt point: 162 degrees C.

PART 3 – EXECUTION3.1 General

- .1 Obtain *Departmental Representative's* approval before placing concrete. Provide 24 hours notice of intended placement. Concrete to be placed in dry form condition.
- .2 Place, consolidate, finish, cure and protect concrete to CSA A23.1 except where specified otherwise.
- .3 Prior to placing of concrete, obtain *Departmental Representative's* approval of proposed method for protection of concrete during placing and curing in adverse weather.
- .4 Comply with additional requirements of CSA A23.1 except where specified otherwise, for concrete exposed to seawater environment.
- .5 Do not commence placing concrete until *Departmental*

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Representative has inspected/reviewed forms, inserts, dowels, reinforcing steel, joints; conveying, consolidation and protective methods.

- .6 Ensure that reinforcement and anchorage are not disturbed during placing.
- .7 Maintain accurate records of placed concrete items to indicate date, location of pour, quality, air temperature and test samples taken.
- .8 Do not place load(s) upon new concrete until *Departmental Representative* is satisfied that the Contractor has carried out all calculations and tests necessary to confirm that the load(s) will not cause damage or create a safety hazard. Calculations and tests to be stamped by a Professional Engineer registered in the Province of Nova Scotia.

3.2 Reinforcing Steel

- .1 Place new reinforcing steel according to Section 03 20 00.
- .2 Provide 75 mm minimum cover for all reinforcing steel unless indicated otherwise on drawings.

3.3 Formwork

- .1 Verify field dimensions to determine applicable sizes of formwork.
- .2 Design and construct form work to allow adequately for proper placement and consolidation while conforming with shape and dimensions shown on plans.
- .3 Formwork design will include closures at both top and bottom of form, and all necessary hardware to support the forms.
- .4 Upon request, submit drawings for review by the *Departmental Representative*, at least 3 weeks before placement of concrete. Drawings, will show formwork details and illustrate dimensions, method of placing of concrete, connections and support.
- .5 Strip formwork after minimum seven (7) days. This condition might be waived only if an alternative method to curing and preventing alternate wetting and drying is provided, to the satisfaction of the *Departmental Representative*. This condition will be waived if the forms are left permanently in place, where approved by the

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Departmental Representative.

- 3.4 Placement of Concrete
- .1 Place and consolidate concrete to CSA A23.1. Concrete to be placed in dry form condition, by coordinating pour with low tide.
 - .2 If allowed by *Departmental Representative*, pump concrete to following requirements:
 - .1 Arrange equipment so that no vibrations result which might damage freshly placed concrete.
 - .2 Where concrete is conveyed and placed by mechanically applied pressure, provide suitable equipment.
 - .3 Operate pump so that concrete, without air pockets, is produced.
 - .4 When pumping is discontinued and concrete remaining in pipe line is to be used, void pipe line in a manner that prevents contamination of concrete or separation of ingredients.
 - .3 Concrete will be deposited in all cases as neatly as practicable, directly in its final position, and will not be caused to flow in a manner to permit or cause segregation.
 - .4 Each layer of concrete will be vibrated and tamped with an appropriate vibrator as allowed by the *Departmental Representative*. The concrete must be compacted to the maximum practicable density, free of air pockets, and until it is in complete contact with the reinforcement and formwork.
- 3.5 Inserts
- .1 Set galvanized sleeves and other inserts and openings as indicated or specified elsewhere. Sleeves and openings greater than 100 X 100 mm not indicated on drawings must be approved by *Departmental Representative*.
 - .2 Do not eliminate or displace reinforcement to accommodate hardware. If inserts cannot be located as specified, obtain approval of all modifications from *Departmental Representative* before placing of concrete.
 - .3 Galvanized items embedded in concrete will be completely separated from reinforcing steel.
 - .4 Anchor bolts:
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- .1 Set anchor bolts to templates under supervision of appropriate trade prior to placing concrete.
- .2 With *Departmental Representative's* concurrence, grout anchor bolts in pre-formed holes or holes drilled after concrete has set. Formed holes to be at least 100 mm in diameter. Drilled holes to be minimum 25 mm larger in diameter than bolts used.
- .3 Protect anchor bolt holes from water accumulations.
- .4 Set bolts and fill holes with non-shrink grout.
- .5 Anchor bolts for base plates will be set to allow at least 25 mm of grout under the base plates.

3.6 Protection and Curing

- .1 Provide protection and curing in accordance with CSA A23.1.
- .2 Protect concrete with windproof shelter to allow free circulation of inside air around fresh concrete. Do not let walls of shelter touch formwork and provide sufficient space for removal of formwork.
- .3 Supply approved heating equipment to maintain inside air at following temperatures:
 - .1 For an initial three days, at not less than 10° C nor more than 25° C at surfaces.
 - .2 At not less than 10° C for an additional 4 consecutive days or for the time necessary to attain 70% of the specified 28-day compressive strength of the concrete.
 - .3 Reduce temperature near end of curing period at rate not exceeding 20° C per day.
 - .4 Do not overheat.
- .4 Keep concrete surfaces continuously moist during protection stage and allow concrete to dry before removal of protection.
- .5 Freshly deposited concrete will be protected from premature drying and excessively hot and cold temperatures, will be maintained without drying at a relatively constant temperature for the period of time necessary for hydration of the cement and proper hardening of the concrete. It will be protected from harmful effects of sunshine, drying winds, cold weather, running or surface water and mechanical shock.
- .6 Wood floating, broom finishing, placing of burlap and inspection of concrete to be done from transverse bridges of rigid construction

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free from wobbles and springing under use, unless other methods have been submitted and accepted.

- .7 All concrete deck pours to be wet-cured for 7 days. Concrete deck to be sprayed with fogging machine until wet curing can begin.

3.7 Finishing

- .1 Finish concrete in accordance with CSA A23.1.
- .2 Grind off fins, nibs and other raised protuberances with an approved hand stone.
- .3 When concrete has hardened sufficiently, give deck surface a uniform finish free from porous spots, irregularities, depressions, small pockets or rough spots using a power float leaving a rough spiral finish with one pass of the float.
- .4 Following use of power float, provide coarse broom finish using steel wire or stiff, coarse, fibre broom. Use broom in a transverse ridges satisfactory to *Departmental Representative*. Brooming will be delayed until concrete is sufficiently hard to retain ridges.
- .5 Rub exposed sharp edges of concrete with carborundum to produce 3 mm radius edges unless otherwise detailed.

3.8 Joint Fillers

- .1 Furnish filler for each joint in single piece for depth and width required for joint, unless otherwise authorized by *Departmental Representative*. When more than one piece is required for a joint, fasten abutting ends and hold securely to shape by stapling or other positive fastening.
- .2 Locate and form separation joint as indicated. Install joint filler.
- .3 Unless indicated otherwise, use 25 mm thick joint filler to separate deck slabs and extend joint filler from bottom of slab to within 25 mm of finished concrete surface.

3.9 Field Quality Control

- .1 Inspection and testing of concrete and concrete materials will be carried out by Testing Laboratory designated by the *Departmental Representative* in accordance with CSA A23.1 and CSA A23.2.
- .2 *Departmental Representative* will pay for costs of tests as specified in Section 01 45 00.

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- .3 *Departmental Representative* will take additional test cylinders during cold weather concreting. Cure cylinders on job site under same conditions as concrete which they represent.
- .4 If tests do not meet requirements of the *Departmental Representative*, take such measures as indicated in CSA A23.1 and CSA A23.2.
- .5 Arrange and pay for inspection and testing when necessary for production control to meet requirements.
- .6 Inspection and testing by *Departmental Representative* will not augment Contractor's quality control or relieve him of contractual responsibility.

3.10 Defective Work

- .1 Concrete is defective when:
 - .1 failing to meet any requirement of this specification
 - .2 concrete contains honeycombing or embedded debris
 - .3 28-day strength in any area is less than 95% of specified minimum.
- .2 Repair or remove and replace defective work as directed by the *Departmental Representative*.
- .3 Take corrective measures as directed by the *Departmental Representative* to prevent occurrence of further defective concrete.

END OF SECTION

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Underwater Concreting

PART 1 - GENERAL1.1 Related Work

- .1 Refer to other Specification Sections for related information.
- .2 Refer to Section 01 33 00 for Shop Drawing/ Submissions requirements.
- .3 Section 03 10 00 – Concrete Forming and Falsework.
- .4 Section 03 20 00 – Concrete Reinforcing.
- .5 Section 03 30 00 – Cast-in-Place Concrete.
- .6 Section 03 41 00 – Precast Structural Concrete.

1.2 Reference Standards

- .1 Do Concrete work in accordance with CSA standard A23.1-14, Concrete Materials and Methods of Concrete Construction, except where stricter standards specify otherwise.
- .2 Do testing for concrete in accordance with CSA standard A23.2-14, Methods of Test for Concrete, except where stricter standards specify otherwise.
- .3 CSA A3000-13, Cementitious Materials Compendium.
- .4 ASTM C494/C494M-16, Standard Specification for Chemical Admixtures for Concrete.

1.3 Definitions

- .1 Tremie concrete is placed underwater through a tube called a tremie pipe. Tremie pipe has a hopper at upper end and may be open ended or may have a foot valve, plug or travelling plug to control flow of concrete. Concrete is placed in hopper and a sufficient head of concrete is maintained in tremie pipe to provide desired rate of flow.
- .2 Pumped concrete method of placing concrete underwater uses a concrete pump with a discharge line used in a similar manner to a tremie pipe.
- .3 Bagged concrete method of placing underwater concrete consists of a diver placing bags partially filled with concrete mix.

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1.4 Samples

- .1 Submit shop drawings in accordance with Section 01 33 00 - Shop Drawings, Product Data, Samples and Mock-Up.
- .2 Shop drawings shall clearly indicate the size and location of existing voids beneath the wharf end and the procedures for filling and restraining the pumped concrete. All materials shall be clearly identified on these drawings.

1.5 Certificates

- .1 Minimum 2 weeks prior to starting concrete work submit to *Departmental Representative*, manufacturer's test data and certification by qualified independent inspection and testing laboratory that the following materials will meet specified requirements:
 - .1 Cement Type 50
 - .2 Admixtures
 - .3 Aggregates
 - .4 Water
- .2 Provide certification that plant, equipment and materials to be used in concrete comply with requirements of CSA standard A23.1
- .3 Provide certification that selected mix proportions will produce concrete of specified quality, yield, strength, and will comply with CSA standard A23.1

1.6 Ready-Mix
Concrete Supply

- .1 Provide with each load of concrete delivered to site, duplicate delivery slips containing following:
 - .1 Name of ready-mix batch plant.
 - .2 Serial number of ticket.
 - .3 Date and truck number.
 - .4 Name or number of project.
 - .5 Class of concrete or mix.
 - .6 Amount of concrete in cubic metres.
 - .7 Time of loading or first mixing of aggregate, cement and water.
 - .8 Time that discharge of concrete begins and ends.
 - .9 Type and quantity of admixtures added at plant.
 10. Quantity of water added at plant.
-

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PART 2 - PRODUCTS2.1 Materials

- .1 Portland Cement: to CSA A3000, Use type 50 cement.
- .2 Water, fine aggregates, normal density, coarse aggregates: to CSA standard A23.1
- .3 Air entraining admixture: to CSA A23.5
- .4 Concrete bags: constructed of coarsely woven material to allow concrete to bond between bags, and capable of containing 0.030 M³ of concrete.
- .5 Reinforcing Steel: Comply with Section 03 20 00.

2.2 Concrete Mixes

- .1 Concrete for bagged concrete.
 - .1 Use type 50 cement.
 - .2 Minimum compressive strength at 28 days, 35 MPa.
 - .3 Class of exposure: C-3.
 - .4 Maximum water cement ratio by mass.
 - .5 Nominal size of coarse aggregate 20 mm.
 - .6 Fine aggregate content 42 to 45% of total aggregate mass.
 - .7 Slump at time of discharge 0-25 mm.
- .2 Concrete grout, for pumped concrete.
 - .1 Use type 50 cement: 342 kg/m³.
 - .2 Maximum water cement ratio 0.45.
 - .3 Fine aggregate: 1159 kg/m³.
 - .4 Superplasticier - To ASTM C494, Type A and F, Rheobuild 1000, or approved equal as per manufacturer instruction: 1 L/100 kg of cement.
 - .5 Compressive strength min. 35 MPa @ 28 days.
 - .6 Slump 100 to 125 mm.

2.3 Admixtures

1. Admixtures will be subject to approval of *Departmental Representative*. Admixtures will only be permitted to correct deficiencies in mix or to improve placement of concrete.
2. *Departmental Representative* may withdraw prior approval of admixture if conditions encountered during course of work indicate unsatisfactory performance.

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3. Do not use calcium chloride or materials containing calcium chloride.

PART 3 - EXECUTION3.1 General

- .1 Perform concrete work in accordance with CSA standard A23.1

3.2 Preparation

- .1 Notify *Departmental Representative* at least 24 hours in advance of intention to commence underwater work.
- .2 Prior to placement of concrete bags and pumped concrete remove silt, soft material, organic material and debris from the undermined area and beneath timber cribwork. Use high pressure water jets or an air hose.
- .3 Place concrete in one continuous operation to full depth required. Provide sufficient supply of concrete to complete pour without interruption and supply complete equipment for every phase of operation.

3.3 Tremie Method

- .1 Provide tremie pipe which is watertight and sufficiently large to allow free flow of concrete. Diameter of tremie pipe to be not less than 250 mm or less than eight times maximum size of coarse aggregate.
- .2 Provide hopper at top of tremie pipe and means to raise and lower tremie.
- .3 Provide plug or foot valve at end of tremie pipe to permit filling pipe with concrete initially.
- .4 Provide minimum of 2 tremie pipes for every 9m² of pour plan area or maximum of 3 m centre to centre. Do not move tremie pipes laterally by dragging through concrete.
- .5 Start pour with tremie pipe full of concrete and keep end of pipe buried in freshly placed concrete at least 300 mm. Control rate of flow by increasing or decreasing depth of end in concrete.
- .6 If seal is lost, allowing water to enter pipe, withdraw pipe immediately.

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.7 If tremie operation is interrupted so that a horizontal construction joint has to be made, cut surface laitance by jetting, within 24 to 36 h and remove loose material by pumping or air lifting before placing next lift.

.8 Do not place concrete in flowing water. Do not vibrate, disturb or puddle concrete after it has been placed.

3.4 Pumped
Concrete Method

.1 Follow procedures as for tremie method in placing concrete using discharge line form concrete pump as tremie pipe.

3.5 Bagged
Concrete Method

.1 Place bagged concrete on prepared hard bottom as shown on the plan in an approved manner. Ensure bag is stable and securely resting in foundation material or previously placed bags.

.2 Place bagged concrete to form retaining dams as required for placing of pumped concrete.

.3 Secure bagged concrete to existing foundation and to adjacent concrete bags by driving min. of 2-15M bars min. 600 mm long through concrete bag.

.4 Concrete bags to be filled just prior to placing, fill bags not more than 80% full, before placing.

3.6 Rigid Formwork

.1 Rigid formwork may be used to form the perimeter of areas designated for pumped concrete provided:

.1 Rigid formwork extends above the base and in front of the structure by 150mm (minimum) to ensure the concrete will provide full support for the structure.

.2 The toe of the repair area is protected with concrete bags to prevent undermining and provide an adequate seal with the harbour bottom. The bags are to extend 3 courses above the harbour bottom and 3 bags across from the wharf face.

.2 Place bagged concrete at the ends of the pumped concrete limits to provide an interior seal for the pumped concrete.

END OF SECTION

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Precast Structural Concrete

PART 1 - GENERAL1.1 Related Work

- .1 Refer to other Specification Sections for related information.
- .2 Refer to Section 01 33 00 for Shop Drawing/ Submissions requirements.
- .3 Section 03 10 00 – Concrete Forming and Falsework.
- .4 Section 03 20 00 – Concrete Reinforcing.
- .5 Section 03 30 00 – Cast-in-Place Concrete.

1.2 Reference Standards

- .1 Do structural concrete work in accordance with CSA A23.1-14, Concrete Materials and Methods of Concrete Construction, except where more stringent standards specify otherwise.
- .2 Do testing for concrete in accordance with CSA standard A23.2-14, Methods of Test for Concrete, except where stricter standards specify otherwise.
- .2 CSA A3000-13, Cementitious Materials Compendium.
- .3 CSA A23.4-16, Precast Concrete – Material and Construction
- .5 ASTM C260/C260M-10a (2016), Standard Specification for Air-Entraining Admixtures for Concrete.
- .6 ASTM C494/C494M-16, Standard Specification for Chemical Admixtures for Concrete.
- .7 CSA G30.18-09 (R2014), Carbon Steel Bars for Concrete Reinforcement.

1.3 Shop Drawings

- .1 Submit shop drawings in accordance with Section 01 33 00 – Submissions/Shop Drawings and in accordance with CSA standards A23.2 and A23.4.
- .2 Include the following items:
 - .1 Design calculations for items designed by manufacturer.
 - .2 Details of reinforcement and their connections.

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Precast Structural Concrete

- .3 Methods of handling and erection.
- .4 Openings, sleeve, inserts and related reinforcement.
- .5 Storage facility.

PART 2 - PRODUCTS2.1 Materials

- .1 Refer to section 03 30 00 – Cast-in-Place Concrete.

2.2 Concrete Mixes

- .1 Proportion structural normal density concrete in accordance with CSA standard A23.1, Alternative 1 to give the following properties for concrete.
- .2 Precast Panels:
 - .1 Cement: Type 20, Moderate Portland Cement.
 - .2 Minimum compressive strength at 28 days: 35 MPa.
 - .3 Class of exposure: C-1.
 - .4 Nominal size of coarse aggregate: 20 mm.
 - .5 Slump at point and time of discharge: 50 mm to 100 mm.
 - .6 Air Content: 5 – 8%.
 - .7 Density of air-drying concrete will be in range of 2240 to 2400 kg/m³.
 - .8 Minimum cement content: 385 kg/m³.
 - .9 Maximum water/cement ratio: 0.4.

PART 3 - EXECUTION3.1 Erection

- .1 Do precast concrete work in accordance with CSA standard A23.4.
- .2 Erect precast elements within 10 mm as shown on drawings.
- .3 Replace or repair damaged precast elements to satisfaction of *Departmental Representative* at no additional cost.

3.2 Cleaning

- .1 After erection, clean precast elements to satisfaction of *Departmental Representative*.

END OF SECTION