

**Prestressed Concrete Component Standards**

August 24, 2022

**1.0 Tendon Stressing**

The dials of gauges shall be at least 200 mm in diameter. Gauges shall be calibrated, with the hoses and jacks with which they are to be used, by an approved testing agency. The calibration shall have been performed within the previous six months of use or 12 months maximum. Before stressing commences, certified calibration curves shall be furnished to the ministry.

If during the work any gauges give erratic results, the tension system or tension device shall be recalibrated.

The contractor shall schedule the work so that placement of concrete follows tensioning of strands within 24 hours. In cases of unavoidable delay, a maximum period of 80 hours will be allowed, provided that the strands do not show unacceptable corrosion (see Precast/Prestressed Concrete Institute (PCI) *Manual for Quality Control*).

Before tensioning, an initial force shall be applied to each strand to equalize stresses and eliminate slack. This force shall not exceed 22 kN. After the initial tension forces have been applied, each strand shall be marked at the outer end of each chuck as a reference line from which the elongation of the strand can be measured.

The method of tensioning shall be such that the specified tension is maintained in the strands until the forces in the strands are transferred to the concrete member(s). The maximum jacking load in each strand shall be 85% of the ultimate strength of the strand.

A tensioning force shall be determined both by reading the jacking load on the calibrated gauge and by measuring the elongation of the strand. When the difference between the two methods is greater than 5%, the cause of the discrepancy shall be ascertained and corrected.

Elongations of strands shall be calculated and shown on the working drawings. Calculations for elongations shall include appropriate allowances for possible slippage or relaxation of the anchorages, friction at hold down points, temperature difference, and strand relaxation.

**2.0 Forms**

All exterior forms shall be of steel and shall be mortar-tight and of sufficient rigidity to prevent distortion due to incidental loadings during construction. Forms for skewed ends may be of rigid steel-reinforced plywood.

Forms shall produce 20 mm chamfers and fillets as shown on the drawings.

The design of the forms shall take into account the effect of vibration of concrete as it is placed.

All exterior forms shall be set and maintained true to the designated lines until the concrete has hardened. When forms are unsatisfactory in any way, either before or during the placing of concrete, the ministry may order the work stopped until the defects have been corrected.

The shape, strength, rigidity, mortar-tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged formwork shall be realigned before being re-used. Forms which are unsatisfactory in any respect shall not be re-used.

Void forms shall be of an approved product and shall be anchored firmly by a means acceptable to the ministry, to prevent displacement during the placing of the concrete. Any member with a void out of position in excess of the specified tolerance will be rejected.

Exterior forms shall be treated in moderation with form oil before placing the concrete. Any material which will adhere to or discolour the concrete shall not be used.

Side forms and any attachments which would obstruct strain of the members shall be removed before transfer of stress.

### **3.0 Admixtures**

The contractor shall add sufficient air-entraining agent to entrain  $5\% \pm 1\%$  air as determined by an air-meter used in accordance with the current CSA-A23.2.

The use of other admixtures, such as water-reducing agent or super plasticizer, shall be subject to the consent of the ministry.

### **4.0 Measurement of Materials**

Measurement of materials shall conform to the current CSA-A23.1. The contractor shall produce a certificate of accuracy for the batching equipment from the Dominion Government Weights and Measures Division which is not over 6 months old. Cement in standard packages need not be weighed.

The surface moisture shall be determined in accordance with the current CSA-A23.2 and the batch weights of aggregates and water adjusted accordingly.

### **5.0 Mix Requirements**

Minimum compressive strength at time of transfer of stress to the concrete and at 28 days as determined by the current CSA-A23.2 shall be as called for on the drawings.

Slump as determined by the current CSA-A23.2 shall be  $50 \text{ mm} \pm 10 \text{ mm}$  for concrete without super plasticizer and a maximum of 100 mm for concrete with super plasticizer.

In order to minimize shrinkage and creep the cement/aggregate ratio shall be kept as low as is consistent with strength requirements.

### **6.0 Batching and Mixing**

The batching plant and mixing of concrete shall conform to the current CSA-A23.1.

Mixing shall begin within 15 minutes after the cement has been added either to the water or aggregate.

Within 30 minutes after the introduction of the mixing water to the cement and aggregate, or the cement to the aggregate, the concrete shall be placed in its final position in the forms. In hot weather or under other conditions contributing to quick stiffening of the concrete, the maximum allowable time may be reduced by the ministry.

Concrete mixing and transporting equipment shall be capable of placing concrete in the forms at the rate of 20 m<sup>3</sup>/hr. Batch delivery shall be uniform and at a maximum interval of 10 minutes.

The maximum size of each batch shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer of the mixer.

Concrete when placed in the form shall have a temperature not less than 10°C nor greater than 30°C.

### **7.0 Handling and Placing Concrete**

In preparation for the placing of concrete, all construction debris and extraneous matter shall be removed from the interior of forms. Struts, stays and braces inside the forms shall be kept to a minimum and entirely removed when the concrete placing has reached an elevation rendering their service unnecessary.

Concrete shall be handled and placed in accordance with the requirements of the current CSA-A23.1 and shall be placed in the shortest possible time after mixing is completed. When rectangular void forms are used, concrete under voids shall be placed and compacted before void forms are in position.

Concrete may be deposited a maximum of 2 m without the use of pipes, provided, when required, suitable measures are taken to prevent segregation and premature coating of upper reinforcing steel. When pipes are used they shall, as far as practicable, be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete.

After initial set of the concrete the forms shall not be jarred and no stress shall be placed on reinforcing bars which project.

### **8.0 Vibration of Concrete**

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be accomplished by mechanical vibration subject to the following provisions:

- Vibration shall be internal for all accessible parts and shall be external for inaccessible parts;

- Vibrators shall be of a type and design approved by the Ministry. They shall be capable of transmitting vibration to the concrete at frequencies recommended in the current CSA-A23.1;
- The intensity of vibration shall be such as to visibly affect a mass of concrete of 50 mm slump over a radius of at least 500 mm;
- The contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms;
- Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcing and embedded fixtures and into the corners and angles of the forms. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective;
- Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms;
- Vibration shall be supplemented by such spading as is necessary to ensure a smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators; and
- Vibrator heads shall be smaller than the minimum clear distance between prestressing strands.

## **9.0 Test Cylinders**

The contractor shall make available, as may be required by the ministry, samples of the concrete to be used in casting the members.

Further, the contractor shall take samples and make test cylinders in the presence of the ministry representative and in accordance with the current CSA-A23.2-1. At least 8 cylinders per casting bed shall be made for testing:

### **Release Strength**

Two cylinders from each end of the casting bed shall be cured in the same manner as the members and tested by the contractor under the discretionary observation of the ministry representative at the contractor's plant to assess the strength of the concrete at the time of transfer of force to the concrete. Only one cylinder from each end need be tested if the average strength of the two cylinders is equal to or greater than the required release strength at transfer and no test cylinder is more than 1.4 MPa below the release strength. No transfer of force shall occur until authorized by the ministry.

If all release cylinders are tested and the release strength has not been attained, further testing with an impact hammer shall be allowed, provided a written procedure acceptable to the ministry is provided by the contractor. The procedure shall correlate readings from areas of a prestressed girder where the release strengths has been determined by concrete test cylinders with similar areas on the girder in question. If this situation occurs, extra pairs of release cylinders shall be made on future casts until confidence in determining the release strength is re-established.

### **28 Day Strength**

Two cylinders from each end of the casting bed shall be identified as "acceptance cylinders" and shall be cured in the contractor's curing tanks. These cylinders shall be tested by the contractor under the discretionary observation of the ministry representative to determine the twenty-eight day strengths. The strength of the concrete in the member shall be taken as the average of the compressive strength of the "acceptance cylinders", however, no individual cylinder shall be more than 3.5 MPa below the specified strength and the average strength shall equal or exceed the 28 day strength.

For special cases, extra cylinders shall be made and tested if required by the ministry. In the case of ready mix, and plant mixed concrete with no established records, extra cylinders, in addition to the release strength or 28 day strength cylinders, shall be made from each load.

## **10.0 Surface Finish**

Throughout the work special precautions shall be employed in formwork and concrete placing to produce a smooth and dense concrete. Exposed surfaces shall be as free as possible from form marks, fins, honey-combing and pock marking. Only a minimum amount of pointing will be allowed. Poor surface finish upon the removal of the forms shall be sufficient cause for the rejection of any member. All exposed edges shall be chamfered unless otherwise noted on the Drawings.

Roadway and walkway surfaces and surfaces to be bonded to shall be rough screeded by wood floating following initial strike off. Roadway and walkway surfaces shall be given a coarse transverse broomed finish. Surfaces to be bonded to shall be sand blasted to remove all laitance and foreign matter and partially expose the coarse aggregate. Loose sand and debris shall be washed or blown off.

The outer surfaces of the outside stringers and any other surfaces indicated on the drawings shall be given a Class 2 finish in accordance with *TRAN Standard Specifications*.

## **11.0 Curing**

Members may be cured by steam or heat as outlined herein.

**Steam Curing:** The concrete shall be allowed to attain its initial set before application of steam: generally 2 to 4 hours after the final placement of concrete or as justified by previous experience and permitted by the ministry.

After the placement of concrete, sufficient steam shall be applied during initial curing to hold the air surrounding the member at a temperature not less than 13°C.

Steam curing shall be done within a suitable enclosure to contain the steam and minimize moisture and heat losses. The enclosure shall allow free circulation of steam around the sides and tops of members and shall not be in contact with the member.

Steam at the outlets shall be at 100% relative humidity and low pressure. Application of the steam shall not be directly on the concrete or test cylinders and shall be from outlets distributed uniformly along the whole length of the member.

During application of the steam the ambient air temperature shall increase at a rate not to exceed 22°C per hour until an optimum temperature of 55°C is reached. In no case shall the ambient curing temperature exceed 80°C. The maximum temperature shall be held until the concrete has reached the transfer strength. In discontinuing the steam, the ambient air temperature shall not decrease at a rate to exceed 33°C per hour until a temperature has been reached about 11°C above the temperature of the air to which the concrete will be exposed. The forms shall not be stripped until the completion of this cooling off period.

Provision shall be made for checking the ambient air temperature either by placing minimum-maximum thermometers under the enclosure or periodically checking with hand thermometers.

**Curing With Radiant Heat and Moisture** - Curing with radiant heat and moisture shall be done by heating the casting area in combination with the continuous application of moisture.

Heat shall be applied by means of pipes circulating steam, hot oil or hot water or by electric heating elements. Pipes shall not be in contact with concrete, form surfaces or test cylinders.

Moisture shall be applied by a continuous sprinkling to a cover of burlap or cotton matting or any other approved method for keeping the members continuously moist.

An auxiliary cover in addition to the moisture retaining cover shall be used above the entire bed to retain the heat. This cover shall be supported at a sufficient distance above the member to allow circulation of the heat.

The cycle of application of heat, temperature limitations, reduction of temperatures and use of recording thermometers shall be similar to the cycle specified for steam curing.

### **12.0 Transfer**

The transfer of the forces in the strands to the concrete member(s) shall be in accordance with the current CSA-A23.4 (section on Detensioning).

### **13.0 Strand Ends**

After completion of concrete curing the ends of tensile strands shall be ground flush with the concrete surface. Where the ends of the members are to be embedded in concrete, the ends of the strands shall be painted with two coats of ministry approved organic zinc rich paint. Where the ends of the members are not to be embedded in concrete, the ends of the members shall be covered with thixotropic epoxy to provide at least 3 mm cover. This material is to be applied in accordance with the manufacturer's recommendations.

### **14.0 Tolerances**

For bridge stringers, the tolerances specified in the *PCI Manual for Quality Control* shall be modified so that the length of each member, measured parallel to the longitudinal axis, to extreme corners, at 20°C, does not exceed the specified length by more than 10 mm per 10 m length (25 mm maximum).

The contractor shall employ an adequate method of checking tolerances both before and after placement of concrete. Review of the method of checking tolerances by the ministry will not limit the contractor's responsibility for the accuracy of the members.

## **15.0 Repairs to Members**

Defective areas should be repaired immediately following removal of forms and before detensioning of strands. Holes, honeycomb spots, etc., shall be treated as for Class 2 finish in accordance with *TRAN Standard Specifications*. The method of repair for cracks, broken corners and edges, bulges and other defects shall be submitted to the ministry representative for review.

## **16.0 Handling, Transportation and Erection**

Stringers shall at all times be kept in their normal upright position during handling, storage and transportation. They shall be picked up by means of vertical forces or forces inclined towards the opposite ends of the members by no more than 30 degrees from the vertical, applied to lifting devices near the ends of the stringers. I-beams shall be adequately stiffened during lifting and transportation.

Stored stringers shall rest on unyielding level supports near the ends of the stringers.

When loaded for transportation, members shall be supported so that they will not be overstressed. In general, beams with straight strands may be supported up to one-tenth of their lengths from each end, whereas beams with draped strands should be supported at their bearings. If the contractor believes that it is possible to safely support members further from their ends, the contractor shall submit to the ministry, sketch(es), sealed by a registered professional engineer, showing the proposed support arrangement. Adequacy of support shall be based on the following assumptions:

- 100% impact on cantilevering ends, when checking stresses at supports;
- 50% negative impact on the whole member, when checking stress near midspan;
- 50% of prestress losses at time of shipping (unless circumstances dictate otherwise);
- Allowable tensile stress =  $0.5\sqrt{f_c}$ ;
- Allowable compressive stress =  $0.6f_c$ ; and
- Where  $f_c$  = estimated strength of concrete at time of shipping.

Such sketch(es) shall be submitted at the time of submittal of the working drawings (see Section 3). Members transported on supports further from their ends than outlined above, without the submittal of sketch(es) acceptable to the ministry, will be rejected.

Any member damaged so as to be, in the opinion of the ministry representative, unfit for the use for which it is intended shall be replaced at the contractor's own expense.