

**SPECIFICATIONS FOR**  
**FABRICATION OF PRECAST PRESTRESSED CONCRETE GIRDERS**

**1.0 DESCRIPTION**

The Work shall consist of:

- .1 The supply of materials and the fabrication of precast prestressed concrete girders and miscellaneous precast components as shown and described on the Drawings and in this Specification;
- .2 The supply and installation of all embedded materials;
- .3 The handling and storage of completed girders in the Fabricator's plant;
- .4 The quality control (QC) testing of all materials; and
- .5 The supply of all cables, anchorages, and other incidental materials for lateral stressing.

The Fabricator shall notify the Department of any Subcontractors that have been contracted in respect of this Specification. The Fabricator shall remain responsible for the work of such Subcontractors. All requirements of this Specification, such as right of access, shall apply to such Subcontractor.

**2.0 REFERENCES AND RELATED SPECIFICATIONS**

All reference standards and related specifications shall be current issue or the latest revision at the date of tender advertisement.

**2.1 References**

- CSA A23.1/A23.2, Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete
- CAN/CSA A3001, Cementitious Materials for Use in Concrete
- CSA G30.14, Deformed Steel Wire for Concrete Reinforcement
- CAN/CSA G30.18, Billet-Steel Bars for Concrete Reinforcement
- CAN/CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel
- CAN/CSA G164, Hot Dip Galvanizing of Irregularly Shaped Articles
- AASHTO T 176, Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test Nineteenth Edition
- ASTM C 29, Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
- ASTM C 40, Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
- ASTM C 42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- ASTM C 70, Standard Test Method for Surface Moisture in Fine Aggregate
- ASTM C 88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
- ASTM C 117, Standard Test Method for Materials Finer than 75- $\mu$ m (No. 200) Sieve in Mineral Aggregates by Washing
- ASTM C 127, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
- ASTM C 128, Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate

- ASTM C 131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- ASTM C 136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
- ASTM C 138, Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- ASTM C 142, Standard Test Method for Clay Lumps and Friable Particles in Aggregates
- ASTM C 260, Standard Specification for Air-Entraining Admixtures for Concrete
- ASTM C 289, Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
- ASTM C 295, Standard Guide for Petrographic Examination of Aggregates for Concrete
- ASTM C 457, Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete
- ASTM C 494, Standard Specification for Chemical Admixtures for Concrete
- ASTM C 535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- ASTM C 586, Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method)
- ASTM C 1017, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
- ASTM C 1064, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- ASTM C 1084, Standard Test Method for Portland-Cement Content of Hardened Hydraulic-Cement Concrete
- ASTM C 1202, Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
- ASTM C 1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
- ASTM C 1583, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method)
- ASTM C 1602, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
- ASTM D 75, Standard Practice for Sampling Aggregates
- ASTM D 4791, Standard Test Method for Flat Particles, Elongated Particles or Flat and Elongated Particles in Coarse Aggregate
- ASTM D 5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D 6928, Standard Test Method for Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- ASTM D 7428, Standard Test Method for Resistance of Fine Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus

## 2.2 Related Specifications

- Specifications for Supplying and Placing Concrete Reinforcement
- Specifications for Supply, Fabrication and Erection of Miscellaneous Metal

### 3.0 SUBMITTALS

The Fabricator shall submit the following to the Engineer, in accordance with this Specification:

- (a) The precast concrete manufacturing plant shall be certified under the CPCI Certified Plant Program and shall meet the requirements of CSA A23.4, including Appendices A and B. The manufacturer shall be certified at the time of bidding.
- (b) Concrete mix design that meets the minimum compressive strengths ( $f'c$  and  $f'ci$ ) as shown on the Drawings shall be stamped, signed and dated by a Professional Engineer licensed to practice in the Province of Manitoba. Any changes to the concrete mix design shall be reviewed by the Engineer prior to the Fabricator implementing the change.

The concrete mix design(s) for the required type(s) of concrete shall specify the following:

- i) Cementitious content in kilograms per cubic metre or equivalent units for each type of cementitious material;
- ii) Designated size, or sizes, of aggregates, and the gradation;
- iii) Aggregate source location(s);
- iv) Weights of aggregates in kilograms per cubic metre or equivalent units. Mass of aggregates is saturated surface dry basis;
- v) Maximum allowable water content in kilograms per cubic metre or equivalent units and the design water/cementitious ratio;
- vi) The limits for slump;
- vii) The limits for air content;
- viii) Quantity in millilitres per cubic meter or equivalent units and brand name for each type of admixture;
- ix) Certification that all concrete constituents are compatible; and
- x) Certification that the concrete mix(es) will meet the specified concrete performance criteria requirements.

The intended method of placement shall be taken into consideration in the development of the concrete mix design(s) as concrete to be pumped must be designed accordingly.

Any change in any one of the constituent materials of the concrete shall require a new concrete mix design. If, during the progress of the work, the mix design is found to be unsatisfactory for any reason the Fabricator shall revise the mix design(s) and submit the proposed changes to the Engineer for review.

The Fabricator shall also submit test data showing that the concrete supplied will meet the performance criteria stated on the Drawings and in this Specification. At a minimum, the test data shall prove that the minimum compressive strength, density, air content, temperature and slump of the concrete to be supplied meets or exceeds the performance criteria.

All testing of concrete and concrete constituents by the Fabricator shall be done by an independent laboratory certified in accordance with CSA A283 for the appropriate category. As a minimum, the following material test results for the concrete and concrete constituent materials shall also be submitted:

- i) All aggregates shall comply with CSA A23.1, Clauses 4.2.3.1 to 4.2.3.6. Aggregate testing specified in CSA A23.1, Clauses 4.2.3.3, 4.2.3.4, 4.2.3.5.1, 4.2.3.6, 4.2.3.7, and Tables 10, 11, and the Standard requirements for concrete exposed to freezing and thawing listed in Table 12;
- ii) Abrasion and impact testing results for coarse aggregate in accordance with CSA A23.2-16A;
- iii) Report on alkali-aggregate reactivity testing, CSA A23.2-27A;
- iv) Report on aggregate petrographic examination, CSA A23.2-15A;
- v) Report on chloride ion penetrability test ASTM C 1202;
- vi) Report on the water soluble chloride ion content by mass of cementing material in the concrete, CSA A23.2-4B; and
- vii) Report on Air Content of Hardened Concrete tested in accordance with ASTM C 457 for all concrete mixes with a specified Category 1 air content.

Concrete materials testing results shall not be more than 12 months old at time of submission, with the exception of CSA A23.2-2A and CSA A23.2-5A which shall not be older than 90 days at time of submission.

- (c) Stressing calculations shall be stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba and include the following:
  - i) Copies of the stressing sequence and strand elongation calculations as well as all data required for checking these calculations. Separate elongation calculations shall be required for each significant variation in Modulus of Elasticity of the strand;
  - ii) A calibration graph for each jack, calibrated not more than 6 months prior to stressing operation;
  - iii) The proposed method of tensioning the draped strands, including a comprehensive description and drawing of the proposed hold-up and hold-down devices;
  - iv) The proposed sequence of stressing and distressing operations;
  - v) The anchorage losses experienced by the Fabricator under similar loading applications, and the proposed method of measuring the anchorage losses during the stressing operation; and
  - vi) A copy of the proposed "Record of Concrete Strength" and "Record of Pre-Tensioning" forms to be used by the Fabricator.
- (d) Copies of the stress-strain curve for the prestressing steel and the lateral stressing cables.
- (e) Copies of all reports, including but not limited to: "Record of Concrete Strength" form, "Record of Pre-Tensioning" form and material quality control test results.
- (f) Details of concrete curing systems.
- (g) Time-temperature graphs showing concrete curing.

- (h) Letter of Validation from the Canadian Welding Bureau (CWB) and CWB approved welding procedures for the Fabricator's miscellaneous metal supplier. The Fabricator's miscellaneous metal supplier shall fulfill the requirements of CSA W47.1, Division 2.1 (minimum).
- (i) Design calculations and Shop Drawings for temporary wind bracing and lateral stability bracing for girders that are required for the Fabricator's handling and storage operations. These design calculations shall be stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba.
- (j) Identification of all Subcontractors and Subconsultants.
- (k) For NU girders only, the Fabricator shall also submit the following that are stamped, signed and dated by a Professional Engineer registered or licensed to practice in the Province of Manitoba:
  - i) Proposed lifting methodology and devices, their locations on girders and patching procedures after erection;
  - ii) Shop Drawings for Welded Wire Fabric (WWF) as shown on the Drawings including lap lengths; and
  - iii) Bending procedures for strands extended at girder ends.

## **4.0 MATERIALS**

### **4.1 General**

The Fabricator is responsible for the supply, storage and handling of all materials set forth in this Specification. Materials are to be obtained from the same source of supply or Manufacturer for the duration of the contract. Storage of materials shall conform to CSA Standards A23.1 and A23.4.

### **4.2 Concrete**

Concrete shall have minimum compressive strengths ( $f'_c$  and  $f'_{ci}$ ) as shown on the Drawings and meet the requirements of CSA A23.1, Exposure Class C-1, Air Content Category 1 for hardened concrete and shall have a maximum air void spacing factor (hardened concrete) of 0.23 mm.

#### **.1 Coarse Aggregate**

The maximum nominal size of coarse aggregate shall be 14 mm and meet the grading requirements of CSA A23.1, Table 11, Group 1. Coarse aggregate shall be uniformly graded and not more than 1 percent shall pass a 75  $\mu\text{m}$  sieve. Coarse aggregate shall consist of crushed stone or gravel or a combination thereof, having hard, strong, durable particles free from elongation, dust, shale, earth, vegetable matter or other injurious substances.

Tests of the coarse aggregate shall not exceed the limits for standard requirements prescribed in CSA A23.1, Table 12, for concrete exposed to freezing and thawing.

#### **.2 Fine Aggregate**

Fine aggregate shall meet the grading requirements of CSA A23.1, Table 10, FA1, be uniformly graded and not more than 3 percent shall pass a 75  $\mu\text{m}$  sieve. Fine aggregate shall consist of sand, stone, screenings, other inert materials with similar characteristics or a combination thereof, having clean, hard, strong, durable, uncoated grains free from injurious amounts of dust, clay lumps, shale, alkali, organic matter, loam or other deleterious substances.

Tests of the fine aggregate shall not exceed the limits for standard requirements prescribed in CSA A23.1, Table 12.

### .3 Admixtures

Air-entraining admixtures shall conform to the requirements of ASTM C 260.

Chemical admixtures shall conform to the requirements of ASTM C 494 or ASTM C 1017 for flowing concrete. All chemical admixtures shall be suitable for use in precast concrete, be supplied by the same manufacturer as the air entrainment agent, and be compatible with each other.

Acceptable admixtures are air entraining agents, superplasticizers, and water reducing agents. The addition of calcium chloride, accelerators, retarders or set controlling admixtures and air reducing agents will not be permitted.

### .4 Cementitious Materials

Cementitious materials shall conform to the requirements of CAN/CSA A3001 and shall be free from lumps. Normal Portland cement, Type GU or GUb, shall be supplied unless otherwise specified on the Drawings or in the Special Provisions.

Should the Fabricator choose to include a silica fume admixture in the concrete mix design, the substitution of silica fume shall not exceed 8% by mass of normal Portland cement. Condensed silica fume shall conform to CAN/CSA A3000 – Cementitious Material Compendium, Type SF, with a SiO<sub>2</sub> content of at least 85%, a maximum of 10% ignition loss and no more than 1% SO<sub>3</sub> content. A compatible superplasticizing admixture accepted by the Engineer shall be used together with the silica fume.

Should the Fabricator choose to include fly ash in the concrete mix design, the fly ash shall be Class CI and the substitution shall not exceed 20% by mass of normal Portland cement. Fly ash shall conform to CAN/CSA A3000 – Cementitious Material Compendium, Class CI.

### .5 Water

Water to be used for mixing and curing concrete or mortar shall be potable, shall conform to the requirements of CSA A23.1 and shall be free of oil, alkali, acidic, organic materials or deleterious substances. The Fabricator shall not use water from shallow, stagnant or marshy sources.

Water of unknown quality shall satisfy the additional requirements listed in Table 9 of CSA 3.1.

## 4.3 Prestressing Strand

The high strength strand shall be in accordance with the size and ultimate strength as shown on the Drawings, CSA G279 and the following:

### .1 Tagging

Size of strand, coil number, heat number and the mark of the Manufacturer shall be recorded on a tag attached securely to each reel. The tag shall also identify the strand with its own stress-strain curve.

### .2 Stress-Strain Curves

One stress-strain curve shall be provided by the Manufacturer for each reel.

### .3 Testing

Should the Engineer consider it necessary, approval of the prestressing strand, in addition to the requirements of CSA G279, shall be based on tests carried out by the Fabricator at his expense in a testing laboratory satisfactory to the Engineer. The Fabricator shall test a minimum of three representative specimens of the strands to be used in the girders. The results of these tests shall be supplied to the Engineer. The Engineer may also require the Fabricator to supply additional representative specimens for independent testing if the results are deemed unsatisfactory or inconclusive.

Where the strand has rusted in storage, the use of such material will be subject to approval by the Engineer. The Engineer, at his discretion, may require physical tests at the Fabricator's expense in order to determine whether the material is suitable for use in the girder.

All strands that are contaminated by substances having a deleterious effect on the steel or concrete or on the bond strength of concrete to strand, or sustain physical damage shall either be replaced or cleaned to the satisfaction of the Engineer at the Fabricator's expense. Stressing strand splices shall not be placed within a precast component.

### 4.4 Reinforcement

Reinforcing steel shall conform to the requirements of CSA G30.18, Grade 400W.

Deformed steel wire shall conform to the requirements of CSA G30.14, Grade 480W.

### 4.5 Embedded Materials

Embedded materials shall conform to the requirements shown on the Drawings and described in Specifications for Supply, Fabrication and Erection of Miscellaneous Metal, and are subject to the approval of the Engineer.

Girder sole plates shall be new Grade 350W and shall be in accordance with CSA G40.20/G40.21. The sole plates shall meet the straightness tolerances of CAN/CSA G40.20. Sole plates may be supplied without planning provided that satisfactory contact bearing is obtained.

### 4.6 Lifting Hooks

Lifting hooks shall be made of stressing strand conforming to the requirements for prestressing strand in this Specification.

### 4.7 Materials for Lateral Stressing

The Fabricator shall supply all cables and anchorages with end fittings for grouting, as required for lateral stressing.

#### .1 Anchorages

Anchorages for post tensioned work shall be capable of accommodating the number of strands specified and of sustaining, without appreciable slip, the loads that will be applied. Anchorages will be subject to the approval of the Engineer.

#### .2 Ducts

Ducts for enclosing the cables shall be rigid ferrous metal sheathing cast into the girders. The duct material shall be such that it is possible to obtain mortar-tight ducts following smooth curves in the correct locations in the concrete girders.

The type of ferrous metal selected for the ducts shall minimize the friction between the cables and the duct walls.

Duct sizes shall be as shown on the Drawings and are subject to the approval of the Engineer.

.3 Lateral Stressing Strand

The lateral stressing strand supplied shall be a “fabricated” galvanized strand.

4.8 Replacement of Damaged Materials

All material supplied by the Fabricator that in the opinion of the Engineer has been damaged or otherwise rendered unusable by improper storage or handling by the Fabricator shall be replaced by the Fabricator at his own expense.

**5.0 CONSTRUCTION METHODS**

5.1 Tolerances

The distance centreline to centreline of bearing areas or the bottom surface of steel plates cast into the girder shall not vary by more than 6 mm from the lengths shown on the Drawings, when measured 12 hours after the completion of the stress transfer.

Cross sectional dimensions throughout the entire length of the girder shall not vary from those shown on the Drawings by more than 3 mm.

The locations of prestressing steel shall not vary from those shown on the Drawings by more than 3 mm. The tolerance for the positioning of the void forms in the box girders shall be 3 mm for the concrete dimensions, concurrent with either no loss in mass for the unit or an increase in mass not exceeding 3 percent of the design dead load mass of the unit.

Horizontal alignment of girders shall conform to the following tolerances. The maximum deviation from a straight line parallel to the centreline of a girder shall be:

For I-beams or NU girders:	L < 12 m	12 mm
	12 m < L < 24 m	20 mm
	L > 24 m	25 mm
For box or channel girders:	L < 18 m	6 mm
	L > 18 m	10 mm

The bottom surface of girders at the bearing areas or the bottom surface of steel plates cast into the girders shall be in a true level plane that does not vary by more than 2 mm from a true straight edge placed in any direction across the bearing area or steel plate. The maximum deviation for other miscellaneous dimensional tolerances shall be:

Bulkheads	Warpage or tilt of ends	5 mm
Rail Anchor Bolts	Out of line	5 mm
	In spacing	5 mm
	In projection	5 mm
Dowel Holes	Out of plumb	5 mm
Void Location	Surface to void dimension	+15 mm after casting

## 5.2 Formwork

### .1 Outside Forms

Precast concrete units shall be fabricated in steel forms accepted by the Engineer.

The faces of the forms shall be smooth so as to impart a good finish to the concrete. Forms shall result in precast prestressed girders that conform to the shape, lines and dimensions as shown on the Drawings and within the tolerances described in this Specification. Forms shall be properly braced or tied together to maintain position and shape.

For all girders the forms shall be designed so that they can be removed without damaging the girder. For all "I" or "NU" girders the side forms shall be removed horizontally away from the girder by a method that prevents any contact of the form with the top flange after release of the form. The top flange shall not be subjected to a vertical force at any time.

Forms shall be designed for the rate and method of concrete placement and constructed to allow for the redistribution of loading and the movement of the form that will take place upon application of the prestressing force.

The faces of the forms shall be treated with release agent to ensure that stripping may be carried out without damage to the concrete. Care shall be taken to prevent the release agent from coming in contact with any reinforcement, prestressing strand or embedded materials.

Forms shall include temporary openings to facilitate the removal of all foreign substances prior to placing the concrete.

Recesses at the ends of the girders to facilitate positioning of prestressing strands will not be allowed.

### .2 Void Forms

Void forms shall be positioned accurately and be strong enough to withstand all pressures and uplift forces without excessive distortion. The void forms shall be well secured and remain in place during the operations of placing and vibrating concrete so that their correct positions with respect to the horizontal and vertical axes of the girder will be maintained within the limits of the dimensional tolerances.

All void forms shall be vented to alleviate expansion forces from occurring during curing. Each void form shall have 15 mm round vent holes in both the bottom and top slab.

The location of the vent holes will be subject to the Engineer's approval. The top vent holes shall be grouted after curing and the bottom vent holes shall be left open.

The void forms and retaining devices shall be tested and approved by the Engineer prior to the fabrication of the girders to ensure that the shape and position of the void forms are maintained throughout girder fabrication. The testing shall be carried out by the Fabricator.

The test section shall be representative of the precast girder, with a minimum length of 2 metres, and the void form anchored and positioned accurately. In the event that the Fabricator proposes to splice the void forms, a characteristic splice shall be incorporated into the test section. Vents in the top and bottom slabs shall be included for the purposes of the test. One end of the test section shall include a typical end while the other end shall be bulkheaded to permit subsequent inspection of the void.

The test shall be repeated until the Fabricator provides a void that meets the tolerances for dimensions and mass.

### .3 Installation of Embedded Materials

Embedded materials, including steel plates at the bearing areas, shall be fabricated and meet the installation requirements described in Specifications for Supply, Fabrication and Erection of Miscellaneous Metal, be placed in the positions as indicated on the Drawings, and fixed securely to the forms to ensure that there is no displacement during the placing and vibrating of concrete.

Embedded materials that are coated shall be cleaned by sandblasting or wheelabrating prior to being coated. The minimum degree of cleaning shall meet the requirements of the Steel Structures Painting Council (SSPC) Specification SP6.

### .4 Placing Anchorages

The anchorages shall be centred in the positions shown on the Drawings within a tolerance of 3 mm coaxial with the ducts. The anchorages shall be fastened securely to the forms to prevent displacement during the placing and vibrating of the concrete. The joints between the forms and anchorages shall be taped to prevent leakage of concrete mortar.

### .5 Placing of Ducts

The method of supporting the ducts shall be approved by the Engineer and shall ensure that the ducts are held true to the locations shown on the Drawings within a tolerance of 3 mm.

The ducts shall be securely in place and supported at the spacing shown on the Drawings in order to prevent horizontal or vertical displacements of the ducts during the placing and vibrating of concrete. In the event that the duct support spacing is not indicated on the Drawings, the maximum spacing shall be 1 metre.

All duct couplers and duct connections to anchorages shall be well glued to prevent separation and the entry of concrete and moisture into the ducts. The ends of the ducts shall be plugged or capped temporarily to prevent entry of debris or other materials prior to the threading of cables.

### .6 Stressing

The submission of the stressing calculations to the Engineer shall in no way relieve the Fabricator of the full responsibility for the success or failure of the stressing operations.

The initial force in each strand shall be as shown on the Drawings or as specified by the Engineer. Prior to the stressing of the strands to the initial force, a 10.0 kN load shall be applied to each strand to eliminate slack and equalize stresses. The 10.0 kN load shall be applied to all strands and then rechecked before stressing any of the strands to the initial force.

The method of draping pretensioned strands shall be approved by the Engineer. The method shall ensure that the strands are held true to the locations shown on the Drawings within a tolerance of 3 mm.

Stressing strands shall not be stressed more than 12 hours prior to being encased in concrete. The stress in the stressing strands shall be measured both by jacking gauges and by elongation of the strands.

Seven wire stressing strands with any broken wire shall be removed and replaced. All stressing strands shall be checked for wire breaks before placement of concrete.

Before the stressing operation begins, the Fabricator shall have filled in on the approved "Record of Pretensioning" form the calculated jack gauge reading, the required gross elongation (based on estimated anchorage losses), and the required net elongation for each strand. During stressing operations, the Fabricator shall record the actual jack gauge reading, measured gross elongation, measured anchorage losses, and then calculate the actual net elongation for each strand.

Tensioning shall be carried out so that the jack is coaxial with the tendon or strand. If the strands are tensioned individually, care shall be taken to ensure that unravelling of the strands does not take place.

Actual net elongation of a strand shall not vary from the required net elongation by more than 1 percent or 3 mm, whichever is smaller. The actual anchorage losses encountered shall be used to modify the gross elongation required, if the actual net elongations are consistently greater or less than the required net elongation.

At no time shall the actual jack pressure vary from the pressure corresponding to the calculated gross elongation by more than 5 percent. If the required gross elongation is not obtained by stressing to this maximum allowable jack pressure at one end of the girder, it will be necessary to complete the stressing from the other end of the girder.

The jack calibration shall be repeated at any given time that a gauging system indications erratic results and at intervals not greater than 6 months during regular usage or not greater than 12 months for other conditions of use.

The fabricator shall have on hand a calibrated load cell that can be used to verify the actual load in the strand as a means of checking the elongation whenever the Engineer considers it necessary.

A copy of the "Record of Pretensioning" form shall be submitted to the Engineer upon completion of the pretensioning of each girder.

For pretensioned girders, the Engineer has allowed for a stress loss due to an increase in temperature of the prestressing strands from the time of tensioning to the time of initial set of the concrete. In order to verify the design values used for this stress loss, the Fabricator shall keep an accurate record of the temperature of the concrete in each girder from the time of placing of the concrete until the completion of curing.

For draped strands, the stressing shall be done from both ends, unless the required gross elongation can be obtained during the stressing at the initial end without exceeding the maximum allowable jack pressure. To ensure a uniform tension, the strands shall be held in their draped position by means of low friction pins or rollers at all hold-up and hold-down points.

The transfer of the pretensioning force from the bulkheads to the girder shall not be carried out until the concrete has reached the minimum compressive strength as shown on the Drawings or as specified by the Engineer. The cylinders used to determine this strength shall be cured under the same circumstances as the concrete of the girder in question (i.e. match cured). Transfer of the pretensioning force shall be carried out by a method approved by the Engineer. If the strands are to be cut, the destressing sequence shall be subject to approval by the Engineer.

All pretensioning strands shall be cut off flush with the end of the girder unless noted otherwise on the Drawings. The exposed ends of the pretensioning strands and a 50 mm strip of adjacent concrete shall be cleaned and painted unless noted otherwise on the Drawings or are to be encased in field cast concrete. Cleaning shall be by abrasive blast to remove all dirt and residue that is not firmly bonded to the concrete surface. The surfaces shall be coated immediately with one thick coat of zinc-rich paint or other waterproofing material approved by the Engineer. The paint shall be mixed thoroughly at the time of application and shall be worked into all voids in the pretensioning strands.

## .7 Reinforcement

Reinforcement shall be placed accurately in the positions shown on the Drawings, and shall be retained in such positions by means of bar accessories and wires to that the reinforcement shall not be moved out of alignment during or after the depositing of concrete. Bar accessories shall be galvanized or shall be made from non-rusting material. Concrete bar supports and sidewall spacers such as "Total Bond" concrete reinforcement supports, as supplied by ConSys Inc., or equivalent as approved by the Engineer will be allowed.

Reinforcement shall be kept free of all foreign materials in order to ensure a positive bond between the concrete and reinforcement. The Fabricator shall remove any material that has been deposited on the reinforcement before concrete is placed.

Intersecting bars shall be tied positively at each intersection.

The reinforcement shall be inspected by the Engineer prior to placement of concrete.

## .8 Depositing of Concrete

The temperature of the mixed concrete shall not be less than 10°C and not more than 25°C at the time of placing in the forms. Aggregates shall be heated to a temperature of not more than 65°C. The heating apparatus and the housing for the aggregates shall be sufficient to heat the aggregates uniformly without the possibility of the occurrence of hot spots that may burn the materials. The water shall be heated to a temperature of not more than 65°C.

Concrete shall be deposited carefully and vibrated so that it fills the forms completely and makes complete contact with all reinforcement, prestressing strands, ducts, anchorages and embedded materials.

Concrete shall be deposited at frequent locations within the forms so that there shall not be a necessity to move large quantities of concrete from place to place in the forms. The concrete shall be vibrated into sufficient place by methods that do not permit the constituent materials to segregate. The Fabricator shall provide sufficient personnel to deposit and vibrate the concrete and shall ensure that each batch of concrete is vibrated properly into place as it is deposited.

Buckets, chutes and other equipment used to deposit concrete in the forms shall be positioned as close to the top of the forms as possible to minimize the free fall of the concrete.

Depositing of concrete shall be a single continuous complete operation so that each girder shall be monolithic without joints. The time from the initial mixing of the concrete until placing the concrete in the forms shall not exceed one hour. The elapsed time between placement of the concrete onto previously placed concrete shall not exceed 30 minutes.

Before any concrete shall be deposited, the interior of the forms shall be cleaned of all chips, earth, shavings, sawdust, rubbish or other foreign substances.

## .9 Vibrating Concrete

Internal vibrators shall be used in all sections that are sufficiently large and they shall be supplemented by platform or screed-type vibrators in the event that satisfactory top surfaces cannot be obtained with the internal type alone. Internal vibrators shall be supplemented with vibrators operated against that outside of the forms to improve the finish of vertical concrete surfaces.

External vibration shall be used when sections are too small or inaccessible for internal vibrators.

Vibrators shall be of sturdy construction, adequately powered and capable of transmitting to the concrete not less than 3,600 impulses per minute when operating under load. The vibration shall be sufficiently intense to cause the concrete to flow or settle readily into place.

A sufficient number of vibrators shall be employed so that at the required rate of placement, vibration and complete compaction are obtained throughout the entire volume of each layer of the concrete. At least one extra vibrator shall be on hand for emergency use.

Internal vibrators shall be constantly moving vertically in the concrete and shall be applied at points uniformly spaced that are not farther apart than the radius over which the vibrator is visibly effective. Internal vibrators shall be applied close enough to the forms to vibrate the surface concrete effectively but care shall be taken to avoid displacing or damaging the forms. For successive lifts of concrete the vibrator shall be inserted to a depth equal to the length of the vibrating head into the underlying lift to provide complete consolidation.

Form vibrators shall be attached to the forms in such a manner as to transmit the vibration to the concrete effectively and the vibrators shall be raised in lifts as filling of the forms proceeds. The height of each lift shall not be more than the height of concrete visibly affected by the vibration. The form vibrators shall be spaced horizontally at distances not greater than the radius that the concrete is visibly affected.

With form or internal vibrators, the vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete but shall not be continued so as to cause segregation or draw a pool of grout from the surrounding area.

Surface vibrators shall be applied only long enough to embed the coarse aggregate and to bring enough mortar to the surface for satisfactory screeding.

Care shall be exercised so as not to damage the prestressing strand in any way or transfer the vibration through the strand to concrete that has already been placed and has started to set.

#### .10 Concrete Finish

The top surfaces of NU girders shall be finished to produce even indentations at right angles to the longitudinal centreline of the girders. The indentations shall be 6 mm (minimum), full amplitude and spaced not greater than 15 mm apart.

The top surfaces of I-girders shall be finished to produce even indentations at right angles to the longitudinal centreline of the girders. The indentations shall be approximately 10 mm deep, V-shaped and spaced 25 mm apart.

The tops of all other girders shall receive a screeded, untrowelled, and broomed finish.

The Fabricator shall construct a 25 mm deep recess around all lifting devices. These recesses shall be rectangular in shape with vertical sides, and the distance between the lifting device and the vertical sides shall not exceed 50 mm.

Prestressing strand ends shall be recessed 19 mm deep from the girder end face using a 38 mm wide expanded foam doughnut or other means as approved by the Engineer. After transfer, the projecting strand is to be cut back flush with the backside of the recess. The recesses shall be cleaned and patched as per this Specification, except that an approved epoxy bonding agent shall be applied to the recess surfaces before placing the grout.

The concrete surfaces of continuous shear keys and expansion joint block-outs shall be rough, clean, free of laitance and prepared to produce a CSP 6 concrete surface profile in accordance with

the International Concrete Repair Institute (ICRI) Guideline No. 03732. The method for roughening and cleaning the above surfaces shall be approved by the Engineer.

Immediately after the removal of the forms, all defects in the concrete shall be repaired as directed by the Engineer, provided the defects are not extensive enough to cause rejection of the girder. Should the top surface exhibit excessive laitance or "frothing", or any other deleterious effects, the Fabricator shall repair the concrete to the satisfaction of the Engineer.

Honeycomb, if any, shall be repaired as soon as the forms are taken off. When approved by the Engineer, repairs shall be accomplished by: saw cutting a regular pattern around the damaged area to a minimum depth of 2/3 the depth of concrete cover (keeping clear of any reinforcing steel); chipping concrete back for a constant depth along the edges; removing all concrete that is loose or that is not bonded thoroughly to the surrounding concrete; washing the sound concrete with clean water; using a wire brush to remove any loose particles; applying an approved epoxy bonding agent to the patch area after the surface has thoroughly dried; and patching with a high strength non shrink grout. Patched areas shall be ground flush and true with the surrounding surface after the cementitious grout has hardened and gained sufficient strength.

Holes made by hold-up or hold-down devices or other fabrication equipment, shall be cleaned of all oil and grease, washed with clean water and then, without delay, patched flush with the surface of the girder with the approved cementitious grout.

All objectionable fins, projections, offsets, streaks and other surface imperfections shall be removed totally to the Engineer's satisfaction by approved means.

Finally, the concrete surface shall be wetted down thoroughly and all air pockets and other surface cavities shall be filled carefully with the approved cementitious grout. When sufficiently dry, the surface shall be rubbed down to leave a smooth and uniform finish. Cement washes of any kind will not be allowed.

If, in the Engineer's opinion, repairs to the concrete are not satisfactory or will be detrimental to the strength or long term durability of the girder, the Fabricator shall, at his own expense and as directed by the Engineer, replace the girder.

#### .11 Identification of Components

Fabricator's name, year of manufacture, unit serial number and design loading shall be cast into the bottom of the units in 50 mm letters about 1.0 m from the unit end.

#### .12 Screed Chair Seats

Screed chair seats shall be installed in the top surfaces of girders as shown on the Drawings. Care shall be taken to install these screed chair seats level and flush with the top surfaces of the girders.

#### .13 Curing

Concrete shall be either moist cured for a minimum of 72 hours from the time of casting or steam cured until the concrete has reached a strength (f'ci) as shown on the Drawings or as specified by the Engineer. The accelerated curing cycle for the precast concrete shall be as specified for moisture category damp in CSA A23.4, Table 2 – Accelerated Curing Cycle.

If steam curing is used, it shall not be applied until after the initial set has taken place. Initial set shall be considered to have taken place 4 hours after the completion of concrete placing. The cylinders used to determine the concrete strength shall be cured under the same conditions as the girder in question.

From the time of pretensioning to the time of initial set, the ambient air temperature of the girder shall not vary by more than  $\pm 3^{\circ}\text{C}$ . During steam curing, the rise in ambient air temperature shall not exceed  $15^{\circ}\text{C}$  per hour to a maximum temperature of  $60^{\circ}\text{C}$ .

Three (3) thermocouples approved by the Engineer shall be placed within the girder after placing of concrete is completed and the thermocouples shall not be removed until after steam curing has been completed. A graph showing the internal temperature plotted against the time of day shall be submitted to the Engineer by the Fabricator upon completion of the steam curing for each girder and prior to any subsequent casting. The graph shall be properly identified as to the hour, day, month and year, as well as to the times of the completion of placing concrete, and of the start and completion of steam curing.

Once curing has been completed, the temperature of the concrete shall not be allowed to fall at a rate exceeding  $20^{\circ}\text{C}$  per hour.

The girder, including any patched areas, shall be properly cured and stored within the plant a minimum of three (3) days. The Fabricator shall monitor the rate of cooling of the girder and avoid thermal shock from prematurely subjecting the girder to freezing temperatures. The Fabricator shall not subject any girder to freezing temperatures before the girder has reached 85 percent of the design strength ( $f'c$ ) as shown on the Drawings.

#### .14 Repairing Damaged Concrete

Serious damage, honeycomb and other casting defects shall be immediately reported to the Engineer. Repair procedures shall be submitted for review by the Engineer and acceptance by the Department prior to commencement of the repair. All repairs shall be completed prior to curing of the unit.

Repairs to defects including cracks, honeycombs or spalls shall be carried out in accordance with the following requirements. Any unacceptable cracks, honeycombs or spalls will result in rejection of the affected unit.

All repair procedures shall be developed by a Professional Engineer, reviewed by the Engineer and accepted by the Department prior to the commencement of the repair. All repairs shall be completed prior to curing of the unit at an ambient temperature of  $15^{\circ}\text{C}$  to  $30^{\circ}\text{C}$ .

The "bearing area" of a girder is defined as the portion of the girder bottom flange extending from the end of the girder to the inside edge of the girder bearing. It does not include the transition between the bottom flange and the web. The "anchorage area" is defined as the full height portion of the girder that is less than two times the girder depth from the end of the girder but is not in the bearing area.

##### .1 Cracks

Cracks in the bearing area of a girder are unacceptable unless they are less than 0.1 mm in width and are initiated by a stress raiser, such as a formed hole in the girder. Unacceptable cracks in the bearing area will result in the rejection of the unit.

Cracks in the anchorage area of a girder exceeding 0.7 mm in width are unacceptable and will result in the rejection of the unit. All cracks in the anchorage area 0.2 mm to 0.7 mm in width shall be repaired by epoxy injection in accordance with the manufacturer's instructions. Coring shall be carried out to confirm the penetration of the epoxy into the cracks if so requested by the Engineer.

Cracks outside the girder bearing and anchorage areas that are wider than 0.3 mm or longer than 300 mm are unacceptable and will result in the rejection of the unit.

## .2 Honeycombs and Spalls

Honeycombs or spalls in the bearing areas of a girder are unacceptable and will result in rejection of the unit.

Major honeycombs and spalls in the anchorage areas of a girder are unacceptable and will result in rejection of the unit. Major honeycombs and spalls are described as honeycombs and spalls that are more than 30 mm deep or more than 0.1 m<sup>2</sup> in area. Repairs of minor honeycombs and spalls in the anchorage areas of a girder may be made after destressing of the girder.

Repairs of honeycombs and spalls outside of the bearing or anchorage areas of a girder may be made using cementitious material in accordance with this Specification prior to destressing of the girder.

## .15 Handling and Storage

The lifting devices shall be of such a nature as to avoid twisting, racking or other distortions while handling, storing, moving and erecting the girders. The devices shall be anchored fully to the main body of concrete. The devices shown on the Drawings are minimum requirements and the Fabricator shall satisfy himself as to the adequacy of the devices. The girders shall be picked up only by the lifting devices.

The Fabricator shall be responsible for storage of the girders from the completion of their fabrication until they are required by the Bridge Contractor. The Fabricator may have to store, free of charge, all or portions of the fabricated material for up to one (1) year past the delivery date specified in the Contract documents, depending upon the actual progress of the Bridge Contractor.

During storage and hauling, the girders shall be maintained in an upright position and shall be supported within 50 mm on the inside of the bearing area. Where girders are to be erected within 6 months of the fabrication date short blocking may be required from the date of manufacture to facilitate desired camber as required by the Engineer. Extreme care shall be exercised during the handling and storage of the precast girders to avoid twisting, cracking or other distortion that may result in damage to the girder.

The Bridge Contractor will give the Fabricator seven (7) days notice of his intention to erect the girders and the sequence for transporting the girders. The Fabricator will be responsible for loading the girders on the Bridge Contractor's transports at the Fabricator's yard.

## .16 Handling and Transportation of Girders From Outside the Province of Manitoba

The Fabricator shall notify the Engineer at least 14 days prior to any girders being fabricated outside of the Province of Manitoba.

All loading and hauling of the girders to be supplied f.ob. General Contractor's truck within the City of Winnipeg shall be under the direction of a Professional Engineer, registered in the Province of Manitoba. This Engineer shall be experienced in bridge girder loading and hauling shall be present for all stages of girder loading and hauling.

When transporting bridge girders using equipment other than a flatbed trailer, the Contractor shall be responsible for ensuring the following:

- i) Pilot vehicles meet the requirements of Part 9, Highway Traffic Act, Regulation 575/88;
- ii) Travel speed not to exceed 80 kph;
- iii) Travel only in daylight between sunrise and sunset; and
- iv) Travel will not be allowed on weekends or statutory holidays unless authorized by the Engineer.

The Fabricator shall submit his proposed route for transporting the girders including traffic control procedures as part of the proposed loading and hauling procedure. In all traffic control situations, the flagman must be trained and properly attired in flagman's vest and approved headgear with approved flagman's stop/slow paddle or fluorescent red flag. The proper advance signing must also be in place. For an example of traffic control procedures at an intersection see Drawing S-TMP-6 of the Work Zone Traffic Control Manual.

The Fabricator shall be responsible for the design, supply, installation and removal of lateral stability bracing for girders as may be required during the Contractor's handling and transporting of the girders.

No loose timber blocking will be permitted for use a temporary works for any aspect of girder handling and hauling.

It is the Fabricator's responsibility to ascertain the actual weight of the girders. The concrete in the precast Prestressed girders may be denser than regular concrete and the girders contain a high percentage of reinforcing steel and stressing strands which also tend to increase the weight of the girders.

No separate payment will be made for this work as it is considered incidental to the Contract Unit Price for "Supply of Precast Prestressed Concrete Girders."

## **6.0 QUALITY MANAGEMENT**

### **6.1 Quality Control**

#### **.1 General**

The Fabricator shall be responsible for all quality control testing identified in this Specification. All testing shall be completed by qualified personnel who are certified at the time of testing as ACI CSA-based Concrete Field Testing Technicians, Grade 1.

#### **.2 Minimum Concrete Compressive Strength**

Concrete compressive strength requirements shall consist of a minimum strength which shall be attained before various loads or stresses are applied to the concrete. With the exception of the concrete strengths required for;

- i) Transfer of the pretensioning forces,
- ii) Subjecting the girder to freezing temperatures (when applicable), and
- iii) Hauling and erecting a girder,

all concrete shall attain the minimum strength as shown on the Drawings at the time of 28 days.

### .3 Test Cylinders

The minimum number of test cylinders that the Fabricator shall mold from each 10 m<sup>3</sup> of concrete to be placed in a girder are as follows:

- i) Two (2) cylinders to be tested prior to the transfer of the pretensioning forces;
- ii) Three (3) cylinders for the 28 day strength;
- iii) One (1) cylinder to be tested prior to subjecting a member to freezing temperatures (when applicable); and
- iv) One (1) cylinder to be tested prior to the member being hauled to the site and erected (where applicable).

The compressive strength of the concrete shall be determined from standard 100 mm diameter x 200 mm test cylinders or 150 mm diameter x 300 mm test cylinders that have been molded, cured and tested in accordance with CSA A23.2.

In the event that the strength of the concrete cylinder(s) tested prior to the transfer of the pretensioning forces or prior to post tensioning is less than the strength required for transferring the pretensioning forces, the Fabricator shall test additional cylinders as determined by the Engineer and accepted by the Department.

All test cylinders shall be cured under the same conditions (i.e. match cured) as the girder until such time as the steam curing or moist curing of the girder has been completed.

### .4 Concrete Batches

In addition to the molding of a specified number of test cylinders the Fabricator shall perform and record the results of the following tests on every separate batch of concrete to be placed in a girder:

- i) Slump;
- ii) Air content; and
- iii) Temperature (Concrete and Ambient).

The Fabricator shall be responsible for maintaining an up-to-date record of all test results on a "Record of Concrete Strength" form approved by the Engineer. A separate "Record of Concrete Strength" form shall be prepared for each girder and the strengths of the test cylinders, as well as the pertinent data, including concrete compressive strengths at destressing, yarding and 28 days, shall be listed in the same order as the batches of concrete were placed in the forms. A complete set of test results shall be submitted to the Engineer within 7 days after the date that the 28 day cylinders from the last girder were tested.

All costs involved in performing and recording the previously mentioned tests shall be the responsibility of the Fabricator.

The Engineer, at his discretion and at the Department's expense, may make any other tests deemed necessary on the concrete, on the components of the concrete, as well as on any finished or partially finished girder. The Fabricator shall allow the Engineer unhindered access to the concrete, concrete components and girders, and shall also assist the Engineer in carrying out any test.

#### .5 Release Strength Test Cylinders

The Fabricator shall make and test concrete cylinders that prove that the required release strength as stated on the Drawings has been attained prior to release of the stressing strand. When one or more units are cast continuously, at least two cylinders shall be taken from the concrete of the last unit poured to represent the release strength for all units. These cylinders shall be cured with the girder. Only testing of the first cylinder will be necessary if the required release strength is obtained. In the event all cylinders are tested without the required strength being obtained, the Engineer shall be contacted and their acceptance obtained for the release of the units.

#### 6.2 Quality Assurance

The Fabricator shall provide an office within the plant facilities for the exclusive use of the Department for the duration of the Contract that is equipped with a desk, two (2) chairs, a digital telephone, and an internet connection. Upon completion of the project, all equipment and the office space will be returned to the Fabricator in an "as-is" condition.

The following stages of manufacturing require the Department's acceptance:

- i) Form dimensions and set-up;
- ii) Placement of reinforcing steel;
- iii) Placement of voids and hardware;
- iv) Stressing;
- v) Concrete mixture and placement;
- vi) Form stripping;
- vii) Clean-up and repair;
- viii) Finishing and application of sealer;
- ix) Curing;
- x) Application of Class 3 finishes; and
- xi) Storage of units.

The Department representative, at his discretion, may complete other tests deemed necessary on the concrete, the concrete constituent materials, or any finished or partially finished girder. The Fabricator shall allow the Department unhindered access to the concrete, concrete constituent materials and girders and shall assist the Department in carrying out any test. There shall be no charge to the Department for materials taken by the Engineer for testing purposes.

The Fabricator shall provide the Department with suitable and safe access to the works for the purposes of testing and inspection. The Fabricator shall provide the following:

- i) Heated laboratory space, minimum of 3 m x 3 m, capable of being locked, located in the proximity of the work;
- ii) A work bench 1 m x 3 m x 1 m high;
- iii) Cylinder storage chest with temperature control and a max/min thermometer, as per CSA Standard A23.2-3C;
- iv) A sump and water supply suitable for cleaning all testing equipment; and
- v) A calibrated weigh scale.

During production of the precast girders, the Fabricator shall weigh completed girders to verify the mass when requested by the Department.

The Department reserves the right to reject any concrete whatsoever that does not meet the specified strength determined in accordance with this Specification and the Drawings.

### 6.3 Inspection Requirements for Fabrication Outside the Province of Manitoba

Should all or part of the precast prestressed concrete girder fabrication be performed at locations outside of the Province of Manitoba, expenses incurred and deemed necessary by the Engineer to carry out the complete inspection of the material will be deducted from amounts payable to the Fabricator.

These expenses will include, but are not limited to, travel, food, lodging for the Engineer and/or the Engineer's representative, and the retention and payment for services of a certified inspection agency of the Engineer's choice for the day-to-day inspections.

## 7.0 METHOD OF MEASUREMENT

The supply of precast prestressed concrete girders will be measured on a unit basis and the number to be paid for will be the total number of girders fabricated and accepted by the Engineer.

The supply of cables and anchorages for lateral stressing and the supply of other incidental materials will be paid for on a lump sum basis and no measurements will be taken for this work.

## 8.0 BASIS OF PAYMENT

Supply of precast prestressed concrete girders will be paid for at the Contract Unit Price per girder for "Supply of Precast Prestressed Concrete Girders", measured as specified herein, which price will be payment in full for performing all operations herein described and all other items incidental to the work including in this Specification.

The supply of cables and anchorages for lateral stressing and the supply of other incidental materials will be paid for at the Contract Lump Sum Price for "Supply of Miscellaneous Material", measured as specified herein, which price will be payment in full for performing all operations herein described and all other items incidental to the work included in this Specification.