METROLINX

GO Transit Signals & Communications Standards – Overhead Signal Structures Specification

Specification 34 42 04

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Preface

This is the second edition of the Overhead Signal Structures Specification. It specifies the design and manufacturing criteria for Overhead Signal Structures for use on Metrolinx property.

The second edition has updates on loading criteria, in addition to the general updates based on stakeholder feedback, including serviceability requirements and overhead signal structure components.

This document was developed by the Signals & Communications Office, Engineering and Asset Management Division, Metrolinx.

Suggestions for revision or improvements can be sent to the Metrolinx Signals and Communications office, Attention: Director of Signals and Communications who shall introduce the proposed changes to the Metrolinx Signals and Communications office. The Director of the Signals and Communications office ultimately authorizes the changes. Be sure to include a description of the proposed change, background of the application and any other useful rationale or justification. Be sure to include your name, company affiliation (if applicable), e-mail address, and phone number.

February 2021

Revision	Date (DD/MM/YYYY)	Comments
0	08/04/2020	Initial release
1	25/02/2021	Revised section 3 and 4, updated loading criteria and general structural components requirements.

CONTENTS

1. Scope

1.1.1. This Specification defines the design criteria for Overhead Signal Structures for use on Metrolinx property. Overhead Signal Structures include span-type bridges and cantilever structures and associated mounting hardware for the attachment of Signal Units. The Overhead Signal Structure scope of supply excludes the Signal Units and the foundations.

1.1.2. The following terms are used in this Specification:

a) Signal Aspect – Individual colour lamp (Red/Yellow/Green);

b) Signal Head – An assembly of up to three Signal Aspect in a housing; or a tri-colour LED Signal Head (Metrolinx preferred type), that a single Signal Head can display multiple Signal Aspect; and

c) Signal Unit – An assembly that can comprise one, two or three Signal Heads.

2. Abbreviations

AASHTO LRFD	American Association of State Highway and Transportation Officials, Load and Resistance Factor Design
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASTM	American Society for Testing and Materials
CROR	Canadian Railway Operating Rules
CSA	Canadian Standards Association
LRFDLTS	AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals 1st Edition, with 2017, 2018 and 2019 Interim Revisions.
OHSA	Occupational Health and Safety Act
SCP	Standard Codes of Practice
SSPC	Society for Protective Coatings

3. Overhead Signal Structures Design Requirements

3.1. Standards

3.1.1. Overhead Signal Structures shall comply with the following standards:

a) The structural design, fabrication, and assembly of Overhead Signal Structures shall be in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals 1st Edition, with 2017, 2018 and 2019 Interim Revisions.

b) The Overhead Signal Structure shall be made of aluminum and designed, fabricated and assembled in accordance with CAN/CSA S157-17/S157.1-17 - Strength Design in Aluminum and CSA W59.2-18 Welded Aluminum Construction.

c) All aluminum extruded tube and structural profiles (I-Beam, channels and angles) shall be alloy 6061-T6 conforming to ASTM B221 and ASTM B308/B308M, with a yielding stress of 240 MPa and tensile strength of 290 MPa.

d) Solid aluminum bars and rods shall be made of alloy 6061-T6 and shall conform to ASTM B 211M standards.

e) Aluminum plates and all other miscellaneous aluminum components shall be made of aluminum alloy 6061-T6 and shall conform to ASTM B209 standard.

f) All steel components shall comply with CAN/CSA S16-14 – Design of Steel Structures.

g) Overhead Signal Structures location and clearance shall be as per GO Transit Signals & Communications Standards SCP-302.

3.2. Loading Criteria

3.2.1. The design of the Overhead Signal Structures shall comply with loading criteria specified in sections 3.3 through 3.8 inclusive. The loading combinations listed in LRFDLTS Table 3.4-1 shall be used. Thermal loading specified in section 3.7.1 shall be applied to all load combinations except for fatigue load cases. Thermal loads shall be applied with a load factor of 1.0.

3.3. Dead Load

3.3.1. The dead load shall consist of the weight of entire Overhead Signal Structure including all appurtenances, and the equipment that will be attached to the structure by others, including the Signal Units, associated cables and signs. The point of application of the weights of the individual items shall be their respective centers of gravity.

3.4. Live Load

3.4.1. The walkways and service platforms of the Overhead Signal Structure shall support a single point load of 500 lb distributed over a distance of 2 feet transversely.

3.4.2. All other elements of the Overhead Signal Structure shall support a single point load of 250 lb.

3.5. Fall Protection Loads

3.5.1. Fall protection shall be compliant with OHSA.

3.5.2. Where fall hazard exists and guardrails are not present, Fall Protection Anchorage Points shall be provided and designed to resist 5,000 lb load in any direction.

3.5.3. Fall Protection Anchorage Points shall be provided at locations where the work involves extending beyond the guardrails especially at locations where working above the walkway or around signals.

3.6. Ice Load

3.6.1. The Overhead Signal Structure shall withstand the following ice loads:

a) working surface areas such as horizontal platforms shall have an ice load of 1 kPa applied uniformly over the entire surface, and

b) all other surfaces shall have an ice load equivalent to 25 mm of surface icing with an ice density of 900 kg/m^3.

3.6.2. The ice load shall be applied to all overhead support elements and on all surfaces of the supported components.

3.7. Thermal Forces

3.7.1. The Overhead Signal Structure shall withstand the thermal forces associated with the temperature range between -35 degrees Celsius and 50 degree Celsius. The design shall assume an erection temperature of 20 degree Celsius.

3.8. Wind Load

3.8.1. The wind load shall be based on a sustained wind speed of 115 mph with 3 second gust in accordance with the AASHTO LRFD Specifications defined in section 3.1.1.a).

3.8.2. Height and Exposure Factor (Kz) shall be 1.0 for Overhead Signal Structures with a maximum height not exceeding 13.7 m; otherwise the AASHTO LRFD Specifications as defined in section 3.1.1.a) shall apply.

3.8.3. Wind load shall be applied to all elements of the Overhead Signal Structure and the supported components. Shielding shall not be assumed for any element unless it is completely encapsulated by another structural element.

3.8.4. Wind exposure area shall take into account the increase in exposure area due to surface icing.

3.9. Structural Analysis

3.9.1. Structural analysis and design shall consider the fixity at element connections and supports. Structural design shall include both member design and connection design (including anchor bolts and base plates of vertical posts).

3.10. Welded Connections

3.10.1. Welding of all aluminum Overhead Signal Structures shall be done by licensed personnel in accordance with CSA W47.2-11 standard and use of welding materials shall conform to CSA W59.2-18 standard.

3.10.2. The Contractor shall supplement the visual inspection of welds with non-destructive testing (NDT) of 50% of the welds as described in an inspection plan produced by the Contractor and approved by Metrolinx. NDT shall consist of Liquid Penetrant Inspection (LPI). LPI procedures shall be in accordance with ASTM E165 and LPI acceptance requirements shall be in accordance with CSA W59.2.

3.10.3. The Contractor shall document the "W" (size of weld) dimensions for skewed T-joints and tubular connections that are measured with weld gauges during visual inspection.

3.10.4. Verification testing shall be performed by an agency retained by Metrolinx. The Contractor shall make provision in the schedule to provide for verification testing and shall give proper advance notification for the time that such testing may be performed.

3.11. Bolted Connections

3.11.1. Design of bolted connections shall conform to CAN/CSA S157-17.

3.11.2. Bolted connections that depend on aluminum to aluminum friction to transfer shear forces (slip critical connections) shall be designed with friction coefficients of 0.50 for roughened surfaces. Surface roughening shall consist of abrasive blasting with coal slag to SSPC-5 to an average substrate profile of 2.0 mils.

3.11.3. The minimum bolt tension used for aluminum slip critical connections shall account for temperature changes and the difference in the coefficients of thermal expansion in the bolt material and the connected parts.

3.11.4. U-bolt connections to truss chords shall ensure that the connected parts are not overstressed in local bending. If necessary, curved saddles shall be used under tubular truss chords at U-bolt locations.

3.11.5. If the U-bolt tension is necessary to develop frictional resistance in the connection, the design shall specify how the minimum U-bolt tension is provided. U-bolts are to be tension only.

3.11.6. Stainless steel bolts, nuts, and washers shall be applied with an approved dielectric coating to protect against oxidation/corrosion due to contact between electrically dissimilar metals.

3.12. Anchor Bolts

3.12.1. Design of anchor bolts shall be in accordance with CAN/CSA A23.3-14 and CAN/CSA S6-14 and the following additional requirements:

a) steel anchor bolts, nuts and washers shall be galvanized per ASTM A123-09 Coating Grade 100;

b) anchor bolts shall conform to ASTM F1554 Grade 55;

c) nuts shall conform to ASTM A325;

d) washers shall conform to ASTM F436;

e) anchor bolts shall be a minimum of 38 mm in nominal diameter and a minimum of 1000 mm in length; and

f) double nuts shall be used at each anchor bolt to prevent loosening from cyclic loads.

3.13. Serviceability Requirements

3.13.1. Vertical Deflection

a) Gantry Supports: Maximum vertical deflection shall be limited to L/150, or 150 mm (whichever is less), where L is the span length.

b) Cantilevered Supports: Maximum vertical deflection shall not exceed L/150, or 150 mm (whichever is less), where L is the cantilever length.

3.13.2. Horizontal Deflection of vertical supports shall not exceed H/40, where H is the height of the Overhead Signal Structure.

3.13.3. Horizontal Deflection of cantilever arms shall not exceed 3 degrees 15 minutes, where the rotation is measured from the base of the cantilever to the tip of the arm.

3.13.4. Camber: Permanent camber equal to L/1000, where L is the unsupported length of the horizontal support, shall be provided in addition to the dead load camber for Overhead Signal Structures.

3.14. Fatigue Design

3.14.1. Fatigue design of the Overhead Signal Structure shall comply with the following:

a) The structure shall be designed for infinite fatigue life;

b) The fatigue importance factor (IF) shall be 1.0;

c) Galloping shall be considered in accordance with the AASHTO LRFD Specifications as defined in section 3.1.1.a); and

d) The Overhead Signal Structure shall withstand vehicle induced gusts in accordance with AASHTO LRFD section 11.7.1.3. The design shall consider train speeds up to the maximum track design speed as confirmed by Metrolinx.

e) Vortex Shedding

i. Vortex shedding shall be evaluated in accordance with the CSA-S6 Canadian Highway Bridge Design Code.

ii. Vortex shedding loads shall not be considered for the design of trusses. Individual aluminum members for trusses shall meet the following member slenderness restrictions to prevent vortex shedding fatigue on individual members:

i) $L/r \leq 105$ for branch members in T-type tubular connections;

ii) $L/r \leq 115$ for branch members in K-type tubular connections;

iii) $L/r \leq 95$ for branch members with gusset plate connections.

iii. The length, L, is the face-to-face length of member as measured along the member centerline. These member slenderness restrictions shall also apply to tubular guardrails.

iv. Vortex shedding loads shall not be considered for the design of posts for bridge type Overhead Signal Structures.

v. Vortex shedding loads shall be considered for all other support structures and elements.

3.15. Vertical Clearance

3.15.1. The lowest point of the horizontal elements of the Overhead Signal Structure shall be a minimum of 31.0 feet above top of rail (unless approved otherwise by Metrolinx).

3.16. Foundations

3.16.1. The Contractor shall provide the foundation design, including drawings, design criteria and loads (reaction load) in accordance with CAN/CSA A23.3 – Design of Concrete Structures and AREMA C&S Manual Section 14.

3.16.2. The Contractor shall provide the anchor bolts to be embedded in the foundation and the associated nuts and washers to allow leveling and fastening of the Overhead Signal Structure.

3.17. Submittals

3.17.1. Structural calculations and engineering drawings of the complete assembly shall be submitted to Metrolinx for approval prior to manufacturing. Engineering drawings shall be provided in electronic format (AutoCAD and PDF). The engineering drawing shall contain the seal and signature of the professional engineer, registered in the Province of Ontario, responsible for the design attesting that the signal bridge meets or exceeds all applicable design criteria herein. Design calculations shall be presented in a legible and logical format and shall be sufficiently detailed to allow a technical review of the concepts and assumptions used in the design.

3.17.2. The structural calculations and engineering drawings shall include moment, shear, axial forces and fatigue analysis for all the components of Overhead Signal Structures including:

a) Columns,

b) Horizontal cantilever arms or trusses,

c) Column, arm or truss flange bolted connections,

d) All welded and bolted connections, stiffeners,

e) Anchor bolts, and

f) Location of fall protection anchorage points where required.

3.17.3. The Contractor shall provide a drawing(s) showing the correct assembly of the Overhead Signal Structure, including part numbers.

3.17.4. The Contractor shall provide a drawing(s) showing conduit and cable cross-section and calculation of conduit fill capacity.

4. Overhead Signal Structure Components

4.1. General Requirements

4.1.1. The Overhead Signal Structure shall be supplied with a ladder, service platforms, guardrails, and Fall Protection Anchorage Points.

4.1.2. All holes, openings, and cavities shall be sealed to prevent entry of moisture, dust or wildlife.

4.1.3. All platform mounting / assembly hardware such as bolts, nuts and washers shall be either stainless steel or hot-dip galvanized steel.

4.2. Ladder

4.2.1. The ladder shall be constructed of aluminum and be designed to comply with current OHSA standards affecting rail size and design, rung length (16 inches) and toe spacing. Rungs shall have a heavy-duty skid-resistant serrated surfaces.

4.2.2. The ladder assembly shall be provided complete with all mounting hardware to secure it to the mast and/or service platform framework.

4.2.3. The base of the ladder shall provide a safe secure footing. A removable aluminum security panel system shall be provided to fit on the ladder to prevent unauthorized access to the ladder structure. It shall be lockable using a standard railway signal lock provided by Metrolinx.

4.2.4. The aluminum ladder shall be designed to be:

a) Secured (bolted) to an approved heavy-duty galvanized steel footing, or

b) Buried to a minimum depth of 18 inches, or

c) Secured to the mast assembly by means of a ladder brace.

4.2.5. Fixed ladders shall have a ladder safety device in compliance with fall arrest requirements of OHSA (O. Reg. 213/91) and include a ladder cage in compliance with fixed access ladder requirements of OHSA (O. Reg. 851/90).

4.2.6. The fixed ladder shall be designed to carry the point loads associated with the ladder safety device. The ladder shall support at least two people of 136 kg each while climbing .

4.3. Service Platform

4.3.1. The service platform(s) shall be constructed of aluminum with a working surface area of not less than 36 inches in length by 32 inches wide.

4.3.2. The platform surface shall be constructed using one of the following components:

a) Cross-linked style, anti-slip tread, aluminum grating welded to an aluminum frame.

b) One-piece aluminum channel perforated plank grating. Grating walking surface shall be slip resistant in all directions.

4.3.3. A service platform shall be provided for each Signal Head, ergonomically located to provide access to the Signal Head for a maintainer.

4.4. Walkway

4.4.1. Maintenance walkways on Overhead Signal Structures shall extend from the access ladder to a point which will provide safe access to Signal Units.

4.4.2. Walkways shall have skid proof surfaces a minimum width of 38.1 cm (15 inches) and shall be of open design to allow drainage.

4.5. Guardrails

4.5.1. Guardrails shall be provided around each service platform and walkways.

4.5.2. Guardrail assemblies shall be able to resist a single concentrated load of 1 kN in all directions on top of the guardrail, applied in any direction at any point along the top.

4.5.3. The guardrails shall comply with the requirements of OHSA Regulation 851 Industrial Establishments, S-14.

4.5.4. The guardrails shall have a minimum height of 106.7 cm (42 inches), measured from the top of the platform surface.

4.5.5. The guardrails shall extend the complete perimeter of the platform area, except at the egress area which shall be no less than 24 inches wide, for which a horizontal footing shall be provided at the mid-point of the egress floor. A hinged security rail designed with a spring return extending across the entry point shall be provided.

4.6. Junction Boxes

4.6.1. A junction box shall be provided on the main mast (U-bolt mounted) to mate with a 2-5/8 x 6-5/8 inch slot located in the main mast 40 inches from the signal base. This slot is not required if wiring is provided in an external conduit.

4.6.2. The junction box shall be equipped with a lockable, weather-sealed hinged door (complete with grease fittings) having a robust security locking latch system designed to accommodate a standard Railway type lock.

4.6.3. The size and number of terminals in the junction box shall accommodate the cabling for the number of signals on the Overhead Signal Structure.

4.6.4. The junction box shall be attached to the bottom of the bridge masts for easy access from the ground.

4.6.5. The junction box shall have a wire mesh screened drain hole to allow rain or condensation water to drain out of the box.

4.7. Signal Support Mast

4.7.1. Overhead Signal Structures shall be provided with 5 inch (nominal) inside diameter and approximate outer diameter of 5.5 inches, vertical masts or struts for mounting Signal Units. Proper clearance of other structure components shall be provided to permit proper adjustment/maintenance of the Signal Units.

4.7.2. The top of the mast(s) shall be closed or booted with a removable aluminum cap. The cap shall be secured to the pipe or mast with set screws.

4.7.3. The Contractor shall provide a tube type signal support arm for each type of Signal Head to be installed on the main mast. A 2-inch by 4-inch slot shall be provided in the mast such that cabling for the Signal Head can be routed through the mast and signal support arm. The edges of the slot and signal support arm tube shall be smooth and free of any burrs. A removable metal cap or plug shall be provided for each slot.

4.7.4. The orientation and spacing of the Signal Units shall be easily accessed, free of any

obstruction which may affect the maintenance or visibility of the Signal Units when mounted, and shall comply with the following:

a) the lowest or first Signal Head shall be located at a nominal height of 3.0 ft. when measured from the top side of the lower platform level to the center of Signal Head.

b) the spacing of additional Signal Heads shall be 72 inches between centers of two consecutive signal heads, or 60 inches as directed by Metrolinx .

c) provision shall be made to allow staggering of Signal Heads as required by latest CROR (Canadian Rail Operating Rules).

4.7.5. The Contractor shall supply all hardware related to the mounting of the Signal Units. This shall include mounting brackets, clamps, bolts, nuts and washers lubricated with NO-OX-ID grease, as required.

4.7.6. The Contractor shall provide for cable access through the underside of the vertical support base plate in order to run cables through the footing, up the vertical columns, and through the signal support arm to the signals. Cables shall remain unexposed throughout the lengths. All openings for cable passage shall be flanged and covered with a cover plate when not used.

4.7.7. As an alternative to section 4.7.6, external conduits may be used where approved in a case-by-case basis. Conduits with 4" diameter or larger shall be Sch. 10 Aluminum 6061-T6. Conduits with diameter less than 4" shall be Sch. 40 Aluminum 6061-T6. Conduits shall be secured to signal mast with formed clamp brackets with U-bolts..

4.7.8. The Contractor shall ensure that all the cables are routed through the Overhead Signal Structure or through external conduits and remain unexposed.

4.8. Electrification Requirements

4.8.1. The Overhead Signal Structure shall be grounded and bonded as per the Metrolinx Performance Specification for Structures Passing Over Electrified Corridors (MX ELEC STR-SPEC-2017-Rev 03).

4.8.2. Grounding lugs at base of structure shall be provided to accept cable as per the grounding design.

4.9. Life Span

4.9.1. Overhead Signal Structures shall have a minimum service life of 100 years. Fatigue calculations shall satisfy unlimited loading cycles.