PRECAST CONCRETE BRIDGE ELEMENTS, FABRICATION - Item No.
PRECAST CONCRETE BRIDGE ELEMENTS, DELIVERY - Item No.
PRECAST CONCRETE BRIDGE ELEMENTS, INSTALLATION - Item No.

Special Provision No. 999S31 March 2018

REQUIREMENTS FOR PRECAST CONCRETE BRIDGE ELEMENTS
(NON-PRESTRESSED AND PRESTRESSED)

1.0 SCOPE

This Special Provision covers the requirements for non-prestressed and prestressed precast concrete bridge elements for prefabricated bridge systems. The requirements include certification of production facilities, production, storage, transportation, and installation of the precast elements.

2.0 REFERENCES

This Special Provision refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 905 Steel Reinforcement for Concrete
OPSS 910 Stressing Systems for Post Tensioning
OPSS 919 Formwork and Falsework
OPSS 929 Abrasive Blast Cleaning Concrete Construction
OPSS 930 Structure Rehabilitation Concrete Patches, Refacing and Overlays
OPSS 932 Crack Repair - Concrete

Ontario Provincial Standard Specifications, Materials

OPSS 1213 Hot Applied Rubberized Asphalt Waterproofing Membrane
OPSS 1302 Water
OPSS 1350 Concrete - Materials and Production
OPSS 1440 Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications:

Laboratory Testing Manual:

LS-432 Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-433 Method of Test for Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration

Structural Manual

CSA Standards

A23.2-9C Compressive Strength of Cylindrical Concrete Specimens
A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing*
A23.4-16 Precast Concrete Material and Construction
3.0 DEFINITIONS

For the purpose of this Special Provision, the following definitions apply:

**Bed** means the assembly consisting of platform, forms and end blocks in which the elements are cast.

**Bughole** means a small regular or irregular cavity resulting from entrapment of air bubbles in the surface of formed concrete during placement or consolidation.

**Cold Joint** means a joint or discontinuity resulting from a delay in placement of sufficient duration to preclude intermingling and bonding of the concrete.

**Cold Weather** means when the air temperature to which the element is exposed is at or below 5 °C, or when the air temperature to which the element is exposed is at or is likely to fall below 5 °C within 96 hours after completion of concrete placement. Temperature refers to shade temperature.

**Element Type** means an element defined by function and cross-sectional shape.

**Honeycombing** means a rough and stony concrete surface with voids where the mortar did not fill the spaces between the coarse aggregate particles.

**Indoor Precast Concrete Plant** means a building, which is a permanent structure, providing protection from sun, wind, and rain and which is temperature controlled, such that the temperature does not fall below 15 °C or exceed 30 °C.

**Laiteance** means a layer of weak and nondurable material on the surface of the concrete containing cement and fines from aggregates, brought by bleeding water to the top surface concrete.

**Lot** consists of all of the same element types, of the same mix design, produced over seven consecutive Days.

**Post-Tensioning** means a method of prestressing in which tendons are tensioned after the concrete has reached a predetermined strength.
Pour Line means a visible delineation between two placements of concrete where the concrete from each placement is well-bonded to the other.

Precaster means the producer of the precast concrete elements.

Precast Element means an individual precast section of the prefabricated bridge. For the purposes of this specification, precast elements do not include precast girders but may include precast bridge deck components, including full and partial depth deck panels, abutments, approach slabs, footings, columns, shafts, ballast walls, wingwalls, and pier caps. “Precast element” is used interchangeably with “element”.

Prestressed Element means a Precast Element in which internal stresses have been initially introduced so that subsequent stresses resulting from dead load and superimposed loads are counteracted to a desired degree. Prestressing may be accomplished by pretensioning or post-tensioning.

Pretensioning means a method of prestressing in which strands are tensioned before the concrete is placed.

Segregation means visible separation of the mortar and coarse aggregate particles in the concrete, resulting in concrete that is not uniform in appearance or proportions.

Strand means a group of wires laid helically over a central core-wire.

Sweep means the lateral deviation from straightness of an element with respect to its design centre line.

Tendon means a high strength steel element consisting of one or more wires, strands or bars; used to impart prestress to the concrete.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Design Requirements

4.01.01 General

The design shall be according to CAN/CSA S6 and the Structural Manual where design is required.

4.02 Submission Requirements

4.02.01 Working Drawings

Working Drawings shall include shop drawings and drawings for handling and installation of the elements.

Three sets of fabrication Working Drawings, including supporting documentation, shall be submitted to the Contract Administrator at least 7 Days prior to commencement of fabrication of the elements, for information purposes only. Prior to making a submission, the design Engineer and the design-checking Engineer shall affix their seals and signatures on the Working Drawings verifying that the drawings are consistent with the Contract Documents.

When other authorities are involved in the approval of the design or construction of a highway structure, the fabrication Working Drawings submission shall be made at least 5 weeks prior to commencement of work and one additional copy of the submission shall be provided for each authority. The requirements of each
authority and the requirements of the Owner as specified in the Contract Documents shall be satisfied prior to commencement of the Work.

The Working Drawings shall include the following information:

a) Element details.

b) Steel reinforcement schedules

c) Lifting point locations.

d) Details and location of all temporary supports.

e) All other applicable details.

The supporting documents shall include the following information:

a) Handling and installation procedures including calculations and lifting point locations.

b) Details of bracing installed to provide adequate support and stability to the element during construction.

4.02.01.01 Additional Requirements for Prestressed Elements

In addition to the above, Working Drawings for prestressed elements shall include:

a) Prestressing reinforcing steel size, grade, location, and jacking force as required by the design.

b) Strand release sequence.

4.02.02 Concrete Mix Design

The Contractor shall be responsible for the concrete mix design and shall submit the concrete mix design according to the Mix Design clause of OPSS 1350.

When self-consolidating concrete (SCC) is proposed to be used by the Contractor, and its use is accepted by the Ministry, the requirements for submission shall be according to the specification for Self-Consolidating Concrete available from the Ministry’s Materials Engineering and Research Office, Concrete Section.

4.02.03 Concrete Plant Certification

The certificate verifying compliance of the plant with the certification requirements of the Canadian Standards Association (CSA) or Canadian Prestressed/PreCast Concrete Institute (CPCI), under the category Group B, Bridges as either subcategory B1 (Precast Bridge Products) or subcategory B2 (Prestressed Miscellaneous Bridge Products), as required for the work, shall be submitted to the Contract Administrator with the concrete mix design submission.

Copies of precast plant certification audit reports of CPCI or CSA, or both as applicable, and related documentation shall be submitted to the Owner upon request.
Documentation verifying certification of the concrete production facility by the Ready Mixed Concrete Association of Ontario shall be submitted, if concrete is supplied by a ready-mixed concrete supplier, with the concrete mix design Form A submission.

4.02.04 Control of Concrete Temperature

One week prior to the commencement of fabricating the concrete elements, a description of the method for monitoring and effectively controlling the temperature of the concrete shall be submitted to the Contract Administrator, for information purposes only. The description shall include the method of controlling and recording the concrete temperature during the curing and protection period.

4.02.05 Manufacturer’s Certificate of Conformance and Precast Report

A Manufacturer’s Certificate of Conformance and a precast report shall be submitted to the Contract Administrator for each shipment of elements, at least 5 Business Days, prior to shipping the elements. The precast report shall contain the following information:

a) List of elements including their ID number, Lot number and description.

b) The mill certificates for the steel reinforcement used in the elements shall be made available upon request.

c) Temperature records for formwork and steel at the time of concrete placement.

d) Temperature control records, including location of thermocouple wires and graphical plots verifying that neither the maximum temperature limit or maximum allowable temperature difference have been exceeded.

e) Record of inspection of moist curing.

f) Summary of material test results for plastic concrete: air content, slump and concrete temperature.

g) Summary of material test results for hardened concrete: transfer strength, confirmation of the projected 28-Day compressive strength. If test results are not available at the time of shipping, they may be submitted within 4 Business Days following completion of testing.

h) Summary of all measurements and inspections required by this specification, including the concrete cover over steel reinforcement, crack measurement summary, tolerances, and surveys for geometric control.

i) Documentation confirming that all repairable defects have been identified, evaluated, and repaired as detailed in the Repair of Defects and Deficiencies Repairable by Standard Methods clause.

j) When steam curing is used, test results indicating that time of initial set was determined, unless standard delay periods are used, according to the Steam Curing and Other Application of Heat clause.

A Request to Proceed shall be submitted to the Contract Administrator before the delivery of each shipment of elements to the site.

The elements shall not be delivered to the site until the Contract Administrator has received the Manufacturer’s Certificate of Conformance, the precast report, Request to Proceed, and issued a Notice to Proceed.
4.02.06 Additional Requirements for Prestressed Elements

In addition to the above, the report for prestressed elements shall include:

a) The mill certificates for the strands, along with the elongation calculations based on the actual material properties specified in the mill certificate of the strands used in the work.

b) Record of the jacking force, elongations, and corrections.

5.0 MATERIALS

5.01 Burlap

Burlap shall be according to AASHTO M182, Class 4, and shall be free from substances that are deleterious to concrete. The burlap shall have no tears or holes.

5.02 Concrete

Concrete materials shall be according to the Materials section of OPSS 1350 with the following additions and amendments:

a) Compressive strength shall be as specified in the Contract Documents.

b) The air void system in hardened concrete when tested according to LS-432 shall be:
   i. Air Content: 3.0% minimum
   ii. Spacing Factor: 0.200 mm maximum

c) Rapid chloride permeability of concrete containing silica fume at 28 to 32 Days shall be equal to or less than 1,000 coulombs and rapid chloride permeability of all other concrete at 28 to 32 Days shall be equal to or less than 2,500 coulombs.

d) Superplasticizer may be added to the mix at time of batching for all types of concrete.

When self-consolidating concrete (SCC) is proposed to be used, it shall be subject to Owner acceptance prior to use. Where accepted for use, SCC shall be according to the Owner’s requirements for self-consolidating concrete. A copy of the requirements can be obtained from the Materials Engineering and Research Office, Concrete Section.

5.03 Concrete Sealers

Concrete sealers shall be from the Owner’s list of acceptable sealers.

5.04 Elastomeric Coating

Elastomeric coating shall be according to OPSS 1213

5.05 Formwork

All formwork shall be according to OPSS 919 and CAN/CSA A23.4. Formwork shall be fabricated to meet the dimensional tolerances and finishes required in the Contract Documents.
5.06 Hardware

All hardware shall be non-corroding or be galvanized according to ASTM A153.

Surfaces of hardware located within 40 mm of the concrete surface shall be chromate coated over an electro-deposited coating of zinc according to ASTM B633.

5.07 Moisture Vapour Barrier

The moisture vapour barrier shall be white opaque polyethylene film according to ASTM C171 and shall not be less than 100 µm thick.

5.08 Post-Tensioning Material

Post-tensioning material, including grout, shall be according to OPSS 910.

5.09 Proprietary Patching Materials

Proprietary patching materials shall be from the Owner’s List of Acceptable Concrete Patching Materials. The list of proprietary patching materials shall be obtained from the Contract Administrator.

5.10 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

5.11 Water

Water used for curing, fog-misting, and steam curing of concrete, including presoaking of material for moist curing, shall be according to OPSS 1302.

6.0 EQUIPMENT

6.01 Chipping Hammers

Chipping hammers shall have a maximum weight of 9.0 kg and a maximum piston stroke of 102 mm. All hammers shall have the manufacturer’s name and model number engraved on them by the manufacturer. All information must be legible.

6.02 Equipment for Pretensioning and Post-Tensioning

Pretensioning equipment shall be according to CSA A23.4. Post-tensioning equipment shall be according to OPSS 910.

6.03 Temperature Monitoring and Recording System

The temperature monitoring and recording system shall provide unalterable records of temperature during the recording period. Prior to use on the Contract, the temperature monitoring and recording system shall be confirmed by the Owner, in writing, to be acceptable.

Thermocouples and associated instrumentation shall have an accuracy of ± 1.5 °C, shall record temperatures at time intervals not exceeding 15 minutes and shall display the temperature.
7.0 CONSTRUCTION

7.01 Fabrication

7.01.01 General

The Contract Administrator shall be notified in writing at least 7 Days prior to commencement of fabrication.

Precast elements of the same type and for a given component shall be fabricated from the same materials and mix design regardless of whether or not they are cast in the same facility.

Each concrete element shall be identified with a unique number and the date of casting within 24 hours of stripping forms. The information marked on the elements shall remain exposed and visible throughout the duration of construction. Markings shall be stencilled, using indelible ink or paint.

7.01.02 Precast Plant Certification

Precast elements shall be fabricated by a plant certified by CSA or by CPCI under the category Group B, Bridges, as either subcategory B1 (Precast Bridge Products) or subcategory B2 (Prestressed Miscellaneous Bridge Products), as required for the work.

7.01.03 Strand Splicing

Strands shall not be spliced within the concrete element.

7.01.04 Welding

Welding of steel hardware, including shear studs, shall be according to CSA W59 and shall be performed by a qualified welder working for a company certified by the Canadian Welding Bureau according to CSA W47.1.

Welding of reinforcing steel bars shall be according to CSA W186 and shall be performed by a qualified welder working for a company certified by the Canadian Welding Bureau according to CSA W186.

For prestressed elements, welding within 3 m of the prestressing steel is not permitted unless the prestressing steel is fully encased in concrete that has reached the transfer strength specified in the Contract Documents. Welding equipment shall not use any components of the prestressing system or any component in contact with the prestressing system as an electrical ground.

7.01.05 Steel Reinforcement

The placement of steel reinforcement shall be according to OPSS 905.

Under no circumstance shall reinforcement be inserted into plastic concrete.

7.01.06 Placing of Sheaths and Anchorages for Prestressed Elements

When elements are to be post-tensioned, the sheaths and anchorages shall be placed as specified in the Contract Documents except that the placing tolerances shall be ± 5 mm at splice points and ± 10 mm elsewhere.
7.01.07 Production of Concrete

Production of concrete shall be according to the General, Temperature Control, Mixing Time and Mixing Rate, and Delivery subsections in OPSS 1350.

When there are multiple batches of concrete in a single ready-mix truck, hopper or other container, the discharge times shall be measured from the time water is first added to the cement for the first batch of concrete in the truck, hopper or other container. Discharge of all concrete in the truck, hopper or other container shall be completed within 1.5 hours, except when the air temperature exceeds 28 °C and the concrete temperature exceeds 25 °C, the discharge shall be completed within 1.0 hour.

7.01.08 Placing of Concrete

7.01.08.01 General

The method of transporting, placing and consolidating the concrete shall be such as to prevent segregation.

Devices for placing and transporting concrete shall not be supported by the steel reinforcement.

Concrete shall be deposited within 0.5 m of the top of the reinforcement and the 2.5 m horizontally of its final position.

Concrete shall be placed at a steady rate, such that a monolithic concrete is obtained without the formation of cold joints or pour lines.

When there is an interruption in placing concrete greater than 20 minutes, the top of the formwork shall be covered with wet burlap to maintain 100% relative humidity above the concrete. The Contract Administrator shall be notified of any interruption resulting in a cold joint. A proposal for remedial action shall be submitted to the Contract Administrator for approval by the Owner.

7.01.08.02 Concrete Placing Restrictions

All surfaces against which concrete is to be placed shall be free of standing water. Fresh concrete shall be protected from contact with rain or snow.

All debris shall be removed from the area where concrete is to be placed.

Any surface against which concrete is placed, including any existing concrete, steel reinforcement, structural steel, forms, or other surfaces shall be at a minimum temperature of 5 °C immediately prior to commencement of placing concrete.

The temperature of the formwork, steel reinforcement or any other material against which concrete is to be placed shall not exceed 30.0 °C.

Temperature measurements shall be taken no more than 10 minutes prior to concrete placement, for each element. Temperature measurements shall be made with a contact thermometer with an accuracy of ± 1 °C. Temperature measurements shall be recorded and included in the precast report.
7.01.09 Consolidation

Internal or external vibrators or both shall be used to thoroughly consolidate concrete, within 15 minutes of placing.

Concrete shall be thoroughly consolidated around all steel reinforcement.

Each layer of concrete shall be vibrated. Vibrators shall extend into the previous layer to produce a homogenous mixture at the layer interface and prevent the formation of pour lines or cold joints.

Vibration shall not be used to make the concrete flow or to spread the concrete more than 1.5 m from the point of deposit.

The above requirements of this clause do not apply to self-consolidating concrete, where accepted for use.

7.01.10 Concrete Finishing

Finishing of the concrete surface shall be done immediately following placement.

No material shall be applied to the concrete surface or the finishing tools to aid in the finishing.

The surface shall be smooth, free from open texturing, undulations, projections, and ridges.

The following surfaces shall be abrasive blast cleaned according to OPSS 929, prior to shipping the elements:

a) Top portion of elements containing laitance.

b) The portion of the element against which new concrete is to be placed.

All concrete surfaces against which new concrete is to be placed shall be clean, sound, and free from any loose particles and laitance.

7.01.11 Control of Temperature

7.01.11.01 General

All necessary actions shall be taken to maintain temperatures within the specified limits. During production, moist curing and the cold weather protection period, the following temperature requirements shall be met:

a) The concrete temperature shall not exceed 60 °C, except if the precast element has a maximum thickness greater than 500 mm, then the concrete temperature shall not exceed 65 °C.

b) The concrete temperature shall not fall below 10 °C before the end of moist curing.

c) The concrete temperature shall not fall below 0 °C before the end of the cold weather protection period.

d) The temperature difference, as measured between thermocouples at the following locations, shall not exceed 20 °C:
   i) Internal concrete temperature and the corresponding surface concrete temperatures.
   ii) Internal concrete temperatures at different locations within the element.
e) The maximum cooling rate of concrete shall not exceed 15.0 °C per hour until the concrete is not more than 20.0 °C above the air temperature. Air temperature is to be measured adjacent to the concrete, within the curing enclosure.

7.01.11.02 Temperature Monitoring and Records

The concrete and air temperatures during the curing period and, if applicable, the cold weather protection period shall be monitored and recorded.

The concrete temperature shall be measured and recorded on each element. As a minimum, thermocouples shall be installed to measure:

a) Air temperature adjacent to the element.

b) The maximum internal temperature, located centrally within the element at the maximum section thickness.

c) For an element with a thickness greater than 200 mm, corresponding surface concrete temperature imbedded in the concrete within 5 mm of the surface, at the maximum section thickness.

Recording of concrete and air temperatures shall begin at the start of placement. The temperatures shall be recorded automatically at time intervals not exceeding 15 minutes until the end of the curing period and, if applicable, the end of the cold weather protection period. The dataloggers shall be left in place until the end of the monitoring period.

The Contract Administrator and any other Owner’s representatives shall be provided access to verify temperature readings and thermocouple function.

A record of temperatures shall be prepared for each Day during the temperature monitoring period.

The record of temperatures, including a graphical plot of temperature versus time, shall be submitted to the Contract Administrator in the precast report. The format of the temperature plot shall be acceptable to the Owner.

7.01.12 Curing

7.01.12.01 General

Concrete elements shall be moist cured for 4 days. Concrete elements containing silica fume shall be moist cured for 7 Days.

Moist curing of exposed surfaces shall commence immediately after concrete placement.

During the moist curing period, elements may be exposed to ambient conditions as per the Exposure clause for the purposes of form removal, filling of bug holes, inspection, and storage.

7.01.12.02 Moist Curing

Moist curing shall be sufficient to keep all surfaces of the precast element in a continuously wet condition, with no dry areas, by applying one or a combination of the following methods:
a) Curing with burlap and water  
b) Curing with water mist  
c) Steam curing  
d) Immersion

Records of moist curing shall be maintained and submitted according to the Precast Report clause. The records shall provide evidence that curing is being confirmed and is satisfactory. As a minimum, records of moist curing shall include the identification of the person checking the moist curing and the time that it was confirmed.

Elements whose surfaces have not been kept in a continuously wet condition shall be rejected and replaced.

Formwork shall be removed from bridge deck components within 24 hours of concrete placement and all surfaces previously covered by forms shall be immediately moist cured as above for the remainder of the specified curing period.

For all other elements, formwork shall be removed within 4 Days of concrete placement and shall be cured with moist curing material for the remainder of the minimum curing period and no less than 24 hours.

7.01.12.03 Curing with Burlap and Water

Burlap shall be pre-soaked by immersing it in water for a period of at least 24 hours immediately prior to placing. Two layers of burlap shall be applied to the surface of the concrete. Burlap strips shall overlap 150 mm and shall be held in place without marring the surface of the concrete.

The burlap shall be maintained in a continuously wet condition throughout the curing period by means of a soaker hose. The soaker hose shall be turned on as soon as possible, when running water will not cause damage to the concrete surface. The burlap shall be covered with a layer of moisture vapour barrier within 3 hours of placing of the concrete, in a manner that shall prevent deformation of the surface of the concrete.

Air flow in the space between the burlap and the element shall be prevented.

Water shall not be allowed to drip, flow or puddle on the concrete surface until the concrete has hardened sufficiently to resist damage.

7.01.12.04 Steam Curing and Other Application of Heat

Application of steam may be used.

The element shall be heated evenly. Steam, heat or forced air shall not be directed on the concrete, forms or reinforcing steel. There shall be free circulation of steam, heat and forced air around the top, sides, and ends of the element. Concrete surfaces shall not be exposed to combustion gases during the curing cycle.

There shall be a delay period prior to application of steam or heat above 30 °C, as follows:

a) Delay period of four hours after completion of concrete placement if the mix does not contain a retarder.

b) Delay period of six hours after completion of concrete placement if the mix contains a retarder.

A shorter delay period may be used if it has been demonstrated to the satisfaction of the Owner that initial set occurs earlier. Time of initial set shall be demonstrated by testing according to ASTM C403, using the same...
mix design, mixing equipment, concrete temperature, and ambient temperature as when producing the elements. Time of initial set testing shall be done in the presence of the Contract Administrator or the Owner’s representative. Time of initial set testing shall be done before production. Demonstration of the time of initial set according to ASTM C403 may be required up to two times per year, upon request by the Contract Administrator.

7.01.13 Cold Weather Protection Period

If cold weather conditions are present at the end of the curing period, the elements shall be provided with protection from cold weather and moisture loss for an additional 24 hours, prior to exposure to cold weather conditions. Protection shall be extended beyond 24 hours if required to meet the requirements in the Control of Temperature clause.

7.01.14 Exposure

During moist curing and cold weather protection periods, the element may be exposed for a maximum total period of 1 hour per day for the purposes of formwork removal, removal from the bed, filling of bug holes, inspection or relocation within the plant, except for indoor precast concrete plants, where the exposure period shall not exceed 2 hours per day.

During the exposure period:

a) The requirements in the Control of Temperature clause do not apply.

b) There shall be no more than 3 consecutive thermocouple measurements of surface temperature below 10 °C, and none below 5 °C, when measured at 15 minute intervals.

On the first day only of the moist curing period, the moist curing requirements do not apply during the 1-hour exposure period (or 2-hour exposure period for indoor precast concrete plants), except for concrete containing silica fume where continuous moist curing shall be applied throughout the exposure period.

7.01.15 Transfer of Prestressing Force for Prestressed Elements

The prestressing force shall not be transferred to the elements until the transfer strength specified in the Contract Documents has been reached. The prestressing force shall be transferred according to the strand release sequence specified on the Working Drawings.

7.01.16 Treatment at Ends of Elements for Prestressed Elements

The prestressing strands at ends of elements that are to be encased in concrete shall be cut off 25 mm beyond the ends of the elements, unless otherwise specified in the Contract Documents. The prestressing strands at the end of elements that are not to be encased in concrete shall be cut back to recess the cable 25 mm from the end of element, unless otherwise specified in the Contract Documents. The recess shall be cleaned, filled with a proprietary patching material, and the ends of the elements coated with elastomeric coating.

7.01.17 Surface Finish

7.01.17.01 General

Concrete surfaces shall not be treated with cement slurry or paste.
Bugholes with a depth less than or equal to 5 mm and a maximum dimension at the surface of 50 mm do not require repair.

Surface defects and deficiencies with dimensions as shown in Table 2 are repairable by standard methods according to Table 2.

A repair proposal may be submitted to the Contract Administrator to repair surface defects and deficiencies with dimensions greater than those listed in Table 2.

7.01.17.02 Exposed Surfaces

The appearance of the concrete and repairs shall be uniform in colour, pattern, and texture when viewed from a distance of 15 m. Material, including proprietary patching materials, shall be selected to achieve uniformity of colour and appearance. This requirement shall apply to all repair methods specified in Table 2.

All projections, such as fins and bulges, and all blemishes, such as stains and rust marks, shall be removed.

7.01.17.03 Surface Tolerance

Formed and unformed surfaces shall be such that, when tested with a 3 m long straight edge placed anywhere in any direction on the surface, there shall be no gap greater than 6 mm between the bottom of the straight edge and the surface of the concrete. When the straight edge is placed across a closure strip the gap between the straight edge and the surface of the concrete shall not be greater than 6 mm.

7.01.18 Sampling and Testing of Plastic Concrete

Sampling and testing of the plastic concrete for slump, air content, and temperature shall be according to OPSS 1350. The results of these tests shall be recorded. The minimum frequency of testing shall be as follows:

a) For concrete supplied by an external concrete supplier and delivered by a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.

b) For batches of concrete produced at the precast plant and transported to a ready-mix truck, once for each of the first three trucks, until satisfactory control is established, and then once every third truck.

c) For batches of concrete produced at the precast plant, and not delivered by a truck, once for each of the first five batches of concrete, until satisfactory control is established, and then once every fifth batch.

Satisfactory control is established when three or five consecutive tests of concrete, as specified above, are within the specified requirements, without adjustments. If any adjustments are required or conducted, testing shall continue until three or five consecutive tests, as specified above, meet the requirements with no field adjustments. Satisfactory control shall be established each Day or when there is a break in production longer than 1.5 hours.

Testing of plastic concrete shall be carried out as close as possible to the location of discharge of concrete into the formwork.

Sampling and testing of slump, air content and temperature of plastic concrete shall be carried out by a person holding either of the following certifications:
a) CCIL Certified Concrete Testing Technician; or

b) ACI Concrete Field Testing Technician - Grade 1

This person shall have a valid, original card issued by the certifying agency in his or her possession at all times.

7.01.19 Transfer Strength for Prestressed Elements

Prior to transfer of the prestressing force, it shall be demonstrated that the transfer strength specified in the Contract Documents has been achieved. The Contractor, when requested by the Owner, shall participate in standard cylinder correlation strength testing programs conducted by the Owner.

7.01.20 Stripping Strength

Prior to stripping the formwork, it shall be demonstrated that the stripping strength specified in the Contract Documents has been achieved. The Contractor, when requested by the Owner, shall participate in standard cylinder correlation strength testing programs conducted by the Owner.

7.01.21 Concrete Cover

The Contractor shall carry out, at the precaster’s facility, a cover meter survey on all elements until satisfactory control is established. For each type, design and size of element, satisfactory control shall be established when three consecutive elements of the same design are within the specified tolerances. After satisfactory control has been established, testing shall be carried out on every fifth element. If testing indicates that cover measurements for an element do not meet the tolerances specified, testing shall resume on each element until satisfactory control is re-established.

Readings shall be taken at locations 500 mm from all corners in a 1 m grid pattern along all surfaces of the element. The results of the concrete cover survey shall be included in the precast report.

All elements shall meet the cover requirements as specified in Table 1.

7.01.22 Dimensional Tolerances

The Contractor shall carry out measurements on each element to determine compliance with tolerance requirements. Elements shall meet the tolerances specified in Table 1 and the Contract Documents.

For dimensional tolerances not specified, the maximum allowable dimensional variation shall be 1:800 or ± 5 mm, whichever is greater.

7.02 Delivery

The Contract Administrator shall be notified in writing 3 Business Days prior to delivery of the elements.

Delivery shall include transportation, loading and unloading, and storage of the elements at the storage site. Transportation and storage of the elements shall be according to CSA A23.4.

Storage includes, but is not limited to, storage while awaiting delivery in temporary locations or, at the job site.
Elements shall be loaded for shipping in such a manner that they can be transported and unloaded at their destination without being damaged or exposed to stresses for which they were not designed.

Elements, when stored, shall be stored in such a manner to avoid excessive stress or other damage.

Advertising by means of removable signing is permitted on elements only while in transit to the specified site. Any other markings on a surface that would be visible after installation shall not be permitted.

Pockets for hardware that are used for shipping and handling shall be reinstated with a proprietary patching material.

7.03 Installation

The Contract Administrator shall be notified in writing of the installation date at least 3 Business Days prior to the commencement of installation. Installation shall be according to CSA 23.4 and the Working Drawings.

The work shall consist of installation and stabilization of the elements. Elements shall be lifted and placed in a manner to ensure they are not overstressed, unstable, or unsafe at any time.

A copy of the Working Drawings shall be kept on the site during installation of the elements.

The Contractor shall inspect the elements for defects before installation.

7.04 Inspection after the Installation of the Elements

A Request to Proceed shall be submitted to the Contract Administrator after the installation of all elements for each structure within a construction stage.

The next operation shall not proceed until a Notice to Proceed has been received from the Contract Administrator.

7.05 Repair of Defects and Deficiencies Repairable by Standard Methods

Any individual element having one or more of the defects and deficiencies specified in Table 2 shall be repaired according to the repair method specified. Such repairs do not require proposals or Owner approval.

Where more than one of the defects or deficiencies listed in Table 2, excluding bugholes, is located in the same area in the element, a repair proposal shall be submitted to the Contract Administrator. All causes, preventative actions, and corrective actions including repair methods and materials used shall be documented and submitted in the precast report.

7.05.01 Assessment of Repair

The Owner may require at their discretion that additional visual inspection be carried out or that further investigative measures, including the removal or cores or other means of assessment be undertaken, to assess the effectiveness of the repair.

The filling of core holes shall be according to OPSS 1350.
7.06  Material Sampling for Acceptance Testing

7.06.01  Sampling of Steel Reinforcement

When requested, samples of steel reinforcement shall be provided to the Owner according to OPSS 905.

7.06.02  Sampling of Water, Admixtures, and Cementing Materials

When requested by the Owner, samples of all cementing materials, admixtures, and water shall be obtained for testing by the Owner.

7.06.03  Sampling of Hardened Concrete for Acceptance Testing

7.06.03.01  General

Precast concrete products shall be sampled on a lot basis for each element type.

Test specimens shall consist of cores removed from completed elements for determination of compressive strength, air void system parameters of hardened concrete and rapid chloride permeability. Test specimens shall be delivered to the designated laboratory for testing by the Owner.

The Contractor shall be responsible for removing cores from the precast elements for testing by the Owner.

7.06.03.02  Notification

A list of elements and their identification numbers shall be submitted to Contract Administrator within 24 hours of completion of a lot.

7.06.03.03  Coring

One set of cores shall be obtained from each lot for quality assurance testing as directed by the Contract Administrator. A set of cores shall consist of six 100 mm diameter and 200 mm long cores. If the element is less than 200 mm thick, the full depth of the element shall be cored such that the core has a length to diameter ratio of at least 1.5, but shall not exceed a minimum diameter of 75 mm.

Cores shall be removed when the element is between 7 to 10 Days of age, and prior to application of any sealer and/or waterproofing membrane. Cores shall be removed in the presence of the Contract Administrator or Owner’s representative. No core shall be taken within 250 mm of any joint or element edge. The element from which core samples shall be taken shall be randomly selected from the lot by the Contract Administrator. All cores of the same set shall be removed at a location no more than 2 meters from the location of the first core for that set.

Coring shall be carried out according to CSA A23.2-14C. Cores shall not contain reinforcement or other embedded material. A covermeter capable of detecting the type(s) of reinforcing materials in the element shall be used to establish the location of reinforcement and other embedded material prior to coring. Care shall be taken to avoid existing prestressing strands.

The contract number, lot number, and element identification number shall be marked legibly on each core with durable ink. Each core shall be placed in a plastic bag, sealed to prevent loss of moisture, fitted with a security tag by the Contract Administrator.
The core holes shall be filled, within 3 Days, according to the Filling of Core Holes subsection of OPSS 1350, with concrete or a proprietary patching material from the Owner’s pre-qualified products list. Concrete used to patch core holes shall have comparable properties to that of the concrete used in the element.

7.07 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

8.0 QUALITY ASSURANCE

8.01 General

The acceptance of elements shall be according to the requirements of this specification, including satisfactory completion of all repairs, if applicable. Elements not meeting the requirements of the Contract Documents shall be deemed unacceptable and shall not be included in the Work.

Acceptance for compressive strength, air void system parameters, and rapid chloride permeability shall be on a lot basis. The lot size shall represent 7 consecutive Days’ production and shall be confirmed with the Contract Administrator prior to commencing production. The established lot size shall remain consistent for the duration of the Contract. Lots not meeting the requirements of the Contract Documents shall be deemed unacceptable and shall not be included in the Work.

8.02 Acceptance of Concrete Compressive Strength

Compressive strength shall be determined according to CSA A23.2-14C on moisture conditioned cores.

Three cores shall be tested to determine the acceptability of compressive strength of the lot. Twenty-eight (28) day concrete compressive strength of a lot shall be considered acceptable when the average of the three individual compressive strength cores is equal to or greater than the specified strength and no individual core result shall be more than 10% below the specified 28 Day compressive strength.

Unacceptable lots shall be rejected and replaced.

Test results shall be forwarded to the Contractor as they become available.

8.02.01 Referee Testing of Compressive Strength

Referee testing of compressive strength may only be invoked by the Contractor within 5 Business Days of receipt of the acceptance test result.

Referee testing of compressive strength shall be carried out on a set of three cores taken by the Contractor from the same element which the acceptance cores represent. The cores shall be 100 mm in diameter and 220 mm long or full depth, whichever is less. The core extraction shall be according to the Coring clause, with the exception that if the elements have not been delivered to the construction site, coring shall take place at the precast plant. Referee cores shall be obtained and transported to the referee laboratory designated by the Owner within 3 Business Days of invoking referee testing.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to CSA A23.2-9C on moisture conditioned cores.

Referee test results shall be forwarded to the Contractor as they become available.
The confirmation value for confirming the acceptance test result shall be the greater of 10% of the specified strength or 10% of the strength of the acceptance cores, expressed to one decimal place.

If the difference between the referee test result and the acceptance test result is less than the confirmation value, the acceptance test result is confirmed, and the acceptance test result shall be used in the determination of acceptance of the Lot. If the difference between the referee test result and the acceptance test result is greater than the confirmation value, the acceptance test result is not confirmed, and the acceptance test result shall be disregarded, and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The cost of referee testing of compressive strength shall be according to OPSS 1350.

8.03 Acceptance of Air Void System in Hardened Concrete

Testing of air void system shall be according to LS-432. One half of a core shall be tested to determine the acceptability of the lot. The other half of the core shall be retained by the Owner for audit purposes.

Test results shall be forwarded to the Contractor as they become available.

For a lot to be considered acceptable, the core shall have air content of 3.0% or more and spacing factor of 0.200 mm or less. Acceptable lots shall be subject to full payment.

Lots with samples with a spacing factor between 0.200 mm and 0.250 mm shall be considered unacceptable. Unacceptable lots shall be removed and replaced, except where the owner permits the work to remain in place. When the Owner permits the work to remain in place it shall be subject to a payment adjustment. The payment adjustment shall be calculated according to the Basis of Payment section.

Lots with samples with spacing factor more than 0.250 mm or air content less than 3.0% shall be rejected and replaced.

8.03.01 Referee Testing Air Void System in Hardened Concrete

Referee testing of air void system parameters shall be according to OPSS 1350.

The cost of air void system referee testing shall be according to OPSS 1350.

8.04 Acceptance of Rapid Chloride Permeability

Acceptance of rapid chloride permeability shall be based on the result obtained on the core representing the lot.

One core per lot shall be tested according to LS-433. Acceptance testing shall be carried out at 28 to 32 Days. Two samples 50 mm long shall be cut from the core representing a lot, tested and averaged to determine the acceptance of the lot. Another core shall be retained for referee testing.

Lots with rapid chloride permeability less than 2,500 coulombs are considered acceptable. Lots with a rapid chloride permeability result greater than 2,500 coulombs and less than or equal to 3,500 coulombs shall be considered unacceptable but with the agreement of the Owner, may be permitted to remain in the Work with a payment adjustment. The payment adjustment shall be calculated according to the Basis of Payment section.
Lots with rapid chloride permeability results exceeding 3,500 coulombs shall be rejected and replaced.

For concrete lots containing silica fume, rapid chloride permeability less than 1,000 coulombs are considered acceptable. Lots containing silica fume with a rapid chloride permeability result greater than 1,000 coulombs and less than or equal to 2,000 coulombs shall be considered unacceptable but, with the agreement of the Owner, may be permitted to remain in the Work with a payment adjustment. The payment adjustment shall be calculated according to the Basis of Payment section.

Lots containing silica fume with rapid chloride permeability results exceeding 2,000 coulombs shall be rejected and replaced.

Test results shall be forwarded to the Contractor as they become available.

8.04.01 Referee Testing of Rapid Chloride Permeability

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 7 Days of receipt of the acceptance test result.

Referee testing shall be carried out on 2-50 mm samples obtained from the reserved core representing the lot for which referee testing was invoked, and the results shall be averaged to obtain the test result for the lot.

The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested by that laboratory.

Referee test results shall be forwarded to the Contractor as they become available.

When the referee result is greater than the acceptance test result or no more than 200 coulombs below the acceptance test result, the acceptance test result is then confirmed and shall remain valid. When the referee test result for the lot is more than 200 coulombs below the acceptance test result, the acceptance test result is then not confirmed, and the referee test result shall replace the acceptance test result in the acceptance requirements of this specification.

The cost of referee testing of rapid chloride permeability for all concrete shall be according to OPSS 1350.

8.05 Acceptance of Water, Admixtures, and Cementing Materials

Acceptance of water, admixtures and cementing materials shall be according to OPSS 1350.

8.06 Acceptance of Concrete Temperature

Elements that meet the temperature requirements of this specification during production, the curing period, and, if applicable, the cold weather protection period, are considered acceptable. Elements that do not meet one or more of the temperature requirements of this specification are considered unacceptable and shall be rejected and replaced.

8.07 Acceptance of Surface Finish

All elements meeting the surface finish requirements of this specification shall be considered acceptable. A proposal for repair or remediation may be submitted by the Contractor for unacceptable surface finish, according to the All Other Defects and Deficiencies clause.
8.08 Dimensional Verification and Concrete Cover Measurements

The Contract Administrator shall carry out measurements to confirm compliance with the requirements of Table 1.

If an element fails to meet the requirements specified in Table 1, it shall be rejected and replaced, and a consultant shall be retained by the Owner at the Contractor’s expense, to verify all other elements are within the tolerances specified in Table 1.

The Contractor may submit a proposal for remediation or for use of the element, subject to the approval of the Owner.

8.09 Defects and Deficiencies

8.09.01 Defects and Deficiencies Repairable by Standard Methods

Any individual element having one or more of the defects and deficiencies listed in Table 2 shall be deemed unacceptable. Unacceptable elements shall be repaired according to Table 2.

When more than one of the defects or deficiencies listed in Table 2 is located in the same area in the element, the Contractor shall be required to submit a repair proposal for acceptance according to the All Other Defects and Deficiencies clause.

8.09.02 Defects and Deficiencies Causing Rejection

An element having any one of the following defects and deficiencies shall be rejected:

a) If concrete temperature exceeds 60 °C, or if the precast element has a maximum thickness greater than 500 mm and the concrete temperature exceeds 65 °C, at any time during the curing period.

b) If concrete temperature falls below 0°C during the moist curing and cold weather protection period.

c) If there is honeycombing, voids, cavities, spalls, delaminations, or cracks, in the concrete that exceed the conditions described in Table 2.

d) If there is a crack that extends through to the opposite face.

e) If breakage of strand wires in prestressed elements exceeds the limit permitted in CAN/CSA A23.4.

f) If cover does not meet specified requirements except as indicated in the All Other Defects and Deficiencies clause.

If the element is deemed rejectable, the element shall not be incorporated into the Work.

8.09.03 All Other Defects and Deficiencies

A repair proposal signed and sealed by an Engineer shall be submitted to the Contract Administrator for acceptance, when,

a) An element has defects or deficiencies that are not identified as rejectable or included in Table 2 in the list of defects and deficiencies repairable by standard methods; or
b) More than one of the defects or deficiencies listed in Table 2, except for bugholes, are located in the same area in the element; or

c) Three occurrences of the same defect are present in the element; or

d) There is the presence of pour lines or cold joints; or

e) Unacceptable surface finish; or

f) The compressive strength of the lot is lower than specified, but not lower than 10% below the specified strength; or

g) Dimensional tolerances of the element do not meet the requirements of this specification; or

h) Failure to maintain moist curing has occurred.

i) For prestressed elements, failure to comply with relevant requirements for stressing where applicable.

The repair proposal, shall include as a minimum:

a) Description of the element and identification of the defects or deficiencies.

b) Detailed sketches, width, length, depths, location and nature and frequency of any defects.

c) An assessment of any impact of the repaired defect(s) on durability, structural adequacy and integrity of the element or on the structure.

d) A detailed repair plan including materials, method and equipment to be used.

e) Verification that the repair plan complies with the applicable standards for the type of work.

f) All relevant supporting information, including material test results, field measurements and observations, production records, photographs, and structural analysis calculations, used for determining that the performance and function originally expected from the element shall be met.

g) Cause(s) of the defect and corrective action to be taken to prevent recurrence of the defect in future production, delivery or installation.

If the repair proposal is deemed acceptable, the element shall be repaired according to the proposal. Repairs shall not be carried out without the prior acceptance of the proposal by the Contract Administrator. If the repair proposal is deemed unacceptable, the element shall be rejected and replaced.

If the Engineer’s assessment is deemed acceptable by the Contract Administrator, the element shall be accepted. If deemed unacceptable, the element shall be rejected and replaced.

8.10 Assessment of Repairs

The Contract Administrator shall conduct a visual inspection and/or other measures as required, including requesting additional coring, covermeter surveys or any other testing deemed necessary to assess the effectiveness of the repairs.
9.0 MEASUREMENT FOR PAYMENT - Not Used

10.0 BASIS OF PAYMENT

10.01 Precast Concrete Bridge Elements, Fabrication - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Rejected elements shall be replaced at no additional cost to the Owner.

10.02 Payment Adjustment for Air Void System in Hardened Concrete

Payment for unacceptable lot represented by the core shall be calculated according to the following:

Payment reduction for a lot = Lot quantity/tender quantity x Price x ((100 – P)/100)

Where:
- Lot quantity = volume of concrete in a lot (m³) (calculated based on plan dimension)
- Tender quantity = volume of concrete in tender (m³) (calculated based on plan dimension)
- Price = Contract price for tender item
- P = pay factor for the lot according to the spacing factor specified below:

<table>
<thead>
<tr>
<th>Spacing Factor, mm</th>
<th>Pay Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200 to 0.220</td>
<td>90</td>
</tr>
<tr>
<td>0.220 to 0.240</td>
<td>80</td>
</tr>
<tr>
<td>0.240 to 0.250</td>
<td>70</td>
</tr>
</tbody>
</table>

10.03 Payment Adjustment for Rapid Chloride Permeability

The payment adjustment shall be calculated based on individual lots and applied as follows:

Payment adjustment = Lot quantity x (C-2500)/5

Where:
- Payment adjustment = payment adjustment of a Lot ($)
- C = rapid chloride permeability of a Lot (coulombs)
- Lot quantity = volume of concrete in a lot (m³) (calculated based on plan dimension)

The payment adjustment for concrete containing silica fume shall be calculated based on individual lots and applied as follows:

Payment adjustment = Lot quantity x (C-1000)/5

Where:
- Payment adjustment = payment adjustment of a lot ($)
- C = rapid chloride permeability of a lot (coulombs)
- Lot quantity = volume of concrete in a lot (m³) (calculated based on plan dimension)
Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment, and Material to do the work.

### Table 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (Note 1) Straight-line measurement taken horizontally at the mid-height of element in the longitudinal direction</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Width (Note 1) Straight-line measurement taken horizontally at the mid-height of element in the transverse direction</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Nominal Depth Straight-line measurement taken vertically at the mid-length of element</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Variation from Specified Plan End Squareness or Skew</td>
<td>± 10 mm</td>
</tr>
<tr>
<td>Horizontal Alignment (Deviation of straightness from all element edges)</td>
<td>± 10 mm</td>
</tr>
<tr>
<td>Stirrup Projection from Surface (Note 2)</td>
<td>± 15 mm</td>
</tr>
<tr>
<td>Shear Key Depth (Note 2)</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Shear Key Width (Note 2)</td>
<td>± 5 mm</td>
</tr>
<tr>
<td>Location of Blockout (Note 2)</td>
<td>± 25 mm</td>
</tr>
<tr>
<td>Size of Blockout (Note 2)</td>
<td>± 25 mm</td>
</tr>
<tr>
<td>Location of Inserts (Note 2)</td>
<td>± 25 mm</td>
</tr>
<tr>
<td>Concrete Cover Over Steel Reinforcement</td>
<td>Concrete cover shall be in accordance with OPSS 905 unless otherwise specified in the Contract Documents.</td>
</tr>
</tbody>
</table>

Notes:
1. Overall length and width of assembled units side by side shall have a combined tolerance of ± 25 mm
2. Not all elements contain the described feature.
<table>
<thead>
<tr>
<th>Repairable Defects and Deficiencies</th>
<th>Condition</th>
<th>Repair Method</th>
</tr>
</thead>
</table>
| Bugholes                           | Bugholes with depth greater than 5 mm and all dimensions at the surface not exceeding 25 mm, or depth less than or equal to 5 mm and any dimension at the surface greater than 50 mm and not exceeding 100 mm. | a) Prior to filling bugholes, surfaces shall be blasted with high pressure water to remove any weak or loose material.  
  b) Bugholes shall be filled with a proprietary patching material placed and cured according to the manufacturer’s instructions. |
| Honeycombing, Voids, Cavities, Spalls, and Delaminations | Any area less than an equivalent area of 300 mm x 300 mm with no steel reinforcement exposed. | a) Square all sides of the repair area.  
  b) Sawcut perimeter of removal area to a depth of 10 mm or to the depth of steel reinforcement, whichever is less.  
  c) Remove all loose concrete using a chipping hammer or hand tools.  
  d) Insert corrosion resistant wires and anchors.  
  e) Abrasive blast clean all concrete surfaces to be patched according to OPSS 929.  
  f) Remove all dust and loose material from the prepared surface by using compressed air.  
  g) Moisten area to be repaired.  
  h) Fill repair area with concrete or a proprietary product patching material.  
  i) Cure concrete according to this Special Provision. Cure proprietary patching material according to the manufacturer’s recommendations. |
| Low Cover                           | Low cover readings between -5 mm and -10 mm of the specified cover. | The entire surface of the element shall be sealed with a two-component sealer acceptable to the Owner. Areas against which concrete is to be placed shall not be sealed. |
| Cracks                             | > 0.3 mm | a) Repair cracks in the areas where the total linear measurement of crack per m² is < 5 m. Repair shall be according to OPSS 932.  
  b) Remove and replace the cracked areas where the total linear measurement of crack per m² is ≥ 5 m. Removals and preparation of concrete shall be according to OPSS 930.  
  | ≤ 0.3 mm | Apply sealer acceptable to the ministry to the cracked areas. Where the total linear measurement of crack per m² is ≥5m the entire element shall be sealed. |