CONSTRUCTION SPECIFICATION FOR GLASS FIBRE REINFORCED POLYMER (GFRP) REINFORCEMENT FOR CONCRETE

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950.01 SCOPE

This specification covers the requirements for the placement of all glass fibre reinforced polymer (GFRP) internal reinforcement used in concrete work.

950.02 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Material

OPSS 1640 Glass Fibre Reinforced Polymer (GFRP) Reinforcement for Concrete

Ontario Ministry of Transportation Publications

~~Designated Sources for Materials (DSM)~~
Guidelines for Inspection and Acceptance of Glass Fibre Reinforced Polymer (GFRP) Reinforcing Bars, September 2022
Structural Manual

MTO Forms:
PH-CC-701 Request to Proceed
PH-CC-702 Notice to Proceed

CSA Standards

S6:19 Canadian Highway Bridge Design Code

950.03 DEFINITIONS

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

Bar means the abbreviated term for GFRP reinforcing bar.

Glass Fibre Reinforced Polymer (GFRP) means a fibre-reinforced composite with a polymeric matrix and continuous fibre reinforcement of glass.

Structural Component means a concrete component of a bridge structure such as bridge deck, concrete barrier and parapet wall, pier cap, etc.

950.04 DESIGN AND SUBMISSION REQUIREMENTS

950.04.01 Design Requirements

950.04.01.01 Design of Structural Components

Design shall be according to Division 1 of the Structural Manual and CSA S6.

950.04.02 Submission Requirements

950.04.02.01 Working Drawings

One hard copy and one electronic copy of the GFRP reinforcement Working Drawings, including supporting documentation, shall be submitted to the Contract Administrator at least 7 Days prior to delivery of the bars. An Engineer's seal and signature shall be affixed on the Working Drawings verifying that they are according to the Contract Documents.

The Working Drawings shall include the following information:

a) Bar placing drawings that include quantity, bar size, location and spacing for all bars;

b) Bar schedule that includes quantity, bar size, type, length and bending dimensions.

The supporting documentation shall include the following information:

a) Manufacturer's instructions on how to deliver, handle, store, and protect the bars;

b) Manufacturer's recommended materials and procedures for removal of unacceptable materials present on the bars, such as those described in the Surface Condition subsection.

A sealed and signed copy of the Working Drawings shall be kept at the site before and during the placing of bars.

950.05 MATERIALS

950.05.01 Associated Hardware

Only hardware, including spacers and support devices, approved by the Owner shall be used with GFRP reinforcement and the hardware shall meet the following requirements:

a) All supports or support systems shall be capable of withstanding the loads to be placed on them;

b) Fastening of the bars shall be with coated tie wire, stainless steel wire or nylon ties;

c) Bar chairs for supporting GFRP reinforcement shall be non-metallic;

d) Concrete chairs shall not be used to support GFRP reinforcement except in footings and against granular surfaces.

950.05.02 Glass Fibre Reinforced Polymer (GFRP)

All bars shall be supplied by a manufacturer listed on the MTO DSM.

GFRP reinforcement shall be according to OPSS 1640.

950.07 CONSTRUCTION

950.07.01 Delivery, Handling, Storage, and Protection of Bars

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator upon completion of fabrication of the GFRP.

Placement of the GFRP reinforcement shall not proceed until the Contract Administrator has received the Request to Proceed and GFRP quality control report and issued a MTO form PH-CC-702, Notice to Proceed.

Delivery, handling, storage, and protection of the bars shall be according to the manufacturer's instructions and the following:

a) Bars shall be lifted, transported, and stored using multiple support points to protect the bars from damage. Support points shall be no more than 4.0 m from one another. Bars shall be lifted using nylon or padded slings. Lifting of bundles of bars shall be with a strong back, spreader bar, multiple supports or a platform bridge. Bars shall be bundled and supported to prevent damage during transportation.

b) Bars shall be stored clear of ground contact on suitable protective cribbing to protect the bars from contamination or damage. Stacks or bundles of bars shall have adequate blocking to prevent contact between the layers of bundles. GFRP bars shall be stored separately from reinforcing steel bars.

c) Bars shall not be dragged, dropped or impacted. Bars shall not be struck by hammers or any other equipment at any time. Bars that have been subjected to any of these unacceptable actions or that show signs of damage, shall be rejected, removed, and replaced. Bars subject to removal shall be marked and removed in the presence of the Contract Administrator.

d) Bars shall be covered with opaque, white polyethylene sheeting during storage. Bars installed in the structure or formwork, including those partially embedded in concrete, shall be protected from the elements by covering with opaque, white polyethylene sheeting, or equivalent protective material when the exposure time is expected to exceed, or exceeds 30 Days. The protection shall be adequately supported and secured in place. This protection shall be maintained until its removal is required for preparation for subsequent concrete placement.

e) Before and after placing, bars shall be protected from any construction operations in their immediate vicinity such as abrasive blasting, pressure washing and concrete spatter from adjacent concrete placement by adequate covering or wrapping with protective material.

f) After placing, bars shall be protected from construction operations and traffic such that the bar and its finishing are not damaged. The surfaces shall be kept free of contamination and damage and the GFRP bars shall be protected from loading which may damage the bars.

~~g) Movement of bars from concreting operations that may leave partially embedded bars out of tolerance for subsequent work shall be prevented. This may be done by using more ties and tie points, temporary bars for cage stability, or other means approved by the Contract Administrator.~~

950.07.02 Placing

GFRP reinforcement shall be placed according to the tolerances shown in Table 1. The tolerances listed include fabrication tolerances. Bars shall be accurately placed in the positions ~~as~~ specified in the Contract Documents and held in the correct location during the operations of placing and consolidating concrete.

Bars shall be tied at least at every third intersection. The maximum untied length of any bar shall be 900 mm.

For slab-on-girder type decks, the bottom layer of deck reinforcement shall be tied to the shear studs or shear stirrups on each girder at approximately 1.5 m centres.

Spacers for spirals shall be equally spaced around the spiral and shall be so that the specified pitch of the spiral is maintained.

Bar support chairs shall not exceed 900 mm average spacing.

Bars within the formwork shall be secured to prevent movement during concrete placement. The bars shall be supported or tied to resist settlement, floating upward, or movement in any direction during concrete placement. For overlays and other horizontal placement where there is no bottom mat of steel reinforcement to tie down the GFRP reinforcement, the GFRP mat shall be anchored down directly to the concrete or formwork to prevent it from floating upward.

Movement of bars from concreting operations that may leave partially embedded bars out of tolerance for subsequent work shall be prevented. This may be done by using more ties and tie points, temporary bars for cage stability, or other means approved by the Contract Administrator.

950.07.03 Surface Condition

The bars shall be free of mud, oil, concrete or other contaminants, and surface finish defects that adversely affect bond strength or other properties at the time the concrete is placed.

The bars shall be protected from contamination caused by concrete splatter during adjacent placements. Any concrete contamination shall be removed immediately while the concrete is still plastic without damaging the bars. Removal of other materials present on the bars shall be according to the materials and methods recommended by the bar manufacturer.

950.07.04 Cutting

The field cutting of straight bars may be carried out only when permitted in writing by the Contract Administrator. Field cutting shall be with a high-speed cutter, fine blade saw, diamond blade, or masonry saw. Bars shall not be flame or shear cut. Cut ends shall be sealed if required by the GFRP reinforcing bar manufacturer. Cut ends shall be inspected for damage and repaired as required by the Contract Administrator.

Bent bars shall not be field cut.

950.07.05 Bending

Field bending shall not be permitted.

950.07.06 Request to Proceed

A MTO form PH-CC-701, Request to Proceed shall be submitted to the Contract Administrator upon completion of the placing of the GFRP.

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

950.07.07 GFRP Reinforcing Bar Defects, Deficiencies and Damage

950.07.07.01 General

All bars shall be inspected for any defects and deficiencies up to the date of completion of the placement of concrete.

Any damage to a GFRP reinforcing bar resulting in visible fibres, other than at cut ends; or any cut or defect greater than 0.7 mm deep for bars of size 15 or less and 1.0 mm deep for larger bars shall be cause for rejection and the bar shall not be incorporated into the Work.

950.07.07.02 Repair of GFRP Reinforcing Bar Defects, Deficiencies and Damage

All visible damage to the GFRP reinforcing bars exceeding 2 percent of surface area per 300 mm length of bar (2% * Circumference of bar * 300 mm) and not resulting in rejection by the Contract Administrator shall be repaired by lap splice of a new GFRP reinforcing bar adjacent to the damaged portion. The appropriate lap length shall be provided on either side of the damage according to the Contract Administrator.

950.07.08 Management of Excess Material

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

950.08 QUALITY ASSURANCE

950.08.01 Sampling

Prior to placing the GFRP reinforcement, the Contract Administrator shall randomly select five samples for quality assurance testing from each sublot. The straight bar samples shall be cut to a length of 2.2 m by the Contractor. If a sublot of straight bars does not contain any pieces that may be cut down to a length of 2.2 m, then the length requirement shall be waived and samples shall be taken from the available lengths as supplied. For bent bars and anchor headed bars, the Contract Administrator shall select five samples at random from each sublot. Samples are not required for anchor headed bars or bent bars of a particular diameter and shape if the total number required in the Contract for each respective bar type is less than 50.

Sublot size shall be according to OPSS 1640.

950.08.02 Testing

At the discretion of the Owner, quality assurance testing for any number of sublots and for any number of properties listed in Table 1 of OPSS 1640 shall be conducted by a laboratory designated by the Owner. The testing shall be performed according to the methods and requirements listed in Table 1 of OPSS 1640. The results shall be provided to the Contractor when they are available.

Pullout capacity of anchor headed bars shall be tested by embedment in concrete block. The test may be conducted with high early strength concrete after the concrete reaches 30 MPa strength. The specified limits for anchor headed bars is 100 kN for 15 mm diameter bar with a maximum slip of 0.5 mm.

950.08.03 Acceptance

950.08.03.01 Test Results

A GFRP sublot shall be rejected if any one of the tested quality assurance samples fails to meet the limits in Table 1 of OPSS 1640 for the tested property.

950.08.03.02 Visual & Dimensional

Individual GFRP bars that do not meet the specified finishing, surface conditions, or dimensional tolerances as described in this specification shall be rejected, removed, and replaced.
The Guidelines for Inspection and Acceptance of Glass Fibre Reinforced Polymer (GFRP) Reinforcing Bars shall also be used as a basis for field inspection and rejection of the bars.

950.10 BASIS OF PAYMENT

950.10.01 Glass Fibre Reinforced Polymer Reinforcing Bar - 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.

All GFRP Sublots or bars rejected by the Contract Administrator shall be removed and replaced with new bars meeting the requirements of this specification at no extra cost to the Owner.

If any structural component incorporates rejected GFRP lots or bars, then that structural component shall be rejected by the Contract Administrator and the structural component shall be removed and replaced at no extra cost to the Owner.

TABLE 1
Tolerances for Cover and Placing Accuracy

TYPE	TOLERANCE (mm)	
Reinforcement	**Cast-in-Place Concrete**	**Precast Concrete**
	Cover to Surface of Concrete and Placing Accuracy (Notes 1 and 2)	
a) Principal Reinforcement	± 20	± 10
b) Concrete Cast Against and Permanently Exposed to Earth	± 25	
c) Stirrups in Webs		+5, -3
d) Stirrups, Ties, Spirals	± 20	± 10
e) Deck Slab		
i. Top	± 20	± 15
ii. Bottom	± 10	± 10
f) Remainder	±30	± 30
g) Lateral spacing in slabs and walls	±30 (Note 3)	± 30 (Note 3)
h) Longitudinal location of bends and ends of bar in continuous member	± 50	± 50
i) Longitudinal location of bends and ends of bar at discontinuous end	± 20	± 20

Notes:

1. The cover to the concrete surface shall not be reduced by more than one-third of the specified cover.
2. The clear distance between bars shall not be less than one and one-half times the nominal diameter of the bar, one and one-half times the nominal size of the coarse aggregate, or 40 mm. In two or more layers, the rebar shall be directly above one another and the clear distance between layers shall not be less than 25 mm. The tolerances e) through f) do not apply to the lateral spacing of bars in slabs and walls.
3. The number of bars specified per metre width shall be placed in the metre width.