# CONSTRUCTION SPECIFICATION FOR PRESTRESSED CONCRETE - PRECAST GIRDERS

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## 909.01 SCOPE

This specification covers the construction requirements for fabrication, delivery, and installation of precast prestressed concrete girders with steel reinforcement.

## 909.02 REFERENCES

This specification 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

**Ontario Provincial Standard Specifications, Material**

OPSS 1002 Aggregates - Concrete
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**

MTO Laboratory Testing Manual:
LS-407 Method of Test for Compressive Strength of Moulded Cylinders
LS-426 Method of Test for Compressive Strength of High Performance Concrete Cylinders
LS-432 Method of Test for Microscopical Determination of Air Void System Parameters in Hardened Concrete
LS-446 Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration – For Precast Girders

Structural Manual

MTO Form:
PH-CC-322 Concrete Construction Report
PH-CC-701 Request to Proceed
PH-CC-702 Notice to Proceed

**CSA Standards**

| | |
|---|---|
| A23.2-3C | Making and Curing Concrete Compression and Flexural Test Specimens * |
| A23.2-1D | Moulds for Forming Concrete Test Cylinders Vertically * |
| A23.2-9C | Compressive Strength of Cylindrical Concrete Specimens* |
| A23.2-14C | Obtaining and Testing Drilled Cores for Compressive Strength Testing* |
| A23.4-09 | Precast Concrete Material and Construction |
| G40.20/G40.21-04 | General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel |
| G189-1966 (R2003) | Sprayed Metal Coatings for Atmospheric Corrosion Protection |
| CAN/CSA S6-14 | Canadian Highway Bridge Design Code |
| W47.1-09 | Certification of Companies for Fusion Welding of Steel Structures |
| W59-03 (R2008) | Welded Steel Construction (Metal Arc Welding) |
| W186-03 (R2007) | Welding of Reinforcing Bars in Reinforced Concrete Construction |

* [Part of A23.1-14/A23.2-14 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

**ASTM International**

A153-09 Zinc Coating (Hot-Dip) on Iron and Steel Hardware
B633-07 Electrodeposited Coatings of Zinc on Iron and Steel
C171-07 Sheet Materials for Curing Concrete
C403-08 Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance

**American Association of State and Highway Transportation Officials (AASHTO)**

M182-05 (2009) Burlap Cloth made from Jute or Kenaf and Cotton Mats

## 909.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

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

**Bughole** means a small regular or irregular cavity resulting from entrapment of air bubbles in the surface of formed concrete during placement and 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 girder is exposed is at or below 5°C, or when the air temperature to which the girder 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.

**Design Proposal** means a submission of proposed changes, when engineering design is required.

**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** means all girders produced during a one-week period (seven consecutive days); or, if more than 4 girders are produced in seven consecutive days, a lot means every 4 girders produced consecutively. Girders of the same lot shall be manufactured by the same supplier, made from the same concrete mix design, for the same ministry Contract, and be of the same cross-section and type of precast concrete girder.

**Girder Type** means a girder differentiated by its cross-section shape such as box girder type (solid or voided), I-girder type (such as Nebraska University (NU) and Canadian Precast Prestressed Concrete Institute (CPCI)), or T-girder type.

**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.

**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 party who produces the girders.

**Prestressed Concrete** means reinforced concrete 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.

**Repair Proposal** means a submission when repairs to the girders are required.

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

**Sweep** means the lateral deviation from straightness of a girder 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.

## 909.04 DESIGN AND SUBMISSION REQUIREMENTS

### 909.04.01 Design Requirements

#### 909.04.01.01 General

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

The jacking force shall be calculated to achieve the theoretical prestressing force in the strand, immediately prior to transfer, as specified on the Contract Documents.

In determining the jacking force, losses due to chuck slip, bed shortening and bulkhead rotation, including abutment tilt, temperature variation, deflected strand friction, sequential strand stressing, and initial relaxation of strand prior to transfer shall be included. Deflected strand friction may be taken as nil where pin rollers are used at the bulkheads (hold-ups) and swivel pin roller devices are used at hold-down locations. Relaxation loss need not to be taken as greater than 15 MPa. During jacking, the strand may be stressed up to 0.80 fpu.

#### 909.04.01.02 Permissible Changes from the Contract Drawings

##### 909.04.01.02.01 General

Changes from the Contract Drawings are permitted and may be implemented by the precaster, without prior approval from the Owner, provided they meet the requirements of this specification.

##### 909.04.01.02.02 Prestressing of Girders

The prestressing strand pattern may be adjusted to suit production requirements provided all changes meet the original design strength without adversely affecting other components of the structure. If the centre of gravity of the strands at the interior hold down closest to mid-span is within ± 10 mm of the original design, then one or more of the following adjustments shall be permitted provided that both the serviceability and ultimate limit states capacities are not adversely affected:

a) Provide additional strands with a lower jacking stress provided the total prestress force is within ± 2% of the original design.

b) Use of imperial strand spacing in lieu of metric, where 25 mm = 1” and 50 mm = 2”.

c) Addition of one hold-down per end is added towards the girder end at the same spacing as the original design.

d) One less hold-down per end when the hold-down closest to mid-span is deleted.

e) Increase or decrease the number of strands in each hold-down group.

f) Increase of vertical strand spacing between hold-down points from 25 mm up to 50 mm.

##### 909.04.01.02.03 Reinforcing of Girders

The stirrup projection may be adjusted from that shown on the original design, based on details such as the predicted camber, provided it meets the deck embedment range indicated elsewhere in the Contract Documents.

Spacing of stirrups around blockouts for diaphragms may be adjusted, provided the minimum spacing requirements of CAN/CSA S6 are satisfied, and up to two stirrups may be added in order to maintain the total reinforcement requirements.

**909.04.01.02.04 Other Design Details**

Details limited to those below may be adjusted to suit production requirements, provided all changes meet the original design without adversely affecting other components of the structure:

a) Dowel holes and inserts may be adjusted vertically within ± 75 mm from the location shown on the original design to avoid any conflict with strands.

b) Undercut dimensions may be adjusted to accommodate the predicted camber.

c) Additional pockets and hardware for temporary bracing may be added.

d) Additional temporary post-tensioning or pre-tensioning for shipping and handling may be added provided they do not adversely affect the girders at any stage.

The production length of the girder may be adjusted to account for elastic shortening.

**909.04.01.03 Temporary Bracing**

Temporary bracing shall be installed at all substructure locations for I-girders at the time of installation to maintain stability.

Temporary bracing for girders shall be designed according to CAN/CSA S6 using a wind load specific for the location and having a return period of 10 years if the girders are to be permanently connected within the same construction season. If the girders are not to be permanently connected within the same construction season, subject to the Owner's approval, the return period to be used in the design shall be 25 years.

In no case shall temporary bracing be less than the minimum requirements specified in the Contract Documents.

**909.04.02 Submission Requirements**

**909.04.02.01 Working Drawings**

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 girders, 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 at least 5 weeks prior to commencement of the 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) Girder details.

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

c) Hold-down locations and forces.

d) Reinforcing steel schedules.

e) Lifting point locations.

f) Details and location of all temporary supports.

g) Strand release sequence.

h) Any changes to the Contract Drawings made according to the Permissible Changes from the Contract Drawings clause.

i) All other applicable details.

The supporting documents shall include the following information:

j) A letter signed and sealed by an Engineer listing all permitted changes made along with supporting calculations. The letter shall state that the changes have not adversely affected the girder capacities.

k) Handling and installation procedures, including calculations and lifting point locations.

l) Details of bracing installed to provide adequate support and stability to the girder during construction.

**909.04.02.02 Concrete Mix Design**

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

**909.04.02.03 Concrete Plant Certification**

The certificate verifying compliance of the plant with the certification requirements of the Canadian Standards Association (CSA) or CPCI, under the category Group B, Bridges as either subcategory B4 (Prestressed Deflected Strand Bridge Members) or subcategory B3 (Prestressed Straight Strand Bridge Members), 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 when concrete is supplied by a ready-mixed concrete supplier.

**909.04.02.04 Control of Concrete Temperature**

One week prior to the commencement of fabricating the girders, 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 the concrete temperature during the curing and protection period.

**909.04.02.05 Manufacturer's Certificate of Conformance and Precast Report**

A MTO form PH-CC-821, Manufacturer's Certificate of Conformance and a precast report shall be submitted to the Contract Administrator for each shipment of girders at least 5 Business Days prior to shipping from the precasting plant.

The precast report shall contain the following information:

a) List of girders in the shipment, including their ID number, lot number, and description.

b) 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.

c) Summary of all measurements and inspections carried out prior to concrete placement to verify compliance with the Contract Documents including reinforcement placement, hold-down positions and other pre-pour checks.

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

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

f) 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.

g) Record of inspection of moist curing.

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

i) 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.

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

k) 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.

l) 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 girders to the site.

The girders 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 MTO form PH-CC-702, Notice to Proceed.

**909.04.02.06 Design Proposals**

Five copies of the design proposal shall be submitted to the Contract Administrator for acceptance. The design proposals shall bear the seal and signature of the design Engineer and the design checking Engineer. The Contractor shall not proceed with the proposed changes until the design proposal has been accepted by the Contract Administrator.

The Contract Administrator shall provide a response within 10 Business Days of receiving the proposal.

## 909.05 MATERIALS

**909.05.01 Bearing Plate**

The bearing plate shall be according to CSA G40.20/G40.21, Grade 300W or greater.

Anchor studs shall be a headed type and be according to CSA W59 and shall be welded to the bearing plates prior to galvanizing.

All surfaces shall be hot dipped galvanized according to ASTM A153 or shall be zinc metallized according to CSA G189.

**909.05.02 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.

**909.05.03 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 Days shall be equal to or less than 2,500 coulombs.

d) Aggregates shall be according to OPSS 1002. The nominal maximum size of coarse aggregate shall be 19.0 mm, except when a smaller nominal size is required in order to meet the requirements of CAN/CSA S6.

e) Slag aggregate shall not be used.

f) 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 approval prior to use. Where accepted for use, SCC shall be according to the Owner's requirements for self-consolidating concrete. A copy of the non-standard Special Provision can be obtained from the Materials Engineering and Research Office, Concrete Section.

**909.05.04 Concrete Sealers**

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

**909.05.05 Elastomeric Coating**

Elastomeric coating shall be according to OPSS 1213.

**909.05.06 Formwork**

Formwork shall be fabricated steel, except for box girders of non-standard width for which wood forms may be used. All formwork shall be according to OPSS 919 and CAN/CSA A23.4. Forms shall be fabricated to meet the dimensional tolerances and finishes specified in the Contract Documents.

**909.05.07 Hardware**

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

The hold down device may be black steel; however, the surfaces of the hold down device located within 40 mm of the concrete surface shall be chromate coated over an electrodeposited coating of zinc according to ASTM B633.

**909.05.08 Moisture Vapour Barrier**

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

**909.05.09 Post-Tensioning Material**

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

### 909.05.10 Proprietary Patching Materials

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

### 909.05.11 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

### 909.05.12 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.

## 909.06 EQUIPMENT

### 909.06.01 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.

### 909.06.02 Pretensioning and Post-Tensioning

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

### 909.06.03 Thermocouples and Dataloggers

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.

## 909.07 CONSTRUCTION

### 909.07.01 General

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

Each girder shall be identified with a unique number and the date of casting within 24 hours of stripping forms. The information shall be marked on the girders and shall remain exposed and visible throughout the duration of construction. When the information is stencilled, indelible ink or paint shall be used.

### 909.07.02 Precast Plant Certification

Girders shall be fabricated by a plant certified by CSA or by CPCI under the category Group B, Bridges, as either subcategory B4 (Prestressed Deflected Strand Bridge Members) or subcategory B3 (Prestressed Straight Strand Bridge Members), as required for the work.

### 909.07.03 Pretensioning

Strands shall not be tensioned in the deflected position, unless the hold-down device used permits free movement of the strand and the use of the device has been tested by its manufacturer to ensure that the final stress along the full length of the strand is uniform.

**909.07.03.01 Strand Splicing**

Strands shall not be spliced within the concrete girder.

**909.07.04 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 performed by a qualified welder working for a company certified by the Canadian Welding Bureau according to CSA W186.

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.

**909.07.05 Steel Reinforcement**

The placement of steel reinforcement shall be according to OPSS 905, with the exception and/or addition of the placing tolerances listed below:

a) Vertical position of prestressing strands: + 5/-10 mm

b) Length of debond on prestressing strands: ± 50 mm

c) Projection of positive moment connection reinforcing steel at girder ends: ± 25 mm

d) Stirrup spacing: ± 15 mm when spacing is 100 mm or less
± 25 mm when spacing is greater than 100 mm
± 30 mm when spacing is 300 mm or greater

Under no circumstances shall reinforcement be inserted into plastic concrete.

**909.07.06 Placing of Sheaths and Anchorages**

When girders are to be post-tensioned, the sheaths and anchorages shall be placed according to OPSS 905 except that the placing tolerances shall be ± 5 mm at splice points and ± 10 mm elsewhere.

When debonding of strands are specified in the Contract Documents, only rigid unsplit polymer sheathing shall be used. Soft flexible split plastic sheathing shall not be permitted.

**909.07.07 Production of Concrete**

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

When there are multiple batches of concrete in a single ready-mix truck, hopper or other container, discharge times shall be measured from the time of introduction of water to cement for the first batch of concrete in the truck. Discharge of all concrete in the truck 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 hour.

## 909.07.08 Placing of Concrete

### 909.07.08.01 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 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.

### 909.07.08.02 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.

Ice and snow shall be removed from the area where concrete is to be placed. Deicing chemicals shall not be used. 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 average temperature of the formwork, steel reinforcement or any other material against which concrete is to be placed shall not exceed 30.0°C, with no individual temperature exceeding 35.0°C, and the maximum difference between the highest and lowest temperature measurement shall not exceed 10.0°C. Average temperature shall be based on the average of a set of 10 temperature measurements, evenly spaced, along the formwork, steel reinforcement or other material against which concrete is to be placed. For formwork, five temperature measurements shall be made on each side of the formwork.

Temperature measurements shall be taken no more than 10 minutes prior to concrete placement, for each girder. 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.

## 909.07.09 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.

**909.07.10 Concrete Finishing**

The top surface of the girders, against which new concrete is to be placed, shall be intentionally roughened while the concrete is sufficiently plastic so that the depth of the indentations is at least 5 mm and the spacing is not greater than 15 mm.

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

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

a) Top portion of girders containing laitance.

b) The portion of the sides and end of the girder against which new concrete is to be placed.

**909.07.11 Control of Temperature**

**909.07.11.01 General**

All necessary actions shall be taken to maintain temperatures within the specified limits. During the moist curing, moisture retention, and protection periods, the following temperature requirements shall be met:

a) The concrete temperature shall not exceed 70.0°C.

b) The concrete temperature shall not fall below 10.0°C before the concrete has reached 75% of the specified 28-Day compressive strength.

c) 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 temperature.
   ii. Internal concrete temperatures at different locations within the girder.

d) 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 temperature next to the concrete, within the curing enclosure.

**909.07.11.02 Temperature Monitoring and Records**

The concrete and air temperatures during the curing period and, if applicable, cold weather protection period shall be monitored and recorded. Thermocouples and dataloggers shall be used to measure and record temperatures for each girder produced.

Thermocouple wires shall be installed prior to placing concrete according to Table 3. Thermocouples for monitoring air temperature shall measure air temperature adjacent to the girder. Thermocouples used to monitor the surface concrete temperature shall be imbedded in the concrete within 5 mm of the surface. Thermocouples to monitor maximum internal temperature shall be placed at the locations where the concrete is expected to reach the highest temperature, according to Table 3.

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. If the datalogger does not have a digital display that allows the Contract Administrator

to verify temperature, the Contractor shall provide the Contract Administrator with the necessary instruments to allow the Contract Administrator to verify thermocouple function and readings.

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, in writing, to be acceptable to the Owner.

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.

**909.07.12 Curing**

**909.07.12.01 General**

Moist curing shall continue throughout the duration of the moist curing period. The moist curing period shall be 48 hours followed by a 48-hour moisture retention period, except for concrete containing silica fume which shall have a moist curing period of 7 Days.

Moist curing of exposed surfaces shall be applied within 2 to 4 m of concrete placement, except for girders produced in an indoor precast concrete plant and not containing silica fume; for such girders, exposed surfaces may be covered with moisture vapour barrier between concrete placement and concrete finishing, for the shortest practical time period and in no cases exceeding 40 minutes.

For all girders, after formwork is removed, formed surfaces shall be moist cured for the remainder of the 48-hour moist curing period, and no less than 24 hours.

**909.07.12.02 Moist Curing**

Moist curing shall be sufficient to keep all surfaces of the precast girder 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.

Girders whose surfaces have not been kept in a continuously wet condition shall be rejected and replaced; the Contractor may submit a proposal for remediation subject to the approval of the Owner.

**909.07.12.02.01 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.

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 girder 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.

**909.07.12.02.02 Steam Curing and Other Application of Heat**

Application of steam may be used.

The girder 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 girder. 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 girders. 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.

**909.07.12.03 Moisture Retention**

After completion of the moist curing period, girder surfaces shall be completely covered by moisture vapour barrier to protect girders from moisture loss for a period of 48 hours.

Alternatively, moist curing methods may be continued during this period.

**909.07.13 Cold Weather Protection Period**

If cold weather conditions are present at the end of the curing period and moisture retention period, the girders 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 subsection.

**909.07.14 Exposure**

During moist curing, moisture retention and cold weather protection periods, the girder may be exposed for a maximum total period of 1 hour per day for the purposes of formwork removal, release of strands at transfer strength, 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 subsection 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 at locations according to Table 3.

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 plants, except for concrete containing silica fume, where continuous moist curing shall be applied throughout the exposure period.

### 909.07.15 Transfer of Prestressing Force

The prestressing force shall not be transferred to the girders 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.

### 909.07.16 Treatment at Ends of Girders

The prestressing strands at ends of girders that are to be encased in concrete shall be cut off 25 mm beyond the ends of the beams. The prestressing strands at the end of girders that are not to be encased in concrete shall be cut back to recess the cable 25 mm from the end of girder. The recess shall be cleaned, filled with a proprietary patching material, and the ends of the girders coated with elastomeric coating.

### 909.07.17 Surface Finish

#### 909.07.17.01 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 according to Table 2 are repairable by standard methods according to Table 2.

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

#### 909.07.17.02 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. Care shall be taken to select material, including proprietary patching materials, to achieve uniformity of colour and appearance.

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

### 909.07.18 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 by 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 adjustments. Satisfactory control shall be established each Day.

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, and casting of cylinders for determination of compressive strength 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.

The person shall have a valid original card issued by the certifying agency in their possession at all times.

**909.07.19 Transfer Strength**

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.

**909.07.20 Concrete Cover Measurement**

The Contractor shall carry out, at the precaster's facility, a cover meter survey on all girders until satisfactory control is established. For each type, design and size of girder, satisfactory control shall be established when three consecutive girders of the same design are within the specified tolerances. After satisfactory control has been established, testing shall be carried out on every fifth girder. If testing indicates that cover measurements for a girder do not meet the tolerances specified in Table 1, testing shall resume on each girder until satisfactory control is re-established.

Readings shall be taken at locations 600 mm from both ends, at mid-span, and at intervals not exceeding 5 metres along the length of the girder.

For I-girders, readings shall be taken at each location, as detailed below:

a) Top of web, both sides.

b) Bottom of web, both sides.

c) Mid-height of each side of bottom flange for CPCI-Girders, and on top of each side of bottom flange, 150 mm from the edge of the flange for NU girders.

d) Underside of girder, located at 150 mm from both edges of flange.

For box girders, readings shall be taken at each location, as detailed below:

a) Top of web, exterior sides.

b) Bottom of web, exterior sides.

c) Underside of girder, located at 400 mm from both edges of flange.

**909.07.21 Dimensional Measurements**

The Contractor shall carry out measurements on each girder to determine compliance with tolerance requirements. Girders shall meet the tolerances specified in Table 1.

**909.07.22 Access for Quality Assurance**

Electrical power, scaffolding, protection from the weather, and unhindered access for inspection and testing of all fabrication, delivery, and installation of girders shall be provided to the Contract Administrator or Owner's representative.

For the purposes of cover meter and dimensional measurements, all debris and obstructions shall be removed.

**909.07.23 Delivery**

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

Delivery shall include transportation and storage of the girders. Transportation and storage of the girders shall be according to CAN/CSA A23.4. The delivery shall include loading of the girders, transportation, unloading, and storage at the storage site.

Girders 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.

Girders shall be handled and transported with their webs in a vertical plane, and the points of support during loading and unloading, lifting, storing, and transporting shall be according to the Working Drawings.

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

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

**909.07.24 Installation**

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

The work shall consist of installation and stabilization of the girders during construction. Girders 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 girders.

The installation tolerance of girders shall be ± 15 mm on the bearing in both the longitudinal and transverse directions.

For box girders placed side-by-side, accumulated tolerance differences shall be distributed equally along the width of the structure. The maximum accumulated increase or decrease in total width of the girders shall not exceed 70 mm with 35 mm maximum on either side.

The forces resulting from the lifting devices acting on the girders shall not be inclined to the vertical at an angle greater than 30 degrees. All lifting devices for girders shall be removed or cut off to maintain the specified cover prior to placement of concrete in the deck.

I-girders and other girders that may experience stability problems during construction shall be braced individually by attaching each end to the substructure, as a minimum, immediately upon installation and according to the Working Drawings.

**909.07.25 Repair of Defects and Deficiencies Repairable by Standard Methods**

Any individual girder having one or more of the defects and deficiencies identified 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, are located in the same area in the girder, a repair proposal shall be submitted. All causes, preventative actions, and corrective actions, including repair methods and materials used, shall be documented and submitted in the precast report.

**909.07.25.01 Assessment of Repair**

When defects or deficiencies occur, at the discretion of the design Engineer, a visual inspection may be conducted or other measures required, such as cores to be taken to assess the effectiveness of the repairs.

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

**909.07.26 Inspection after the Installation of the Girders**

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator, for each structure, after the installation of all girders within a construction stage.

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

**909.07.27 Material Sampling for Acceptance Testing**

**909.07.27.01 Sampling of Steel Reinforcement**

Samples of steel reinforcement shall be provided to the Owner according to OPSS 905 when requested.

If required, samples shall be delivered to:

Head, Concrete Section
Ontario Ministry of Transportation
145 Sir William Hearst Avenue, Room 15
Downsview, Ontario, M3M 0B6

**909.07.27.02 Sampling of Water, Admixtures, and Cementing Materials**

When requested by the Owner, samples of all cementing materials, admixtures, and water shall be obtained and delivered for testing by the Owner. If required, samples of admixtures and water shall be delivered to the Regional Quality Assurance laboratory and samples of cementing materials shall be delivered to:

Head, Concrete Section
Ontario Ministry of Transportation
145 Sir William Hearst Avenue, Room 15
Downsview, Ontario, M3M 0B6

**909.07.27.03 Sampling of Hardened Concrete for Acceptance Testing**

**909.07.27.03.01 General**

Test specimens shall consist of cylinders cast from plastic concrete for determination of compressive strength and cores removed from completed girders for determination of 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.

Girders shall be sampled on a lot basis according to Table 4 of this specification.

### 909.07.27.03.02 Cylinders for 28-Day Compressive Strength Testing

Sets of cylinders, as defined in Table 4, shall be cast for 28-Day compressive strength testing by the Owner.

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 girder 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 Form A of the concrete mix design for the girder.

### 909.07.27.03.03 Coring

The number of cores removed from a girder shall be according to Table 4.

Cores shall be removed at the plant or on site when the girder is between 7 to 10 Days of age. Cores shall be removed in the presence of the Contract Administrator or Owner's representative. The girder from which core samples shall be taken shall be randomly selected from the lot by the Contract Administrator.

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 girder shall be used to establish the location of reinforcement and other embedded material prior to coring.

Cores shall be taken from locations selected by the Contract Administrator as follows:

a) For I-girders, cores shall be from the middle quarter of the girder length, in the upper half of the web, outside of the flange area.

b) For box girders, cores shall be taken at random locations of the top slab.

The Contract number, lot number, and girder 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. Cores shall be transported to the designated laboratory within 24 hours of coring with a transmittal form and the Form A of the concrete mix design for the girder. Cores shall be transported in a manner to avoid damage.

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 girder.

## 909.07.28 Management of Excess Material

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

## 909.08 QUALITY ASSURANCE

### 909.08.01 General

The acceptance of girders shall be according to the requirements of this specification, including satisfactory completion of all repairs, if applicable. Girders 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. Lot size, of the lesser of either 7 consecutive Days' production or 4 consecutively produced girders, shall be confirmed with the Contract Administrator prior to commencing production.

For Contracts requiring high-volume production, the use of a larger lot size may be proposed, up to a maximum of 20 girders per lot produced over no more than 7 consecutive Days, and shall be subject to the approval of the Owner. The established lot size shall remain consistent for the duration of the Contract.

### 909.08.02 Lot Size and Samples for Compressive Strength, Air Void System, and Rapid Chloride Permeability

Acceptance of 28-Day compressive strength shall be based on testing of cylinders.

Acceptance testing of air void system and rapid chloride permeability shall be performed on cores removed from the girders. Testing of cores for air void system shall commence when the sample is delivered to the designated laboratory.

The sample type and size, and number of samples per lot shall be according to Table 4.

### 909.08.03 Acceptance of Concrete Compressive Strength

Compressive strength of cylinders, for acceptance, shall be determined according to LS-426 for concrete with silica fume and high strength concrete, and according to LS-407 for all other concrete.

#### 909.08.03.01 Basis of Acceptance

28-Day compressive strength of a lot shall be considered acceptable when it meets all of the following:

a) The average of the set of three cylinder compressive strengths shall be equal to or greater than the specified 28-Day compressive strength.

b) No individual cylinder 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.

#### 909.08.03.02 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 girder which the acceptance cylinders represent. The Contractor shall remove the cores in the presence of the Contract Administrator. 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 subsection of this specification, with the exception that if the girders have not been delivered to the construction site, coring shall take place at the

precast plant in the presence of the Contract Administrator. 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 A 23.2-9C on moisture conditioned cores.

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

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 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.

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

**909.08.04 Acceptance of Air Void System in Hardened Concrete**

Testing of air void system shall be according to LS-432. One half of the sample shall be tested to determine the acceptability of the lot. The other half of the sample 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 sample shall have a minimum air content of 3.0% and a spacing factor of 0.200 mm or less. Acceptable lots shall be subject to full payment.

Lots with samples with a spacing factor greater than 0.200 mm and less than or equal to 0.250 mm shall be considered unacceptable and shall be repaired according to Table 2.

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

**909.08.04.01 Referee Testing of Air Void System in Hardened Concrete**

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

**909.08.05 Acceptance of Rapid Chloride Permeability**

Cores shall be tested for rapid chloride permeability according to LS-446. Three 50-mm long test specimens shall be prepared for each core:

a) One specimen shall be tested immediately after the core is delivered to the laboratory. Results shall be provided to the Contractor for information purposes as they become available.

b) Two specimens shall be tested between 28 and 32 Days of age to determine acceptance of the lot. The acceptance test result for the lot shall be the average of the two 50-mm long samples tested between 28 and 32 Days of age. The test result shall be used to determine the acceptance of the lot.

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.

**909.08.05.01 Referee Testing of Rapid Chloride Permeability**

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

Referee testing for rapid chloride permeability shall be carried out on a new core taken by the Contractor from the same girder from which the acceptance sample was obtained. A core for referee testing shall be removed in the presence of the Contract Administrator, for each disputed lot, at a location no more than 1 meter from the location from which the disputed acceptance core was removed. The core 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 subsection of this specification. 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 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 Acceptance of Rapid Chloride Permeability for Silica Fume Overlays and High Performance Concrete.

**909.08.06 Acceptance of Water, Admixtures, and Cementing Materials**

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

**909.08.07 Acceptance of Concrete Temperature**

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

Each girder for which the highest temperature has been maintained below 65.0 °C during the moist curing, moisture retention, and protection periods and which meets all other requirements of the Contract Documents shall be eligible for a payment bonus. The bonus shall be $1,000 for each girder, up to a maximum of $10,000 in total for all of the girders in a single structure. A girder which is rejectable or fails to fully meet the requirements of the Contract Documents shall not be eligible for a bonus.

### 909.08.08 Acceptance of Surface Finish

All girders meeting the surface finish requirements of this specification shall be considered acceptable. A proposal may be submitted by the Contractor for unacceptable surface finish, according to the All Other Defects and Deficiencies section of this specification, subject to the approval of the Owner.

### 909.08.09 Dimensional Verification and Concrete Cover Measurements

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

If a girder fails to meet the requirements specified in Table 1,

a) It shall be rejected and replaced, and

b) A consultant shall be retained by the Owner, at the Contractor's expense, to verify all other girders are within the tolerances of Table 1.

If a girder fails to meet the dimensional tolerances in Table 1, it shall be rejected and replaced; the Contractor may submit a proposal for remediation or for use of the girder, subject to the approval of the Owner.

### 909.08.10 Defects and Deficiencies

#### 909.08.10.01 General

Defects and deficiencies are classified as follows:

a) Defects and deficiencies repairable by standard methods.

b) Defects and deficiencies causing rejection.

c) All other defects and deficiencies.

#### 909.08.10.02 Defects and Deficiencies Repairable by Standard Methods

Any individual girder having one or more of the defects and deficiencies listed in Table 2 shall be deemed unacceptable and the girder 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 girder, the Contractor shall be required to submit a repair proposal for acceptance according to the All Other Defects and Deficiencies clause.

#### 909.08.10.03 Defects and Deficiencies Causing Rejection

A girder having any one of the following defects and deficiencies shall be rejected and replaced:

a) If concrete temperature exceeds 70°C at any time during the curing period.

b) For I-girders, if there is honeycombing, voids, cavities, spalls, delaminations, or cracks in the concrete within a bearing surface area defined by the contact area of the bearing plus 30 mm on all sides, except when the bearing area of the girder is fully encased in concrete.

c) For box girders, if there is honeycombing, voids, cavities, spalls, or delaminations in the concrete within a bearing surface area defined by the contact area of the bearing plus 30 mm on all sides, except when the bearing area of the girder is fully encased in concrete.

d) If there is a crack in the bottom flange that extends through to the opposite face, unless the entire crack is located at the end of the girder and will be fully encased in concrete.

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

f) If the sweep of the girder on site and in position without any intermediate bracing is in excess of 1.5 mm/m length of girder.

g) If cover does not meet specified requirements except as indicated in the All Other Defects and Deficiencies section of this specification.

**909.08.10.04 All Other Defects and Deficiencies**

The Contractor shall submit a proposal for repair or remediation to the Contract Administrator for acceptance, when,

a) A girder 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 girder; or

c) Three occurrences of the same defect are present in the girder; 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 4 MPa below the specified strength; or

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

h) Failure to maintain moist curing has occurred; or

i) Has horizontal or inclined cracks in the web, where the maximum width of crack is greater than 0.2 mm but less than 0.3 mm.

Horizontal or inclined cracks in the web, where the maximum width of crack is less than 0.2 mm, shall not be considered a defect or deficiency.

The repair proposal, signed and sealed by an Engineer, shall include, as a minimum,

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

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

c) Assessment of any impact of the repaired defects on durability, structural adequacy, and integrity of the girder or on the structure.

d) A detailed repair plan, including material, 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 girder shall be met.

g) Causes 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 girder shall be repaired according to the proposal. The Contractor shall not carry out any repairs without the prior acceptance of the proposal by the Contract Administrator. If the repair proposal is deemed unacceptable, the girders shall be rejected and replaced.

In addition, the repair proposal shall be signed and stamped by an Engineer, including, as a minimum, assessment of any impact on the durability, structural adequacy, and integrity of the girder or on the structure, of either low or high cover, and submitted to the Contract Administrator for acceptance, when,

a) Low cover at soffit of girders at locations other than bearing cutouts: any cover readings less than 40 mm and greater than 35 mm.

b) High cover at soffit of girders at locations other than bearing cutouts: any cover readings less than 70 mm and greater than 60 mm.

c) High cover at all locations other than between bearing cutouts on soffit of girders: any cover readings less than 55 mm and greater than 45 mm.

For low cover at all locations except girder soffits between bearing cutouts, the girder may be sealed for cover readings between -5 mm and -10 mm of the specified cover, according to Table 2 of this specification.

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

## 909.10 BASIS OF PAYMENT

### 909.10.01 Prestressed Concrete Girders (Type) Fabrication - Item<br>Prestressed Concrete Girders Containing Silica Fume (Type) 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 girders shall be replaced at no additional cost to the Owner.

Girders stored at the precaster's premises or at some other location away from the Working Area shall be paid for when the Contractor obtains a lease from the property owner that names the Owner as the tenant. The Owner shall provide the form of lease for this purpose that specifies a payment of $10.00 for the term of the lease. The Contractor shall retain full responsibility for the girders.

### 909.10.02 Payment Adjustment for Rapid Chloride Permeability

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

Payment adjustment = lot quantity ×(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 × (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) |

**909.10.03** **Prestressed Concrete Girders (Type) Delivery - Item**
**Prestressed Concrete Girders Containing Silica Fume (Type) Delivery - 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.

**909.10.04** **Prestressed Concrete Girders (Type) Installation - Item**
**Prestressed Concrete Girders Containing Silica Fume (Type) 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**
**Tolerances**

| Item | Tolerances |
|---|---|
| Length:<br>Straight-line measurement taken horizontally at the mid-height of girder | ± 1.0 mm/m; not to exceed ± 25 mm maximum |
| Overall Depth | ± 8 mm for depths up to 600 mm<br>± 12 mm for depths over 600 mm |
| Flange Depth and Web Width for Girders Without Voids | Flange depth ± 5 mm<br>Web width -5/+10 mm |
| Flange Depth and Web Width for Girders With Voids | Flange depth ± 10 mm<br>Web width ± 10 mm |
| Width:<br>Flanges and Box Girders | ± 10 mm |
| Sweep:<br>I-girders, spaced box girders, and spaced hollow slab girders<br>Abutting box and hollow slab girders | 1 mm/m length of girder.<br>± 10 mm |
| Squareness and Plumbness | 1 in 200 maximum |
| Camber Difference:<br>Between adjacent girders spaced apart<br>Between adjacent girders placed side-by-side | 25 mm<br>15 mm |
| Hold-Down Position Along Length | ± 300 mm |
| Void and Diaphragm Position Along Length | ± 25 mm |
| Concrete Cover Over Steel Reinforcement | Unless otherwise specified in the Contract Documents, the tolerance for concrete cover over steel reinforcement shall be -5/+15 mm |
| Stirrup Projection | -10/+15 mm |

**TABLE 2**
**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.<br>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 × 300 mm with no reinforcing steel or strand exposed.<br><br>Cumulative total area of this type of repair shall not exceed 10% of each face of the girder. | a) Square all sides of the repair area.<br>b) Saw cut perimeter of removal area to a depth of 10 mm or to the depth of reinforcing steel or strands, whichever is less.<br>c) Remove all loose concrete using a chipping hammer or hand tools.<br>d) Insert corrosion resistant wire mesh and anchors.<br>e) Abrasive blast-clean all concrete surfaces to be patched according to OPSS 929.<br>f) Remove all dust and loose material from the prepared surface by using compressed air.<br>g) Moisten area to be repaired.<br>h) Fill repair area with concrete or a proprietary patching material.<br>i) Cure concrete according to moist curing requirements of this specification. Cure proprietary patching material according to the manufacturer's recommendations. |
| Low Cover (all girder surfaces except girder soffits between bearing cutouts) | Low cover readings between -5 mm and -10 mm of the specified cover. | The entire surface of the girder shall be sealed, with an acceptable sealer, except areas against which new concrete is to be placed or in contact with bearings. Where sealing of an exterior girder is required all exterior girders in the same line of girders shall be sealed for consistency of appearance. |
| Air Void System Parameters | Any lot with spacing factor greater than 0.200 mm, but less than or equal to 0.250 mm. | The entire surface of all the girders of the lot shall be sealed, with an acceptable sealer, except areas against which new concrete is to be placed or in contact with bearings. Where sealing of an exterior girder is required, all exterior girders in the same line of girders shall be sealed for consistency of appearance. |
| Sweep | Sweep greater than 1.0 mm /m length but less than or equal to 1.5 mm/m length. | Push or pull the girders to within tolerance. Girders that can be brought into tolerance and maintained at that position without visible signs of distress shall be accepted. Girders greater than or equal to 1,900 mm in depth shall be pulled or pushed at both the top and bottom flange. |

**TABLE 3**
**Concrete and Air Temperature Measurements**

| Temperature | Location of Thermocouple for Concrete and Ambient Temperature |
|---|---|
| Internal | I-Girders:<br>• Centroid of bottom flange at mid-span (1), for maximum temperature<br>• Middle of web, 1 m from each end of the girder (2)<br>Box Girders:<br>• Mid-depth at the centroid of solid section at each end of the girder (2), for maximum temperature<br>• Middle of bottom slab at mid-span (1) |
| Surface | For each internal thermocouple above, a corresponding thermocouple shall be installed at the closest adjacent concrete surface. This thermocouple shall be imbedded in the concrete within 5 mm of the surface of the concrete (3). |
| Air Temperature | Air temperature next to the concrete within the enclosure at each end of the girder (2). |
| Note: Number of thermocouples shown above in parentheses, total for each girders = 8 | |

**TABLE 4**
**Sampling for Acceptance Testing**

| Element Type | Sample Type and Size | Number of Samples per Lot |
|---|---|---|
| Prestressed Precast Girders | Cylinders<br>100 mm diameter and 200 mm long | One set of 3 cylinders for 28-Day compressive strength. The girder for which the cylinders shall be cast shall be randomly selected from the Lot. (for acceptance testing) |
| | Cores*<br>100 mm diameter 220 mm long or full depth, whichever is less | One set of 2 cores, for acceptance testing of air void system parameters (1) and rapid chloride permeability (1). |
| * Cores to be taken from a single girder in the Lot. | | |