
PART 1 - GENERAL

1.1 REFERENCES

- .1 Canadian Standards Association (CSA)
 - .1 CSA-A23.1-09/A23.2-09, Concrete materials and methods of concrete construction/Test methods and standard practices for concrete.
 - .2 CSA-O86-09, Consolidation-Engineering Design in Wood (Limit States Design).
 - .3 CSA O121-08(R2013), Douglas Fir Plywood.
 - .4 CSA S269.1-1975(R2003), Falsework for Construction Purposes.
 - .5 CAN/CSA-S269.3-M92(R2013), Concrete Formwork.
- .2 Council of Forest Industries of British Columbia (COFI)
 - .1 COFI Exterior Plywood for Concrete Formwork.

1.2 SHOP DRAWINGS

- .1 Submit shop drawings for formwork and falsework in accordance with Section 01 33 00.
- .2 Indicate method and schedule of construction, shoring, stripping and re-shoring procedures, materials, arrangement of joints, special architectural exposed finishes, ties, liners, and locations of temporary embedded parts. Comply with CAN/CSA-S269.3 for formwork drawings.
- .3 Indicate formwork design data, such as permissible rate of concrete placement, and temperature of concrete, in forms.
- .4 Each shop drawing submission shall bear stamp and signature of qualified professional engineer registered or licensed in Province of Ontario, Canada.

1.3 WASTE MANAGEMENT

- .1 Separate and recycle waste materials in accordance with Section 01 74 21.
- .2 Place materials defined as hazardous or toxic waste in designated containers.
- .3 Ensure emptied containers are sealed and stored safely for disposal away from children.
- .4 Use sealers, form release and stripping agents that are non-toxic, biodegradable and have zero or low VOC's.

PART 2 - PRODUCTS

2.1 MATERIALS

- .1 Formwork materials:
 - .1 Use wood and wood product formwork materials to CSA-O86.

- .2 Form ties:
 - .1 Removable or snap-off metal ties, fixed or adjustable length, free of devices leaving holes larger than 25 mm dia. in concrete surface.
 - .2 Plywood: Douglas Fir to CSA O121 square edge, 22 mm thick, urea formaldehyde free.
- .3 Form release agent: non-toxic, biodegradable, low VOC.
- .4 Form stripping agent: colourless mineral oil, non-toxic, biodegradable, low VOC, free of kerosene, flashpoint minimum 150°C, open cup.
- .5 Falsework materials: to CSA-S269.1.

PART 3 - EXECUTION

3.1 FABRICATION AND ERECTION

- .1 Install formwork to cover the openings at all junction locations throughout the service tunnel.
- .2 Co-ordinate all other locations of formwork and bulkheads with the Lightweight Cellular Concrete sub-contractor.
- .3 Verify lines, levels and centres before proceeding with formwork/falsework and ensure dimensions agree with drawings.
- .4 Fabricate and erect falsework in accordance with CSA-S269.1 and COFI Exterior Plywood for Concrete Formwork.
- .5 Do not place shores and mud sills on frozen ground.
- .6 Provide site drainage as required.
- .7 Fabricate and erect formwork in accordance with CAN/CSA-S269.3 to produce finished concrete conforming to shape, dimensions, locations and levels indicated within tolerances required by CSA-A23.1/A23.2.
- .8 Align form joints and make watertight. Keep form joints to minimum.
- .9 Use 25 mm chamfer strips on external corners and/or 25 mm fillets at interior corners, joints, unless specified otherwise.
- .10 Form chases, slots, openings, drips, recesses, expansion and control joints as indicated.
- .11 Build in anchors, sleeves, and other inserts required to accommodate Work specified in other sections. Assure that all anchors and inserts will not protrude beyond surfaces designated to receive applied finishes, including

painting.

- .12 Clean formwork in accordance with CSA-A23.1/ A23.2, before placing concrete.

3.2 REMOVAL AND RESHORING

- .1 Leave formwork in place for following minimum periods of time after placing concrete.

.1 Co-ordinate formwork minimum placement requirements with the supplier of the lightweight cellular concrete.

- .2 Remove formwork when concrete has reached 75% of its design strength or minimum period noted above, whichever comes later, and replace immediately with adequate reshoring as required.

- .3 Provide all necessary reshoring of members where early removal of forms may be required or where members may be subjected to additional loads during construction as required.

- .4 Re-use formwork and falsework subject to requirements of CSA-A23.1/A23.2.

END OF SECTION

PART 1 - GENERAL1.1 REFERENCES

- .1 American Concrete Institute (ACI)
 - .1 SP-66-04, ACI Detailing Manual 2004.
- .2 CSA International
 - .1 CSA-A23.1-09/A23.2-09, Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete.
 - .2 CSA-G30.18-09, Carbon Steel Bars for Concrete Reinforcement.
 - .3 CSA W186-M1990(R2007), Welding of Reinforcing Bars in Reinforced Concrete Construction.
- .3 Reinforcing Steel Institute of Canada (RSIC)
 - .1 RSIC-2004, Reinforcing Steel Manual of Standard Practice.

1.2 ACTION AND
INFORMATIONAL
SUBMITTALS

- .1 Submit in accordance with Section 01 33 00.
- .2 Prepare reinforcement drawings in accordance with RSIC Manual of Standard Practice and SP-66.
- .3 Shop Drawings:
 - .1 Indicate placing of reinforcement and:
 - .1 Bar bending details.
 - .2 Lists.
 - .3 Quantities of reinforcement.
 - .4 Sizes, spacings, locations of reinforcement and mechanical splices if approved by Departmental Representative, with identifying code marks to permit correct placement without reference to structural drawings.
 - .5 Indicate sizes, spacings and locations of chairs, spacers and hangers.
 - .2 Detail lap lengths and bar development lengths to CAN/CSA-A23.3, unless otherwise indicated.
 - .1 Provide type C tension lap splices unless otherwise indicated.

1.3 QUALITY ASSURANCE

- .1 Mill Test Report: upon request, provide Departmental Representative with certified copy of mill test report of reinforcing steel.
- .2 Upon request submit in writing to Departmental Representative proposed source of reinforcement material to be supplied.

1.4 DELIVERY, STORAGE
AND HANDLING

- .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.
- .2 Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labeled with manufacturer's name and address.
- .3 Storage and Handling Requirements:
 - .1 Store materials off ground in dry location and in accordance with manufacturer's recommendations in clean, dry, well-ventilated area.
 - .2 Replace defective or damaged materials with new.

PART 2 - PRODUCTS

2.1 MATERIALS

- .1 Substitute different size bars only if permitted in writing by Departmental Representative.
- .2 Reinforcing steel: billet steel, grade 400, deformed bars to CSA-G30.18, unless indicated otherwise, minimum 30% recycled content.
- .3 Chairs, bolsters, bar supports, spacers: to CSA-A23.1/A23.2.
- .4 Mechanical splices: subject to approval of Departmental Representative.

2.2 FABRICATION

- .1 Fabricate reinforcing steel in accordance with CSA-A23.1/A23.2, SP-66 and Reinforcing Steel Manual of Standard Practice by the Reinforcing Steel Institute of Canada.
- .2 Obtain Departmental Representative's written approval for locations of reinforcement splices other than those shown on placing drawings.
- .3 Upon approval of Departmental Representative, weld reinforcement in accordance with CSA W186.
- .4 Ship bundles of bar reinforcement, clearly identified in accordance with bar bending details and lists.

2.3 SOURCE QUALITY CONTROL

- .1 Provide Departmental Representative with certified copy of mill test report of reinforcing steel, showing physical and chemical analysis, minimum 4 weeks prior to beginning reinforcing work.
- .2 Inform Departmental Representative of proposed source of material to be supplied.

PART 3 - EXECUTION

3.1 FIELD BENDING

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

3.2 PLACING REINFORCEMENT

- .1 Place reinforcing steel as indicated on placing drawings and in accordance with CSA-A23.1/A23.2.
- .2 Prior to placing concrete, obtain Departmental Representative's approval of reinforcing material and placement.
- .3 Ensure cover to reinforcement is maintained during concrete pour.

3.3 CLEANING

- .1 Progress Cleaning: clean in accordance with Section 01 74 11.
 - .1 Leave Work area clean at end of each day.

- .2 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 11.

END OF SECTION

PART 1 - GENERAL

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| <u>1.1 REFERENCES</u> | .1 | CSA International |
| | .1 | CSA A23.1-09/A23.2-09, Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete. |
| | .2 | CAN/CSA-A3000-08, Cementitious Materials Compendium (Consists of A3001, A3002, A3003, A3004 and A3005). |
| | .3 | CSA-G30.18-09, Carbon Steel Bars for Concrete Reinforcement. |
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<u>1.2 ADMINISTRATIVE REQUIREMENTS</u> |
.1 |
Pre-installation Meetings: convene pre-installation meeting one week prior to beginning of concrete works. |
| | .1 | Verify project requirements. |
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<u>1.3 ACTION AND INFORMATIONAL SUBMITTALS</u> |
.1 |
Provide submittals in accordance with Section 01 33 00. |
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<u>1.4 QUALITY ASSURANCE</u> |
.1 |
Provide to Departmental Representative, 4 weeks minimum prior to starting concrete work, valid and recognized certificate from plant delivering concrete. |
| | .1 | Quality Control Plan: provide written report to Departmental Representative verifying compliance that concrete in place meets performance requirements. |
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<u>1.5 DELIVERY, STORAGE AND HANDLING</u> |
.1 |
Delivery and Acceptance Requirements: |
| | .1 | Concrete hauling time: deliver to site of Work and discharged within 120 minutes maximum after batching. |
| | .1 | Do not modify maximum time limit without receipt of prior written agreement from Departmental Representative and concrete producer as described in CSA A23.1/A23.2. |
| | .2 | Deviations to be submitted for review by the Departmental Representative. |
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.2 |
Concrete delivery: ensure continuous concrete delivery from plant meets CSA A23.1/A23.2. |
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.3 |
Packaging Waste Management: remove for reuse and return by manufacturer of pallets, crates, padding. |

PART 2 - PRODUCTS

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| <u>2.1 DESIGN CRITERIA</u> | .1 | Alternative 1 – Performance to CSA A23.1/A23.2, and as described in |
|----------------------------|----|---|

MIXES of PART 2 - PRODUCTS.

- 2.2 PERFORMANCE CRITERIA .1 Quality Control Plan: ensure concrete supplier meets performance criteria of concrete as established by Departmental Representative and provide verification of compliance as described in PART 1 - QUALITY ASSURANCE.
- 2.3 MATERIALS .1 Cement: to CAN/CSA-A3001, Type 10.
- .2 Other concrete materials: to CSA A23.1/A23.2.
- 2.4 MIXES .1 Alternative 1 - Performance Method for specifying concrete: to meet Departmental Representative performance criteria to CSA A23.1/A23.2.
- .1 Ensure concrete supplier meets performance criteria as established below and provide verification of compliance as described in 3.3 Verification.
- .2 Provide concrete mix to meet following plastic state requirements:
- .1 Workability: free of surface blemishes colour variations and segregation.
- .2 Set time: 2 hours maximum.
- .3 Provide concrete mix to meet following hard state requirements:
- .1 Durability and class of exposure: N.
- .2 Compressive strength at 28 days 30 MPa minimum.
- .3 Aggregate size 20 mm maximum.
- .4 Concrete supplier's certification.
- .5 Provide quality management plan to ensure verification of concrete quality to specified performance.
- .6 Other performance requirements: 100 mm lump maximum.

PART 3 - EXECUTION

- 3.1 PREPARATION .1 Provide Departmental Representative 24 hours' notice before each concrete pour.
- .2 Place concrete reinforcing in accordance with Section 03 20 00.
- .3 Coordinate the reinforced concrete walls at the ends of the tunnel distribution system with the bulkhead requirements of the Lightweight Cellular Concrete.
- .4 During concreting operations:
- .1 Development of cold joints not allowed.
- .2 Ensure concrete delivery and handling facilitates placing with minimum of rehandling, and without damage to existing structure or Work.

- .5 Protect previous Work from staining.
- .6 Clean and remove stains prior to application of concrete finishes.

3.2 INSTALLATION/ APPLICATION

- .1 Do cast-in-place concrete work in accordance with CSA A23.1/A23.2.
- .2 Sleeves and inserts:
 - .1 Cast in sleeves, ties, slots, anchors, reinforcement, frames, conduit, bolts, water stops, joint fillers and other inserts required to be built-in.
 - .2 Sleeves and openings greater than 100 mm x 100 mm not indicated, must be reviewed by Departmental Representative.

3.3 VERIFICATION

- .1 The supplier shall provide the following information to verify compliance with the performance criteria:
 - .1 Certification that the plant, equipment, and all materials to be used in the concrete comply with the requirements of this Standard.
 - .2 Certification that the concrete complies with the performance criteria specified.
 - .3 Quality control plan to ensure that the Departmental Representative's and contractor's performance requirements will be met if required.
 - .4 At the request of the Departmental Representative, submit documentation to the satisfaction of the Departmental Representative demonstrating that the proposed mix design will achieve the required strength, durability, and performance requirements.

3.4 FIELD QUALITY CONTROL

- .1 Concrete testing: to CSA A23.1/A23.2 by testing laboratory designated and paid for by Departmental Representative.
- .2 Contractor will take additional test cylinders during cold and hot weather concreting. Cure cylinders on job site under same conditions as concrete which they represent.

3.5 COLD WEATHER PROTECTION

- .1 When the air temperature is below, or is likely to fall below 5 deg C (40 deg F) (as forecast by the local meteorological office) carry out all concrete work in accordance with the recommendations of CSA A23.1, Clause 21.2. Have all equipment prepared and operational before commencing to place concrete.
- .2 When heated concrete is exposed to drying effects of wind, provide

adequate windbreaks to protect the surface.

- .3 Methods of heating shall be such as to prevent discharge of combustion products over, or drying of, surface of fresh concrete.
- .4 Keep a permanent temperature record conforming to following requirements:
 - .1 Records to show date, time, outside temperature and maximum and minimum temperature at several points within any enclosure, before the placing of concrete in or above enclosure.
 - .2 Use maximum and minimum type thermometers for measuring temperature. If concrete is placed on forms heated from an enclosure below, place thermometers close to the underside of the forms. Temperature record to be kept available for Consultant's inspection at any time.
 - .3 Temperature of air within enclosures shall not exceed 32 deg C (90 deg F). Maintain concrete temperatures at 21 deg C (70 deg F) for 5 days. Removal of concrete protection shall conform to CSA A23.1, clause 21.2.6.
 - .4 Do not place concrete on frozen ground, on ground which contains frozen materials, nor on or against any surface which is at a temperature of less than 10 deg C (50 deg F.).

3.6 HOT WEATHER PROTECTION

- .1 Carry out hot weather concreting, unless otherwise specified, in accordance with CSA A23.1.
- .2 Protect concrete from effect of hot or drying weather conditions. Protect forms and reinforcing from the direct rays of the sun, or cool by fogging and evaporation.
- .3 Refer to curing article for special curing precautions in hot weather.

3.7 CLEANING

- .1 Clean in accordance with Section 01 74 21.
- .2 Use trigger operated spray nozzles for water hoses.
- .3 Designate cleaning area for tools to limit water use and runoff.

END OF SECTION

PART 1 – GENERAL

1.1 REFERENCES

- .1 CAN/CSA A3001, Cementitious Materials for Use in Concrete.
- .2 CSA A23.1, Concrete Materials and Methods of Concrete Construction.
- .3 ASTM C 869, Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.
- .4 ASTM C 796, Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam.
- .5 ASTM C 495-99a, Standard Test Method for Compressive Strength of Lightweight Insulating Concrete.

1.2 SHOP DRAWINGS

- .1 Submit product information sheets, installation procedure and all other relevant information in accordance with section 01 33 00

1.3 QUALIFICATION

- .1 Use lightweight cellular concrete Supplier with the following qualifications:
 - .1 capable of developing a mix design, batching, mixing, handling, and placing cellular concrete;
 - .2 certified by the manufacturer of the foaming agent and regularly engaged in the production and placement of cellular concrete; and,
 - .3 has qualified workers who are thoroughly trained and experienced in the production and placement of cellular concrete.

1.4 EQUIPMENT

- .1 Provide specialized batching, mixing, and placing equipment that is automated and certified for the purpose by the manufacturer of the cellular concrete material.
- .2 Provide dry-mix equipment that is capable of receiving bulk cement and producing over 100 m³/hour on-site, continuously, from one piece of equipment, and pumping through hoses or pipes up to a flat lineal distance of 1000 metres.

- .3 Provide a bulk cement scale that operates within a tolerance of 1 and 1.5% per batch.
- .4 Provide wet-mix equipment that is capable of receiving slurry on-site into the equipment and process it continuously during ready-mix supply, and pump through hoses or pipes up to a flat lineal distance of 200 metres.
- .5 Pump cellular concrete using a positive displacement pump (Peristaltic or similar). Do not use concrete piston pumps.
- .6 Provide a foam generator to continuously produce pre-formed foam, which is injected and mixed with the cementitious slurry downstream of the positive displacement slurry pump.
- .7 Calibrate the equipment to produce a precise and predictable volumetric rate of foam with stable uniform microbubbles.

PART 2 - PRODUCTS

2.1 MATERIALS

- .1 Provide lightweight cellular engineered concrete fill with the following properties:
 - .1 Minimum unconfined compressive strength at 28 days of 1 MPa; and,
 - .2 Wet cast density of 550 kg/m³ (+/-10%).
- .2 Provide Portland cement conforming to the requirements of CSA Standard CAN/CSA A3001, Type GU or HE. Provide supplementary cementing materials conforming to the requirements of CSA Standard CAN/CSA A3001.
- .3 Provide mixing water conforming to the requirements of CSA Standard A23.1. Water of questionable quality shall not be used unless proven to produce specimens whose 28 day compressive strength is at least 90% of those made with known acceptable water and an identical material mix.
- .4 Provide foaming agents conforming to the requirements of ASTM C 869 when tested in accordance with the provisions of ASTM C 796. Any Subcontractors shall be pre-qualified and approved in writing by the foaming agent manufacturer, referencing this Project.
- .5 Measure and record the fresh cellular concrete density once per production run, or once for every 50 m³, or once per 30 minutes, whichever is more frequent. The density shall be maintained within +/-10% of the design density.

- .6 Capture, cure, and test concrete samples to verify that the compressive strength requirement is satisfied. One sample is comprised of one set of 3 cellular concrete cylinders. Do one sample for each placement, or every 100 m³, whichever is more frequent. Cast in 3 inch x 6 inch cylindrical plastic molds. Line the sample mold with "freezer paper" with the plastic side against the cellular concrete. Cure and test the cellular concrete cylinders as required by ASTM C495-99a, modified to represent the field curing conditions for geotechnical applications.
- .7 The departmental representative may perform similar capture, cure and tests to verify the compressive strength and density requirements are met. The departmental representative may order that lightweight cellular concrete not meeting the specification requirements be removed and replaced.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Properly set and stabilize any items to be fully or partially encased in the cellular concrete prior to the installation of the cellular concrete.
- .2 Where required, design and install formwork to withhold cellular concrete, and where required provide lining with poly sheeting or similar to prevent leakage.
- .3 Take measures to prevent damage to the cellular concrete until sufficient strength has been attained when placing during freezing conditions. Take measures to avoid freezing before initial set.
- .4 Do not place cellular concrete during heavy or prolonged precipitation events.
- .5 The placement area shall be free of standing water during placement of cellular concrete and until backfill of cast concrete fill is placed on top of the cellular concrete. Snow and Ice must be removed from the area prior to placement.
- .6 Once mixed, promptly convey the cellular concrete to the location of placement without excessive handling.
- .7 Determine the maximum lift thickness based on density and any other considerations that may impact placement. Place cellular concrete within 1 to 2 hours to permit an undisturbed setting.

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- .8 Prevent loading of or traffic on, the cellular concrete until the material has attained sufficient strength to withstand the loads with no damage.
 - .9 If light weight cellular concrete is being placed in cold weather or hot weather conditions, refer to Cast in Place Concrete 03 30 00 for concreting instructions. In cold weather, as a minimum guideline, the area where the light weight cellular concrete is to be placed will require insulated protective hoarding and is to be heated for a minimum of 30minutes prior to placement of concrete, or until the specified temperature is reached. The water and pipe lines are also to be heated up to manufacturers specifications.

END OF SECTION