TENDER DOCUMENTS

SUBSECTION 6.32
FORMWORK

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SUBSECTION 6.32 FORMWORK

6.32.1 GENERAL

6.32.1.1 This subsection sets out the requirements relating to formwork under this Contract.

6.32.1.2 Any specific requirements pertaining to formwork under this Contract are set out on the drawings and in Section 4 *Special Technical Conditions*.

6.32.1.3 The requirements relating to reinforcing steel are described in subsection 6.31 *Reinforcing Steel for Concrete*.

6.32.1.4 The requirements relating to cast-in-place concrete and underwater repairs are described in subsection 6.33 *Cast-in-Place Concrete*.

6.32.2 MEASUREMENT UNITS

6.32.2.1 The measurement units and respective symbols thereof used in this subsection are described as follows:

Measurement Unit	Designation	Symbol
length	meter	m
length	millimeter	mm
mass	gram	g
volume	liter	L
temperature	Celsius degree	°C

6.32.3 REFERENCE STANDARDS

6.32.3.1 The **Contractor** shall carry out all formwork in accordance with the requirements of the following standards and documents to which the provisions of this Contract are added:

6.32.3.1.1 (ASTM) ASTM International:

- ASTM A123/A123M *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*;
- ASTM A325 *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*.

6.32.3.1.2 CAN/CSA Group (Canadian Standards Association):

- CAN/CSA-A23.1/A23.2 *Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete*;
- CAN/CSA-G40.20 /G40.21 *General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel;*
- CAN/CSA-O86 *Engineering Design in Wood*;

- CAN/CSA-O121-08 *Douglas Fir Plywood;*
- CAN/CSA-S269.1 *Falsework for Construction Purposes*;
- CAN/CSA-S269.3 *Concrete Formwork*;
- CANCSA S6 *Canadian Highway Bridge Design Code*;
- CAN/CSA-W47.1 *Certification of Companies for Fusion Welding of Steel*;
- CAN/CSA-W59 *Welded Steel Construction (Metal Arc Welding)*.

6.32.3.1.3 (MTQ) Ministère des Transports du Québec:

- MTQ – *Cahier des charges et devis généraux* (CCDG).

6.32.4 MATERIALS

6.32.4.1 FORMWORK

6.32.4.1.1 The **Contractor** shall use metal or wood formwork to carry out repairs, in accordance with standard CAN/CSA-S269.3.

6.32.4.1.2 Lumber and plywood shall comply with standards CAN/CSA-S269.3 and CAN/CSA-O121.

6.32.4.1.2.1 The plywood shall be manufactured from 19 mm thick Douglas fir or equivalent authorized by the Engineer, with squared edges, and of minimum dimensions of 2400 mm x 600 mm.

6.32.4.1.3 Bolts, nuts and washers used for steel formwork shall be made of high-strength steel in accordance with standard ASTM A325.

6.32.4.1.4 The steel shall be 300W grade steel and compliant with standard CAN/CSA-G40.20/G40.21.

6.32.4.1.5 Welds shall meet the requirements of standard CAN/CSA-W59.

6.32.4.1.6 The **Contractor** or subcontractor thereof, if any, who performs the welding shall be certified by the Canadian Welding Bureau in accordance with standard CAN/CSA-W47.1. Prior to fabrication, the **Contractor** shall provide the Engineer with a document certifying its qualification or that of its subcontractor.

6.32.4.1.7 The cut edges of steel plates and steel members shall be smooth and free of cracks, cavities and breaks. The edges shall not be cut and the holes shall not be pierced manually with a torch. Holes shall be drilled or carried out by shearing process.

6.32.4.2 FORMWORK TIE RODS

6.32.4.2.1 Formwork tie rods shall be steel bars with a diameter greater than 12 mm and shall comply with the indications on the drawings, if any.

6.32.4.2.2 Formwork tie rods shall comply with Article 15.4.3.1.3 *Accessoires des coffrages* of the CCDG.

6.32.4.3 FORMWORK BRACKETS

6.32.4.3.1 The vertical walls of the formwork shall be connected to each other by metal brackets fitted with a plastic cone at each end.

6.32.4.3.2 Formwork brackets shall comply with Article 15.4.3.1.3 *Accessoires des coffrages* of the CCDG.

6.32.4.4 CHAMFERS

6.32.4.4.1 Wooden chamfer strips shall be free of warping, knots or splinters that could affect the appearance of the concrete surface.

6.32.4.5 FORMWORK RELEASE AGENT

6.32.4.5.1 The formwork release agent shall be non-toxic and biodegradable, have a maximum content of 450 g/L of volatile organic compounds (VOC) and shall be the product *Euco Super Slip* manufactured by The Euclid Chemical Company, or an equivalent authorized by the Engineer.

6.32.4.6 FORMWORK RELEASE OIL

6.32.4.6.1 The formwork release oil shall be a colorless, non-toxic and biodegradable mineral oil, with a 0 g/L VOC content, free of kerosene, whose *Soybolt Universel* viscosity expressed in seconds is of at least 70 and no more than 110 at a temperature of 40°C, whose flash point in open crucible is of at least 150°C and shall be the product *FORM-EZE NATURAL* manufactured by The Euclid Chemical Company or an equivalent authorized by the Engineer.

6.32.4.7 MATERIALS FOR TEMPORARY SHORING

6.32.4.7.1 The materials for temporary shoring shall comply with standard CAN/CSA-S269.1.

6.32.5 EXECUTION OF WORK

6.32.5.1 PLANNING

6.32.5.1.1 At least fourteen (14) days prior to the start of formwork, the **Contractor** shall provide the Engineer with the drawings of the formwork, signed and sealed by an engineer who is a member of the *Ordre des ingénieurs du Québec* (OIQ) and has at least five (5) years of relevant experience.

6.32.5.1.2 The formwork shall comply with standards CAN/CSA S269.3 and CAN/CSA-A23.1 as well as Article 15.4.3.1 *Coffrages* of the CCDG.

6.32.5.1.3 Before formwork fabrication begins, the **Contractor** shall verify, on site, all dimensions of the components of the structure and the possible interference with the formwork, including the supports and girders, and any other obstacles that could hinder the installation of the formwork and formwork supports.

6.32.5.2 TIE RODS

6.32.5.2.1 In the case of repair work, the formwork may be held in place by means of prefabricated tie rods, secured to the existing concrete and meeting the following requirements:

6.32.5.2.1.1 anchor depth: minimum of 200 mm in sound concrete;

6.32.5.2.1.2 tie rod diameter: 12 mm;

6.32.5.2.1.3 tie rod spacing: maximum 600 mm centre to centre.

6.32.5.2.2 The **Contractor** shall, however, check whether the minimum spacing is sufficient given the height of the concrete pour, the type of mix, any other stress applied to the tie rods and the quality of the concrete in which the tie rods are secured.

6.32.5.2.3 Tie rods shall be positioned at a minimum distance of 75 mm from the repair limit.

6.32.5.2.4 Tie rods shall be positioned at right angles to the concrete surface of the element to be constructed or repaired.

6.32.5.2.5 Unless authorized in writing by the Engineer, it is prohibited to install anchors in the deck slab of a bridge to support the formwork.

6.32.5.2.6 Tie rods are not allowed for the construction of barrier formwork.

6.32.5.3 FORMWORK BRACKETS

6.32.5.3.1 Formwork brackets shall be positioned so as not to hinder concrete placement. They shall be installed on vertical planes at a horizontal distance calculated by the **Contractor**'s engineer. The ends shall be cut inside the concrete and at 40 mm from the surface.

6.32.5.3.2 Formwork brackets shall be positioned at a minimum distance of 75 mm from the repair limit.

6.32.5.3.3 Formwork brackets shall be positioned at right angles to the concrete surface of the element to be constructed or repaired.

6.32.5.3.4 Formwork brackets are not allowed for the construction of barrier formwork and precast concrete elements.

6.32.5.4 CHAMFERS

6.32.5.4.1 Unless otherwise indicated on the drawings, any visible sharp edges of the surfaces shall be chamfered to 40 mm.

6.32.5.4.2 Chamfer strips shall be placed so as to leave in the concrete a neat and unbroken taper along the sharp edges.

6.32.5.4.3 When the chamfer strips are prepared, the **Contractor** shall ensure that they are all of equal section so that the ends of the strips can be butted with precision during placement.

6.32.5.4.4 Chamfer strips shall be placed level and aligned correctly.

6.32.5.4.5 Chamfer strips shall be coated with a formwork release agent.

6.32.5.5 INSTALLATION OF FORMWORK

6.32.5.5.1 Steel formwork shall be assembled and installed by workers having "*Compagnon monteur d'acier de structure"* competency cards issued by the *Commission de la Construction du Québec* (CCQ) and at least five (5) years of experience erecting steel structures.

6.32.5.5.2 Metal formwork shall be cleaned before use so as to eliminate any trace of rust or deterioration.

6.32.5.5.3 Metal formwork shall not be reused if the last pour was such that formwork sections show a mis-alignment therebetween.

6.32.5.5.4 The formwork shall be firmly secured in place, braced and supported so as to withstand the loads to which they are subjected, taking into consideration the vibrations caused by traffic, while retaining their alignment and shape until the concrete has set.

6.32.5.5.5 The falsework and shoring supporting the formwork shall be manufactured and installed in accordance with standard CAN/CSA-S269.1.

6.32.5.5.6 The formwork shall meet the shapes, alignments and dimensions of the structure indicated on the drawings.

6.32.5.5.7 Formwork joints shall be aligned and watertight.

6.32.5.5.8 Formwork panels shall be positioned so as to minimize the number of joints.

6.32.5.5.9 The formwork used for placing concrete in adjacent sections in continuous parts of the structure shall be adjusted to provide concrete surfaces whose finish and lines are regular, uniform and harmonious.

6.32.5.5.10 The formwork shall be watertight and shall not allow any mortar or laitance to flow out.

6.32.5.5.11 The **Contractor** shall make openings in the wooden formwork to properly vibrate the concrete during placement thereof. Openings are, however, optional in steel formwork.

6.32.5.5.12 Openings in the formwork shall be spaced so as to prevent the segregation of concrete during placement thereof, but shall not exceed 2.5 m from centre to centre.

6.32.5.5.13 Unless otherwise indicated on the drawings, the inner side of the formwork, whether metal or wooden, shall be covered with formwork lining in accordance with Article 6.37.4 *Formwork Lining* of subsection 6.37 *Miscellaneous Products for Concrete Work*.

6.32.5.5.14 The **Contractor** shall install the formwork so as to comply with the concrete oversize coverage indicated on the drawings, if any.

6.32.5.5.15 For repairs using formwork without oversize coverage or full-depth repair of a slab, the formwork shall be securely fastened to prevent smudges on the edges of the surfaces to be repaired. After removal of the formwork, the surfaces shall be in the same plane as the surrounding surfaces. No formwork brackets shall be fixed on a girder, except on the top thereof, if previously authorized by the Engineer.

6.32.5.5.16 The deck slab underside formwork shall, over the entire perimeter of the repairs and at each high point of the repair volume, have vents located no farther than 600 mm from each other. Following the release of the air contained in the formwork during concreting, the vents shall be closed and the pressure shall be increased in accordance with Article 6.33.6.10 *Concrete Placement* of subsection 6.33 *Cast-in-Place Concrete*. The vents shall remove the air contained in the formwork towards the slab underside. The **Contractor** is not permitted to drill vents through the deck slab.

6.32.5.5.17 Prior to concreting, the **Contractor**'s design engineer shall, in the presence of the Engineer, inspect all formwork, falsework and shoring. The **Contractor**'s design engineer shall provide a certificate of conformity, thereby signed and sealed, confirming his approval of the complete installation of the formwork, including the shoring, falsework and anchors, and cleaning of the bottom of the formwork.

6.32.5.6 REMOVAL OF THE FORMWORK

6.32.5.6.1 The **Contractor** shall not remove the formwork or the formwork supports and bracing before having obtained authorization from the Engineer.

6.32.5.6.2 After the concrete is poured and after having obtained authorization from the Engineer, the **Contractor** may, unless otherwise indicated on the drawings, remove the formwork when the following minimum requirements have been met:

6.32.5.6.2.1 soffit of any element: the formwork shall be left in place for a minimum period of seven (7) days. In addition, the compressive strength of the new concrete shall have reached at least 75% of the specified strength at twenty-eight (28) days;

6.32.5.6.2.2 vertical faces of any element: the formwork shall be left in place for a minimum period of three (3) days. In addition, the compressive strength of the new concrete shall have reached at least 60% of the specified strength at twenty-eight (28) days.

6.32.5.6.3 The formwork shall be considered as removed when it is loosened and no longer comes into contact with the concrete.

6.32.5.6.4 The periods specified in paragraphs 6.32.5.6.2.1 and 6.32.5.6.2.2 shall be extended as long as the results of the tests conducted on samples cured on site are less than the required strengths specified in said paragraphs or, where applicable, on the drawings.

6.32.5.6.5 At the end of the work, the **Contractor** shall ensure that no formwork element is left in place.

6.32.5.6.6 After having removed the formwork, the **Contractor** shall remove the tie rod and/or bracket retaining cones, cut the tie rods and/or brackets at the bottom of the hole left by the cones and fill the holes with the *SikaTop 123 PLUS* cementitious mortar, manufactured by SIKA or an equivalent authorized by the Engineer.

6.32.5.7 PERMANENT STEEL FORMWORK

6.32.5.7.1 Unless otherwise indicated on the drawings, the steel panels and other members used for the permanent formwork shall be hot dip galvanized in accordance with standard ASTM A123/A123M.

6.32.5.7.2 The **Contractor** is responsible for determining the diameter and number of tie rods required to withstand the stresses during concreting, without exceeding the tolerances for displacement and deformation of the permanent steel formwork panels indicated on the drawings.

6.32.5.7.3 At least fourteen (14) days prior to the start of fabrication of the permanent steel formwork, the **Contractor** shall provide the Engineer with the design notes of the shoring and supports of the permanent steel formwork system that the **Contractor** intends to use during the concrete pour. These design notes shall be signed and sealed by an engineer who is a member of the OIQ and has at least ten (10) years of relevant experience in the design of steel structures and wooden and steel formwork.

6.32.5.7.4 Prior to concreting, the **Contractor**'s design engineer shall, in the presence of the Engineer, inspect the permanent steel formwork, shoring and supports. The **Contractor**'s design engineer shall provide a certificate of conformity, thereby signed and sealed, confirming his approval of the installation of the permanent formwork system.

6.32.5.7.5 The **Contractor** is responsible for developing methods for the installation of the permanent steel formwork panels and for ensuring the integrity thereof during the concrete pour. If the height of the permanent formwork exceeds 2.8 m, the **Contractor** may drill a hole at mid-height to install a formwork tie rod for the concrete pour. The hole shall, in that case, have a diameter that is minimum, but of a sufficient size to allow the cutting of the anchor afterwards and the sealing of the opening with the *SikaTop 123 PLUS* cementitious mortar, manufactured by SIKA or an equivalent authorized by the Engineer or the *Sikadur XL Gel* epoxy-based product, manufactured by SIKA or an equivalent authorized by the Engineer.

6.32.5.7.6 In cases where there is not enough space between the demolished concrete and the permanent formwork steel panels to introduce a downpipe for concreting, the **Contractor** may make openings in the permanent steel formwork to pour the concrete in freefall without a downpipe, insofar as a maximum height of 2.8 m is met. The number and location of such openings shall first be submitted to the Engineer for review. Each opening shall be circular and have a bearing plate on the inner side to allow the installation of a flushing cover. The **Contractor** shall ensure there is a free area all around the cover to make a full penetration weld after using the opening.

END OF SUBSECTION