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

MATERIAL AND CONSTRUCTION SPECIAL PROVISION FOR PRECAST CONCRETE BRIDGE ELEMENTS AND SYSTEMS

1.0 SCOPE

This Special Provision covers the requirements for material, fabrication, delivery, and construction requirements for precast concrete bridge elements and systems.

2.0 REFERENCES

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

Ontario Provincial Standard Specifications, Construction

OPSS 904	Concrete Structures
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 1306	Burlap
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete

Ontario Ministry of Transportation Publications:

Structural Manual

MTO Laboratory Testing Manual:

LS-407	Method of Test for Compressive Strength of Moulded Cylinders
LS-410	Method of Test for Compressive Strength of Concrete Cores
LS-426	Method of Test for Compressive Strength of High Strength Concrete
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

MTO Forms:

PH-CC-322	Concrete Construction Report
PH-CC-433A	Concrete Mix Design Submission Form A
PH-CC-701	Request to Proceed
PH-CC-702	Notice to Proceed
PH-CC-821	Manufacturer's Certificate of Conformance

CSA Standards

A23.2-1D	Moulds for Forming Concrete Test Cylinders Vertically*
A23.2-3C	Making and Curing concrete Compressive and Flexural Test Specimens*
A23.2-14C	Obtaining and Testing Drilled Cores for Compressive Strength Testing*
A23.4-16 (R2021)	Precast Concrete Material and Construction
S6:19	Canadian Highway Bridge Design Code
W47.1:19	Certification of Companies for Fusion Welding of Steel
W59-18(R2023)	Welded Steel Construction

* [Part of A23.1-19/A23.2-19 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

ASTM International

A153/A153M-23	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
B633-23	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
C171-20	Standard Specification for Sheet Materials for Curing Concrete
C403/C403M-23	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

National Cooperative Highway Research Program

Project 12-98, Appx. C	Proposed Guidelines for Prefabricated Bridge Elements and Systems Tolerances

Precast/Prestressed Concrete Institute

MNL-135-00	Tolerance Manual for Precast and Prestressed Concrete Construction

3.0 DEFINITIONS

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

Assembly Plan means a package of plans, specifications and calculations developed by the Contractor that describes the process for the assembly of the prefabricated bridge elements and systems.

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 ºC, or when the air temperature to which the element is exposed is at or is likely to fall below 5 ºC 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.

Erection Drawings means those drawings which show the relationship of the precast elements and their connections in the erected structure, and which provide such information as is necessary to properly erect and connect the various elements.

Erection Tolerances means the total allowable deviation from a theoretically exact dimension locating a precast element relative to a work line, work point, or grid coordinates after they are erected.

Grid Coordinates means a survey coordinate system.

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.

Interfacing Tolerances means those allowable variations in dimensions associated with other materials or systems in contact with or in close proximity to precast concrete. These could include, but are not limited to, tolerances of cast-in-place concrete footings, structural steel or cast-in-place concrete frames, and subsystems such as electrical and ATMS ducts.

Laitance 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 7 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 a category of prefabricated bridge elements and systems (PBES) that consists of an individual precast section of a bridge. For the purposes of this Special Provision, 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 interchangebly with “element”.

Prefabricated Bridge Elements and Systems (PBES) means structural components of a bridge that are built offsite or near the site.

Prefabricated Bridge System means a category of PBES that consists of an entire superstructure, an entire superstructure and substructure, or a total bridge that is procured in a modular manner such that traffic operations can be allowed to resume after placement. A prefabricated bridge system is rolled, launched, slid, lifted, or otherwise transported into place.

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. This 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 as defined in OPSS 905.

Structure means any bridge, culvert, tunnel, retaining wall, wharf, dock, or guideway, or any part thereof, or other reinforced concrete component designed to carry loads, including but not limited to high mast pole footings and sign support footings.

Tendon means as defined in OPSS 910.

Work Lines means dimensional control lines based on a common datum which are mathematically tied to the vertical or horizontal geometry of the structure.

Work Points means dimensional control points based on a common datum which are mathematically tied to the bridge coordinate system.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Design Requirements

4.01.01 Precast Bridge Elements and System.

The design shall be according to CSA S6, Structural Manual Division 1, and as specified in the Contract Documents.

4.01.02 Concrete Mix Design

The concrete mix shall be designed to provide adequate strength and durability for the intended use and to meet the requirements specified in the Contract Documents.

4.01.03 Formwork and Falsework

Formwork and falsework shall be designed according to OPSS 919.

4.02 Submission Requirements

4.02.01 Working Drawings

4.02.01.01 General

One electronic copy of all Working Drawings, including supporting documentation, shall be submitted to the Contract Administrator at least 14 Days prior to the commencement of fabrication of any precast elements, for information purposes only. Prior to submitting, the design Engineer and the design-checking Engineer shall affix their seals and signatures on the Working Drawings and supporting documentation verifying that the drawings and documentation are consistent with the Contract Documents.

When other authorities are involved in the approval of the design and/or construction of a highway structure, the fabrication Working Drawings submission shall be made at least 5 weeks prior to the 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 the commencement of the work.

4.02.01.02 Precast Concrete Bridge Elements

The precast concrete bridge elements Working Drawings shall include shop drawings, erection drawings, and drawings for handling and installation of the elements.

The Working Drawings shall include the following information:

a) Element details including all projections, recesses, notches, openings, blockouts, and other pertinent details;

b) Steel reinforcement schedules;

c) Size, dimensional fabrication tolerances and markings of individual elements;

d) For prestressed elements include:

   i. Prestressing reinforcing steel size, grade, location.
   ii. Jacking force as required by the design.
   iii. Strand release sequence.

e) When post-tensioning is required, the post-tensioning details shall be included according to OPSS 910;

f) Stripping strength;

g) Installation details including:

   i. Lifting point details and locations;
   ii. Temporary shoring;
   iii. Supports and guys; and
   iv. Sequence for installation and removal of temporary and permanent works.

h) Details and location of all temporary supports;

i) Layout details which includes:

   i. All information required to identify, and install precast elements and shall be based on work lines, work points or grid coordinates.
   ii. Markings of individual elements;
   iii. Special installation methods;
   iv. Sequence of installation where this is critical; and
   v. Layout dimensions for each element. In the layout dimension centre-to-centre spacing shall not be used.

j) Erection tolerances;

k) Interfacing tolerances;

l) Details of bracing installed to provide adequate support and stability to the element during construction; and

m) All other applicable details.

The supporting documents shall include the following information:

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

b) Fabrication schedule of all precast elements.

4.02.01.03 Assembly Plan

The assembly plan Working Drawings shall be developed and coordinated with the shop drawings to ensure details are consistent. The assembly plan Working Drawings shall be sealed by an Engineer with specific knowledge of the Contractor's equipment, means, and methods.

The assembly plan Working Drawings shall include, but not be limited to:

a) Assembly sequence and construction methods detailing:

   i. Overall construction process;
   ii. Installation sequence taking into account the actual loading on the structure, previously installed elements, attachments, sealing and tolerances;
   iii. Any formwork, including temporary supports, falsework, scaffolding, etc. for closure joints, including methods for attachment to the adjacent elements;
   iv. Methods and materials to be used for attachment, such as casting and curing of closure joints;
   v. Equipment that will be employed for assembly of the bridge;
   vi. Equipment that will be used to lift elements including, but not limited to cranes, excavators, lifting slings, sling hooks, and jacks;
   vii. All affected utilities, drainage and protective measures that will be employed throughout construction;
   viii. Methods of adjusting, stabilizing and securing elements after placement until final completion;
   ix. Methods for controlling erection tolerances for both horizontal and vertical directions including any surveying requirements;
   x. Removals and disposals of any temporary and excessive materials after completion.

b) Identification marking of each element for erection;

c) Erection drawings including a site plan showing crane locations and operation radii. If multiple crane set-ups are required, a separate plan shall be included for each crane set-up. The site plan shall show the layout of multi-crane lifts if required. The plan shall also depict all affected utilities, drainage and protective measures that will be employed;

d) Shipping and handling; and

e) Geometry control plan including details of the layout process used for checking the location and elevation of each element prior to releasing the element from the erection equipment.

The supporting documents shall include the following information:

a) Calculations:

   i. Bridge temporary works;
   ii. Analysis of elements and calculation of forces for shipping, handling and lifting; maintenance of stability of elements; and modification of lifting and handling methods and/or the addition of supplemental reinforcement to resist shipping and handling forces if they cannot be resisted by the as-designed element;
   iii. Lifting calculations for all crane lifts. The centre of gravity shall be determined for all elements. Special care shall be used for elements that are not symmetrical and may require special lifting hardware to allow for installation to the proper grades specified in the Contract Documents.
   iv. Required strength of poured material that can produce connections capable of resisting forces during construction.

b) Material specifications including estimated timeframe of strength gain for closure joint materials.

c) Scheduling:

   i. Related to the construction schedule;
   ii. Weather limitations for the assembly work, including but not limited to temperature and wind;
   iii. Contingency plan for schedule adjustment in the event of a major equipment breakdown or other major delays.

4.02.02 Welding

When resistance welding is planned for fabricating steel reinforcement cages, a proposal shall be submitted to Contract Administrator for Owner's approval a minimum of 14 Days prior to fabrication.

4.02.03 Design Engineer – Assembly Plan Working Drawings

The qualifications of the Design Engineer sealing the assembly plan Working Drawings shall be submitted to the Contract Administrator prior to fabrication.

4.02.04 Concrete Mix Design

The concrete mix design shall be submitted to the Contract Administrator according to the Mix Design clause of OPSS 1350.

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

4.02.05 Precast Concrete Plant Certification

The certificate verifying compliance of the plant with the certification requirements of the Canadian Standards Association (CSA) or Canadian Precast Concrete Quality Assurance Program (CPCQA), under one of the following categories:

a) Precast Concrete Bridge Elements - Non-Prestressed

   i. Category: CSA A 23.4 Structural; non-prestressed.
   ii. Product Group: Group B - Precast Bridge Products; B1.

b) Precast Concrete Bridge Elements - Prestressed

   i. Category: CSA A 23.4 Structural; prestressed.
   ii. Product Group: Group B - Prestressed Miscellaneous Bridge Products or Prestressed Straight Strand Bridge Members; B2 or B3.

Copies of precast plant certification audit reports of CPCQA 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.

4.02.06 Control of Concrete Temperature

A description of the method for monitoring and effectively controlling the temperature of the concrete during the curing and protection period shall be submitted to the Contract Administrator, 7 Days prior to the commencement of fabricating the concrete elements.

4.02.07 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 identification (ID) number, lot number and description;

b) Mill certificates for the steel reinforcement used in the elements shall be made available upon request;

c) For prestressed precast elements: record of the jacking force, elongations, and corrections;

d) Temperature records for formwork and steel reinforcement at the time of concrete placement;

e) Temperature control records, including:

   i. Location of thermocouple wires; and
   ii. Graphical plots verifying that the maximum temperature limit, maximum allowable temperature difference or the maximum cooling rate have been met.

f) Record of inspection of moist curing;

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

h) Summary of material test results for hardened concrete:

   i. Transfer strength;
   ii. Stripping strength;
   iii. Confirmation of the projected 28-Day compressive strength; and
   iv. If test results are not available at the time of shipping, they may be submitted within 4 Business Days following completion of testing.

i) Summary of all measurements and inspections required by this Special Provision, including:

   i. Concrete cover over steel reinforcement;
   ii. Crack measurement summary;
   iii. Tolerances; and surveys for geometric control.

j) 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; and

k) 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 MTO form PH-CC-701, 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 MTO form PH-CC-821, Manufacturer's Certificate of Conformance, the precast report, Request to Proceed, and issued a MTO form PH-CC-702, Notice to Proceed.

5.0 MATERIALS

5.01 Associated Hardware

Associated hardware shall be according OPSS 905. 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.

5.02 Burlap

Burlap shall be according to OPSS 1306.

5.03 Concrete

Concrete and 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 Engineering Materials Office, Concrete Section.

5.04 Concrete Sealers

Concrete sealers, if required, shall be from the Owner's list of acceptable sealers. The list shall be obtained from the Contract Administrator.

5.05 Elastomeric Coating

Elastomeric coating shall be according to OPSS 1213.

5.06 Formwork and Falsework

Formwork and falsework shall be according to OPSS 919 and CSA A23.4. Formwork shall be fabricated to meet the dimensional tolerances and finishes required in the Contract Documents.

5.07 Mechanical Connectors

Mechanical connectors shall be according to OPSS 905.

5.08 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.

5.09 Post-Tensioning Material

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

5.10 Prestressing Steel

Prestressing steel shall be low alloy steel bar or uncoated, low relaxation 7-wire strand according to OPSS 1440.

5.11 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.

5.12 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

5.13 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 Compressor - Air Blasting

The compressor for air blasting shall have a minimum capacity of 3.5 m^3/minute. The compressed air shall be free of oil or other contaminants.

6.03 Consolidating Equipment

Consolidating equipment shall be according to OPSS 904.

6.04 Contact Thermometers

Contact thermometers shall have an accuracy of ± 0.5 °C.

6.05 Hand Finishing Tools

Hand finishing tools shall be according to OPSS 904.

6.06 Pretensioning and Post-Tensioning Equipment

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

6.07 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 Canadian Precast Concrete Quality Assurance Program (CPCQA) under one of the following categories required for the work:

a) Precast Concrete Bridge Elements - Non-Prestressed

   i. Category: CSA A 23.4 Structural; non-prestressed.
   ii. Product Group: Group B - Precast Bridge Products; B1.

b) Precast Concrete Bridge Elements - Prestressed

   i. Category: CSA A 23.4 Structural; prestressed.
   ii. Product Group: Group B - Prestressed Miscellaneous Bridge Products or Prestressed Straight Strand Bridge Members; B2 or B3.

7.01.03 Pretensioning Hold Down Devices

Hold down devices shall permit the free movement of the strand. The device shall be tested by its manufacturer to ensure that the final stress along the full length of the strand is uniform.

7.01.04 Formwork and Falsework

Formwork and falsework shall be according to OPSS 919.

Formwork shall be fabricated to meet the dimensional tolerances and finishes specified in the Contract Documents.

7.01.05 Strand Splicing

For prestressed elements, strands shall not be spliced.

7.01.06 Steel Reinforcement and Mechanical Connectors

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

Under no circumstance shall steel reinforcement be inserted into plastic concrete.

7.01.07 Welding

Welding of steel hardware, including shear studs, shall be according to CSA W59 and shall be performed by a welder qualified by the Canadian Welding Bureau (CWB) working for a company certified according to CSA W47.1, Division 1 or 2.

Tack welding of reinforcing steel shall not be permitted.

Resistance welding shall only be used if approved by the Owner.

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 as 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.

7.01.08 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.

7.01.09 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.

7.01.10 Placing of Concrete

7.01.10.01 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 made of aluminum or supported by steel reinforcement.

Concrete shall be deposited within 0.5 m of the top of the steel reinforcement and 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.

7.01.10.02 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. Temperature measurements shall be recorded and included in the precast report.

7.01.11 Consolidation

Internal or external vibrators or both shall be used to thoroughly consolidate the 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 subsection do not apply to SCC, where accepted for use by the Owner.

7.01.12 Concrete Finishing

Finishing of the concrete surface shall be carried out immediately following placement.

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

Concrete surfaces against which new concrete is to be placed against shall be:

a) Left with a rough surface finish (so that the depth of the indentations is at least 5 mm and the spacing is not greater than 15 mm).

All other concrete surface shall be smooth, free from open texturing, undulations, projections, and ridges.

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

7.01.13 Curing

7.01.13.01 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.

7.01.13.02 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 and other application of heat.

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 as specified in Contract Documents. 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. Prior to stripping the formwork, it shall be demonstrated that the stripping strength specified on the Working Drawings has been achieved.

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.

7.01.13.03 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 prevents 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.

7.01.13.04 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.

Application of steam curing and other application of heat to raise the ambient temperature above 30°C shall not be applied until after the concrete has attained its initial set. A delay period prior to the application of steam or other application of heat shall be according to the following:

a) Delay period of 4 hours after completion of concrete placement if the mix does not contain a retarder.

b) Delay period of 6 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 carried out in the presence of the Contract Administrator or the Owner's representative prior to production. Demonstration of the time of initial set according to ASTM C403 may be requested by the Contract Administrator up to two times per year.

7.01.14 Cold Weather Protection Period

Concrete shall be protected against cold weather during the curing period. If cold weather conditions are present at the end of the curing period, the elements shall be protected 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 subsection. The conditions shall be monitored, and the protection system modified as required.

7.01.15 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.

7.01.16 Control of Temperature

7.01.16.01 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.

7.01.16.02 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.

7.01.17 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.

7.01.18 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.

7.01.19 Surface Finish

7.01.19.01 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 1 are repairable by standard methods according to Table 1.

A repair proposal shall be submitted to the Contract Administrator to repair surface defects and deficiencies with dimensions greater than those listed in Table 1.

7.01.19.02 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 1.

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

7.01.19.03 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.

7.01.20 Material Sampling and Testing

7.01.20.01 Sampling of Steel Reinforcement

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

7.01.20.02 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.

7.01.20.03 Sampling and Testing of Plastic Concrete

Field sampling and testing of the plastic concrete for slump, air content, and temperature shall be according to the Material Sampling and Testing subsection of OPSS 1350, except 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

a) 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.

7.01.20.04 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.

7.01.20.05 Stripping Strength

Prior to stripping the formwork, it shall be demonstrated that the stripping strength specified on the Working Drawings has been achieved.

7.01.20.06 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 element 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 2.

7.01.20.07 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 2 and the Contract Documents.

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

7.01.20.08 Sampling Concrete for Acceptance Testing

7.01.20.08.01 Notification

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

7.01.20.08.02 Sampling

Precast elements shall be sampled on a lot basis for each element type. One set of samples shall be obtained from each lot for quality assurance testing as directed by the Contract Administrator.

A set of samples shall consist of the following:

a) For precast elements greater than or equal to 200 mm thick, a set of samples shall consist of five cores 100 mm diameter x 200 mm long:

   i. 3 – 28-Day compressive strength.
   ii. 1 - air void system parameters of hardened concrete (AVS).
   iii. 1 - rapid chloride permeability (RCP).

b) For precast elements less than 200 mm thick but greater than or equal to 120 mm, a set of samples shall consist of five cores:

   i. 3 – 28-Day compressive strength. The full depth of the precast element shall be cored such that the core has a length to depth ratio of at least 1.5 but shall not be less than 75 mm in diameter.
   ii. 1 - AVS, 150 mm diameter x a maximum of 50 mm long.
   iii. 2 - RCP, 100 mm diameter x 70 mm long.

c) For precast elements less than 120 mm thick, a set of samples shall consist of the following:

   i. 3 – 28-Day compressive strength cylinders, 100 mm diameter x 200 mm long according to Cylinders for 28-Day Compressive Strength Testing clause.
   ii. 1 core for AVS, 150 mm diameter x a maximum of 50 mm long.
   iii. 2 cores for RCP, 100 mm diameter x 70 mm long.

The precast element from which core samples shall be taken shall be randomly selected from the lot by the Contract Administrator. Cores shall be removed when the precast element is between 7 to 10 Days of age, and prior to application of any concrete 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 precast element edge. 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 steel reinforcement or other embedded material. A covermeter capable of detecting the type(s) of reinforcing materials in the precast element shall be used to establish the location of steel reinforcement and other embedded material prior to coring. Care shall be taken to avoid existing prestressing strands.

The Contract number, lot number, and precast 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, and fitted with a security tag by the Contract Administrator. All acceptance cores shall immediately be given to the Contract Administrator, with the transmittal form and MTO form PH-CC-433A, Concrete Mix Design Submission Form A of the concrete mix design, for transportation to the designated laboratory.

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. Concrete used to patch core holes shall have comparable properties to that of the concrete used in the precast element.

7.01.20.08.03 Cylinders for 28-Day Compressive Strength Testing

When specified for acceptance, a set of three cylinders shall be cast for 28-Day compressive strength testing by the Owner. Every time a set of acceptance cylinders is cast, a second set of cylinders shall be cast for referee testing purposes.

All concrete test cylinders shall be cast in new, single-use moulds conforming to the requirements of CSA A23.2-1D and made of plastic, with a lid. The lids shall be chemically and physically compatible with the concrete and shall provide watertight closure for the moulds.

Concrete test cylinders shall be cast, cured, and transported to the designated laboratory according to CSA A23.2-3C with the exception that cylinders shall be cured with the precast element prior to delivery to the laboratory. Cylinders shall be delivered to the laboratory for demoulding.

Test information shall be recorded on MTO form PH-CC 322. A copy of the form shall be submitted with each set of the concrete cylinders along with a transmittal form and the MTO form PH-CC-433A, Concrete Mix Design Submission Form A of the concrete mix design for the precast element.

7.02 Storage

Storage includes, but is not limited to, storage at the fabrication plant while awaiting delivery, in temporary locations or, at the job site. Elements, when stored, shall be stored in such a manner to avoid excessive stress or other damage.

7.03 Delivery

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

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

Precast 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.

Advertising by means of removable signing is permitted on precast 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.

7.04 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 as specified in the Working Drawings, assembly plan, and the Contract Documents.

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

Precast elements shall not be stacked temporarily on other precast elements during installation unless allowance has been made for this in the design of the precast elements and the connections.

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

The Contractor shall inspect the precast elements for defects before installation. Repairs shall be completed according to this Special Provision, prior to installation. When repairs are carried out prior to installation, a MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator after the repair(s) have been completed and prior to installation. Installation of precast members shall not proceed until a MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

Repairs to erected material shall only be permitted after the Contract Administrator has accepted the repair procedure.

Any error that prevents the proper assembly and fitting of parts shall be reported and the proposed method of correction shall be submitted to the Contract Administrator. Corrective measures shall not commence until the submitted proposal is accepted.

7.05 Installation Tolerances

Precast elements shall meet the installation tolerances of Table 2, Table 3 and as specified in the Contract Documents. The installation tolerances are a combination of the fabrication tolerances, erection tolerances and interfacing tolerances. Unless otherwise specified, the installation tolerances shall be according to NCHRP Project 12-98 Appendix C, CSA A23.4, or MNL-135-00.

7.06 Inspection after the Installation of the Precast Elements

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator after the installation of each element type for each structure within a construction stage and prior to the cutting or removal of any temporary lifting, setting or levelling devices, or casting of concrete or grouted joints.

The next operation shall not proceed until a MTO form PH-CC-702, Notice to Proceed has been received from the Contract Administrator.

7.07 Repair of Defects and Deficiencies Repairable by Standard Methods

7.07.01 General

Any individual precast element having one or more of the defects and deficiencies specified in Table 1 shall be repaired according to the repair method specified. Such repairs do not require proposals.

Where more than one of the defects or deficiencies listed in Table 1, excluding bugholes, is located in the same area in the precast 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.

7.07.02 Assessment of Repair

The Owner may require at their discretion that additional visual inspections 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 work shall be done at no additional cost to the Owner.

The filling of core holes shall be according to OPSS 1350.

7.08 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 precast elements shall be according to the requirements of this Special Provision, including satisfactory completion of all repairs, if applicable. Precast 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' of production of the same element type 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

8.02.01 General

Testing of compressive strength cores shall be according to LS-410. Three cores shall be tested to determine the compressive strength of the lot.

Testing of compressive strength cylinders shall be according to LS-426 for concrete with silica fume and high strength concrete, and according to LS-407 for all other concrete. Three cylinders shall be tested to determine the compressive strength of the lot.

The 28-Day concrete compressive strength of a lot shall be considered acceptable when:

a) The average of the three individual compressive strength test specimens is equal to or greater than the specified 28-Day strength: and

b) No individual specimen test shall be more than 4.0 MPa 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.

8.02.02 Referee Testing of Compressive Strength

Referee testing of compressive strength may only be invoked by the Contractor within 3 Business Days of receipt of the acceptance test result.

Where acceptance testing is carried out on core samples, referee testing of compressive strength shall be carried out on a set of three cores taken within 3 Business Days of invoking referee testing, by the Contractor from the same precast element which the acceptance cores represent. Referee cores shall be taken according to the Sampling clause. Referee cores shall immediately be given to the Contract Administrator for transportation to the designated laboratory. The referee laboratory shall be designated by the Owner based on the applicable roster and cores shall be tested according to LS-410.

Where acceptance testing of compressive strength is done on cylinder samples, the referee testing process for concrete compressive strength is based on duplicate cylinders cast at the same time as the acceptance cylinders. The referee laboratory shall be designated by the Owner based on the applicable roster and cylinders shall be tested according to LS-426 for concrete with silica fume and high strength concrete, and according to LS-407 for all other concrete.

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 Special Provision.

8.02.03 Referee Testing Cost

The cost of compressive strength referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be charged the cost of compressive strength referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

8.03 Acceptance of Air Void System in Hardened Concrete

8.03.01 General

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 having a spacing factor greater than 0.200 mm and less than or equal to 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 having a spacing factor more than 0.250 mm or air content less than 3.0% shall be rejected and replaced.

8.03.02 Referee Testing Air Void System in Hardened Concrete

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

8.03.03 Referee Testing Cost

The cost of air void system referee testing shall be as specified in the Contract Documents.

When the referee results indicate that the refereed lot is acceptable, the Owner shall bear the cost. When the referee results indicate that the refereed lot is not acceptable, the Contractor shall be charged the cost of the air void system referee testing.

8.04 Acceptance of Rapid Chloride Permeability

8.04.01 General

Acceptance of rapid chloride permeability shall be based on the result obtained on the core representing the lot. Acceptance testing shall be carried out at 28 to 32 Days.

For precast elements greater than or equal to 200 mm in thickness, one core per lot shall be tested according to LS-433. Two 50 mm long samples shall be cut from the core representing a lot, tested, and averaged to determine the acceptance of the lot.

For precast elements less than 200 mm in thickness, one 50 mm sample shall be cut from each of the two cores representing the lot and the results averaged to determine the acceptance of the lot.

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

8.04.02 Concrete Without Silica Fume

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.

8.04.03 Concrete Containing Silica Fume

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.

8.04.04 Referee Testing of Rapid Chloride Permeability

Referee testing of rapid chloride permeability may only be invoked by the Contractor within 5 Days of receipt of the acceptance test result.

Referee testing shall be carried out on the core(s) taken, within 3 Business Days of invoking referee testing, by the Contractor from the same precast element which the acceptance core was taken. Referee cores shall be taken according to the Sampling clause.

For precast elements greater than 120 mm thick, one core, 100 mm diameter x 100 mm long shall be taken. Referee testing shall be carried out on two-50 mm long samples obtained from the core representing the lot for which referee testing was invoked, and the results averaged to obtain the test result for the lot.

For precast elements less than 120 mm thick, two cores, 100 mm diameter x 60 mm long shall be taken. Referee testing shall be carried out on 50 mm samples cut from each core representing the lot for which referee testing was invoked, and the results averaged to determine the acceptance of the lot.

The referee core shall immediately be given to the Contract Administrator for transportation to the designated laboratory.

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 Special Provision.

8.04.05 Referee Testing Cost

The cost of referee testing shall be as specified in the Contract Documents.

When the referee result confirms the acceptance test result, the Contractor shall be responsible for the cost of rapid chloride permeability referee testing. When the referee result does not confirm the acceptance test result, the Owner shall bear the cost.

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

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

8.07 Acceptance of Surface Finish

All precast elements meeting the surface finish requirements of this Special Provision 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 of at least one element per lot to confirm compliance with the requirements of Table 2.

If a precast element fails to meet the requirements specified in Table 2, it shall be rejected and replaced, and a consultant shall be retained by the Owner at the Contractor's expense, to verify all other precast elements are within the tolerances specified in Table 2.

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

8.09 Verification of Installation Tolerances

The Contract Administrator shall be notified in writing when the precast bridge elements are ready for the verification measurements. The Contract Administrator will carry out measurements to confirm the installation tolerances which include fabrication, erection and interfacing tolerances are according to Table 2 and Table 3 and as specified in the Contract Documents.

If a precast element fails to meet the tolerances specified in the Contract Documents, the Contractor shall submit a proposal for remediation. The proposal shall include but not be limited to rejection of the precast element, adjusting the precast element, modification of erection activities, grinding, or acceptance of out of tolerance precast elements.

Acceptance of the proposal for remediation is at the sole discretion of the Owner. Acceptance of out of tolerance precast elements may be considered if the structural integrity is not affected by exceeding the tolerance; or, the erection of the overall structure can be performed by satisfactory means such as minor adjustments to layout of connecting precast elements.

8.10 Defects and Deficiencies

8.10.01 Defects and Deficiencies Repairable by Standard Methods

Any individual precast element having one or more of the defects and deficiencies listed in Table 1 shall be deemed unacceptable. Unacceptable precast elements shall be repaired according to Table 1.

When more than one of the defects or deficiencies listed in Table 1 is located in the same area in the precast element, the Contractor shall be required to submit a repair proposal for acceptance according to the All Other Defects and Deficiencies clause.

8.10.02 Defects and Deficiencies Causing Rejection

A precast 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 1.

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 CSA A23.4.

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

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

8.10.03 All Other Defects and Deficiencies

A repair proposal signed and sealed by an Engineer shall be submitted to the Contract Administrator for acceptance, when any one of the following are applicable:

a) A precast element has defects or deficiencies that are not identified as rejectable or included in Table 1;

b) More than one of the defects or deficiencies listed in Table 1, except for bugholes, are located in the same area in the precast element;

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

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

e) Unacceptable surface finish;

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

g) Dimensional tolerances of the precast element do not meet the requirements of this Special Provision;

h) Failure to maintain moist curing has occurred; or

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 precast 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 precast 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 precast 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 precast 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 precast element shall be rejected and replaced.

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

8.11 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 precast 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 (m^3) (calculated based on plan dimension)
Tender quantity	=	Volume of concrete in tender (m^3) (calculated based on plan dimension)
Price	=	Contract price for tender item
P	=	Pay factor for the lot according to the spacing factor specified below:

Spacing Factor, mm	Pay Factor
0.200 to 0.220	90
0.220 to 0.240	80
0.240 to 0.250	70

10.03 Payment Adjustment for Rapid Chloride Permeability

10.03.01 Concrete Without Silica Fume

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 (m^3) (calculated based on plan dimension)

10.03.02 Concrete Containing Silica Fume

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 (m^3) (calculated based on plan dimension)

10.04 Precast Concrete Bridge Elements, Delivery - Item
Precast Concrete Bridge Elements, Installation - Item

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
Defects and Deficiencies Repairable by Standard Methods

Repairable Defects and Deficiencies	Condition	Repair Method
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 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 precast element shall be sealed with a two-component concrete sealer. 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 m^2 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 m^2 is ≥ 5 m. Removals and preparation of concrete shall be according to OPSS 930.
	≤ 0.3 mm	Apply concrete sealer to the cracked areas. Where the total linear measurement of crack per m^2 is ≥ 5 m the entire precast element shall be sealed.

TABLE 2
Fabrication Dimensional Tolerances for Precast Concrete Bridge Elements

Item	**Tolerances**
Length (Note 1) Straight-line measurement taken horizontally at the mid-height of precast element in the longitudinal direction	± 5 mm
Width (Note 1) Straight-line measurement taken horizontally at the mid-height of precast element in the transverse direction	± 5 mm
Nominal Depth Straight-line measurement taken vertically at the mid-length of precast element	± 5 mm
Variation from Specified Plan End Squareness or Skew (Note 2)	± 10 mm
Stirrup Projection from Surface (Note 3,4)	± 15 mm
Shear Key Depth (Note 4)	± 5 mm
Shear Key Width (Note 4)	± 5 mm
Location of Blockout (Note 4)	± 25 mm
Size of Blockout (Note 4)	± 25 mm
Location of Inserts (Note 4,5)	± 25 mm
Concrete Cover Over Steel Reinforcement	Concrete cover shall be in according to OPSS 905 unless otherwise specified in the Contract Documents.

Notes:
1. Overall length and width of assembled units, side by side shall have a combined tolerance of ± 25 mm.
2. For Partial Depth Precast Deck Panels use ± 6 mm.
3. For Partial Depth Precast Deck Panels use ± 10 mm.
4. Not all precast elements contain the described feature.
5. For Partial Depth Precast Deck Panels use ± 13 mm.

TABLE 3
Erection Tolerances

Item	Footing	Column	Pier Cap	Wall Element	Full Depth Deck Panel	Partial Depth Deck Panel
Plan location from structure datum (straight-line measurement taken horizontally from the plan datum)	±13 mm	±13 mm or ±9 mm for architectural features	±13 mm	±13 mm or ±9 mm for architectural features	±7 mm	±25 mm
Top surface elevation from nominal top surface elevation (straight-line measurement taken vertically from the elevation datum)	13 mm max low 7 mm max high	13 mm max low 7 mm max high	13 mm max low 7 mm max high	13 mm max low 7 mm max high		
Maximum jog in alignment of matching edges (straight line measurement taken horizontally from adjacent precast elements)		13 mm (visually non-critical) 7 mm (architectural)	7 mm	7 mm		15 mm
Joint width				±9 mm	±10 mm	±10 mm
Joint taper				13 mm over length of panel 9 mm over 3 m length		±6 mm
Bearing length in span direction					±13 mm	±13 mm
Differential elevation between adjacent panels					3 mm	19 mm
Maximum plumb variation over height of precast element		1H:200V up to a maximum of 25 mm				
Maximum plumb variation in any 3 m		7 mm	7 mm	7 mm		

Notes:

1. Unless otherwise specified, the installation tolerances shall be according to NCHRP Project 12-98 Appendix C, CSA A23.4, or MNL-135-00.

WARRANT: Always with these tender items.