Department of Transport

Road Sign and Lighting Structures

BTN 014

Version 2.2 21 October 2022

1 Scope and Application

Bridge Technical Note BTN 014 – Road Sign and Lighting Structures – states the Department of Transport's (DoT) requirements for the design and construction of road sign and lighting structures on DoT's network.

Bridge Technical Notes are a Code of Practice. Compliance with Bridge Technical Notes is mandatory.

BTN 014 is to be read in conjunction with the following DoT/VicRoads Standard Specification sections:

- Standard Specification 630
- Standard Specification 760

Other than as stated in this document and the relevant DoT/VicRoads Standard Specifications, the provisions of AS5100 must apply. Where this document differs from AS5100, its requirements override those of AS5100. Where the provisions of AS5100 do not apply, these are detailed in this BTN.

2 Scope

The requirements set out in this BTN apply to all the structures listed in AS5100.1 Clause 23.1.

In addition to the structures listed in AS5100.1 Clause 23.1, directional signs, variable message signs, trip condition signs, tourist signs, overhead traffic signals, advertising signs (static and electrical), all lighting poles and any other sign greater than 2 m^2 area attached to gantry/cantilever structures are required to comply with this BTN.

The requirements of this BTN also apply to structures mounted on bridges.

3 Definition

A sign structure/gantry is a structure that supports and carries the forces induced by the attached road signs, traffic signals, tolling systems, variable message signs, or other equipment. The structure may be ground-supported or be mounted on a structure, pursuant to the requirements of this BTN.

A gantry is a frame that supports various signs and similar equipment and includes both portal and cantilever structures that typically span over the roadway.

A high-mast light structure is a column that supports luminaires at ≥ 15 m height. The height is measured from the highest part of the luminaire to the ground level directly under the luminaire or the adjacent bridge deck level where mounted on a bridge.

4 Foundations

4.1 Foundations

Foundations must be designed to minimise settlements or tilting that could reduce vertical and/or horizontal clearances, induce additional stresses in the structure or result in malfunctioning of any of the attached equipment.

Settlements must be determined on the basis of a geotechnical investigation, and the differential settlement of foundations must not exceed 10mm over the design life.

4.2 Mounting

Static signs with panel sizes less than 900mm x 1200mm (e.g speed sign) may be mounted to bridge barriers.

Where it is necessary to mount sign structures/gantries on a bridge, the mounting point shall be desirably independent of the bridge barrier. All elements of the sign structure/gantry/lighting column must be located outside of the barrier working width. The bridge must be assessed for the additional vertical and lateral loads imposed by the added structure. The dynamic interaction of the bridge and the attached structure must be evaluated.

Where sign structures/ gantries or lighting structures/poles are to be mounted on road traffic barriers, the barriers are to be designed to carry the additional load of the structure and must prevent an errant vehicle from impacting the attached structure.

5 General Design

Terrains both along the road and across the road must be evaluated. The more adverse of the two terrain categories must be adopted for computation of wind forces.

Appendix C of AS/NZS 1170.2:2021 provides in Table C.3 drag force coefficients for squares with rounded corners, having a bend radius to width ratio of 1:3. Standard square hollow sections in Australia have bend radius to width ratios significantly smaller than 1:3. Drag force coefficients for standard Australian square and rectangular hollow sections must be computed from Table C.4, C.5 and Figure C.2 of AS/NZS 1170.2:2021 as for sharp-edged sections or from relevant literature but must not be smaller than 2.0.

For multiple open frames, any benefit of shielding must be neglected for computation of wind forces.

Signs must be side-mounted, positioned in front of the gantry arm, and connected to both the top and bottom flanges of the gantry arm where possible. (refer to Appendix B of this document for the proposed arrangement drawing).

Signs must be positioned vertically such that the forces on the connections between the sign framing structure and the gantry arm(s) are minimised as far as possible. Two or more gantry arms must be provided if required to support two rows of signs or to reduce connection forces to comply with fatigue limit state design.

Sign structures/gantries horizontal (arms) must be designed so that the completed structure under the action of self-weight must have a minimum 1:100 slope towards the support ends of the structure to ensure that water/moisture can drain effectively toward the support ends (refer to Appendix C of this document for the portal gantry slope requirement). Internal gantry stiffener plates must be designed to facilitate water draining through the structure toward the discharge points. The discharge point must be located in front of the support leg and be designed in a manner that would prevent water travelling down the support leg.

All stiffener and gusset plates that are required to transfer forces at connections between sign supports and gantry arms must be external to the gantry arm(s). These plate elements must be designed for all relevant limit states including buckling.

Gantry columns must be structurally designed to integrate architectural elements within the form.

If columns and horizontals (arms) are proposed to be jointed/integrated in an arch form for structures, approval from the Chief Engineer Roads is required.

Columns and horizontal arm joints must be located behind signage where possible, so they are not visible from the approach side of the carriageway in accordance with DoT ITS standard drawings TC-2250-2319.

When sign (including advertising) structures are mounted on bridges, subject to the requirements of this BTN, the design must ensure that the bottom edge of the sign is at least 200mm above the bridge soffit, to a maximum height of 6.0m above the road surface below.

6 Modifications

Where an existing sign or sign structure is to be modified, the condition of the sign structure must be assessed in accordance with AS5100.7 Clause 10.3. A Level 3 inspection must be conducted before any modifications take place. DoT must be notified immediately if any cracking, including fatigue cracking, of any steel members or connections, loss of section due to corrosion, or any other damage or defect that reduces structural capacity or design life is observed. Modifications must not take place without corrective actions to restore the strength of any damaged/defective members and connections.

Where modifications increase loads on or reduce capacity of any structural element, a full structural and geotechnical assessment must be carried out and the structure strengthened in accordance with AS5100 and the requirements of this document before any modifications are made.

Where there is no information of the material properties of the structure, materials testing must be performed.

7 Fatigue Limit State Design

When configuring a structure and when choosing and designing connection details, primary consideration must be given to ensures that the structure will have good fatigue strength and be fit for purpose over its design life.

Connection details must have robust and clearly defined load paths such that a smooth transfer of stress flow from a member into a connection is achieved. The designer must ensure that there is no sudden changes in geometry or stiffness at the load transfer zones. The designer must adopt the arrangement which produces the lowest stress concentrations.

Structures must be detailed to avoid conditions that create highly constrained joints and crack-like geometric discontinuities that are susceptible to constraint induced fracture. Refer to AASHTO LRFD Bridge Design Specifications [1] Clause 6.6.1.2.4 for further information.

7.1 High-Mast Light Poles

Fatigue limit state design of high-mast light poles must be in accordance with the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals [2]. The calculation of fatigue loads must be in accordance with Section 7.3 below.

High-mast light poles that could fall onto traffic lanes or shoulders must be treated in accordance with AASHTO [2] requirements for Fatigue Category I.

7.2 Sign Structures

Fatigue design loads for sign structures, including drag coefficients, must be calculated for an infinite fatigue life, Fatigue Category I in accordance with the AASHTO [2]. Where loading in AASHTO [2] is not relevant to roadside and bridge-mounted sign structures covered by this document, equivalent fatigue loading must be determined from appropriate relevant literature. The calculation of fatigue loads must be in accordance with Section 7.3.

Fatigue assessment and design of circular and multi-sided cross-sections must be in accordance with AASHTO [2], including the minimum number of sides requirement for multi-sided cross-section in Clause 5.6.2 of AASHTO [2].

Notwithstanding Clause 13.11.3 of AS5100.6, steel fatigue assessment and design of all other sections and their connections must be based upon AS5100.6, unless noted below. The fatigue requirements of AS5100.6 are largely taken from the International Institute of Welding (IIW) recommendations as described in Recommendations for Fatigue Design of Welded Joints and Components [3]. This IIW document [3] provides comprehensive and thorough explanation of the fatigue requirements in AS5100.6 and designers are advised to consult it.

AS5100.6 must be amended as follows:

- Sign structures must be designed for an endurance of 100 million cycles i.e. N_R = 1 x 10^8 cycles. Therefore:

  AS5100.6 equation 13.11.1(2) must be replaced by:

  $$\frac{\gamma_{Ff}\Delta\sigma_s}{\emptyset_{Mf}\Delta\sigma_R} \leq 1.0$$

  AS5100.6 equation 13.11.1(3) must be replaced by:

  $$\frac{\gamma_{Ff}\Delta\tau_s}{\emptyset_{Mf}\Delta\tau_R} \leq 1.0$$

  $\Delta\sigma_s$ and $\Delta\tau_s$ are the design fatigue stress ranges calculated from the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals [2], then modified by factors k_t and k_1 as required by AS5100.6 and;

  $\Delta\sigma_R$ and $\Delta\tau_R$ are either read from AS 5100.6 Figures 13.10.1(A) and 13.10.1(B) at N = 1 x 10^8 cycles or calculated from AS 5100.6 equations 13.10.1 (3) and 13.10.1(4) at N_R = 1 x 10^8 cycles.

  AS5100.6 equation 13.10.1(3) must be replaced by:

  $\Delta\sigma_R^m N_R = (0.585\Delta\sigma_c)^m 10^7$ with m = 22 for N > 10^7

  AS5100.6 equation 13.10.1(4) must be replaced by:

  $\Delta\tau_R^m N_R = (0.457\Delta\tau_c)^m 10^8$ with m = 22 for N > 10^8

  $\Delta\sigma_R$ and $\Delta\tau_R$ must be modified by factor k_s as required by Clause 13.10.3.2, AS5100.6.

- Load factor γ_{Ff} must be taken equal to 1.0.

- Capacity reduction factor for fatigue strength ϕ_{Mf} must be taken equal to 0.75.

Where a preferred detail is not represented in the categorised fatigue detail tables in AS5100.6, reference may be made to the categorised fatigue detail tables in the current AASHTO LRFD Bridge Design Specifications [1] and the current AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals [2].

Alternatively, the appropriate stress concentration factor to convert nominal stress range to geometric stress (also called **hot-spot stress**) can be determined using CIDECT Design Guide for Circular and Rectangular Hollow Section Welded Joints Under Fatigue [6]. The application of CIDECT is strictly limited to the specified connections in the design guide.

Where a preferred detail is not represented in AS5100.6 or the AASHTO standards [1] [2] or CIDECT [6], the detail must be reconsidered; and the connection and/or structure must be reconfigured so that a categorised fatigue detail can be used.

Where the Designer can demonstrate there are no options to reconfigure the connection so the categorised fatigue detail in any of the standards listed above can be used (e.g. strengthen or modify existing structures), geometric stress (also called **hot-spot stress**) can be determined using an elastic Finite Element (FE) analysis with approval from Chief Engineer - Roads. The elastic FE analysis must be in accordance with DNVGL-CG-0127 Class Guideline on Finite Element Analysis [4] and Recommended Practice DNVGL-RP-C203 [5]. The hot-spot stress must be calculated in accordance with Recommended Practice DNVGL-RP-C203 [5] or IIW Recommendation for Fatigue Design of Welded Joints and Components [3]. The hot-spot stress calculated must be assessed against the fatigue resistance as per detail category listed in AS/NZ5100.6 Table I2.

When using the AASHTO standards [1] [2] or CIDECT [6], sign structures must be designed for the relevant Constant-Amplitude Fatigue Limit (CAFL), Cut-off Limit and S-N curves. Capacity reduction factor for fatigue strength ϕ_{Mf} must be taken equal to 0.75.

The local stress method with FE analyses must not be used for details that are not represented in the AS5100.6 or AASHTO S-N fatigue curves and detail tables [1] [2]. Typically, robust and extensive full-scale physical testing regimes are required as a part of a rigorous procedure to establish the fatigue strength for details that are not represented on current S-N curves. FE analyses are not accepted on their own as adequate to determine local stress in welded connection without being backed up by rigorous physical testing carried out in accordance with international standards. Refer to Clause 13.5 of AS5100.6 and Clause C.1 Appendix C of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals [2].

7.3 Calculation of Fatigue Loads - General

The AASHTO publication [2] provides values of equivalent fatigue-limit-state static wind pressure ranges without requiring consideration of the site-specific wind loading. The wind pressures ranges in the AASHTO [2] formulae must be adjusted where average wind speed exceeds that used to derive AASHTO pressure ranges. Adjustment may be required for differences in the averaging interval used for wind speed data in Australia and in the USA.

For high-mast light poles, AASHTO [2] requires the equivalent fatigue-limit-state static wind pressure range to be selected based upon the yearly mean wind velocity. For these structures, the wind pressure range must not be lower than the maximum value of the equivalent fatigue-limit-state static wind pressure range stated in AASHTO [2].

Cantilever and portal sign structures may also be susceptible to a resonant response from galloping wind effect if the structural system is too flexible. The natural frequency of the structural system must be greater than 1 Hz.

The potential for a resonant response of the cantilever arms of sign structures to vortex shedding originating from the column must be assessed, including designs in which steel box sections are used for the principal members. If a resonant response is possible, this must be mitigated in the design (for example by the installation of impact dampers or wind-flow spoilers).

8 Rag Bolt Design

Rag bolt assemblies must be used to connect the structure to the footings. Rag bolt assemblies are to be cast in-situ at the same time with the footings.

The rag bolt length between concrete foundation and the underside of the levelling nut below the base plate must not exceed the rag bolt diameter.

Design of rag bolts must be prepared on the basis that all loads are supported by the rag bolts. No account must be taken of the capacity of the grout to support compressive loads or provide lateral support to rag bolts.

Rag bolts must be designed such that their ductile failure precedes the brittle failure modes. Refer to Section 5.17.3 of AASHTO [2] for guidance on ductile and failure modes of rag bolts.

Refer to Appendix A for grouting requirements.

9 Steel Grade

Further to AS/NZS5100.6 Cl.14.4, for the purpose of selecting the grade of steel, the design service temperature must be taken as LODMAT – 5ºC.

10 Requirements for Design and Proof Engineering

Designs for sign structures and high-mast light poles must be prepared by a Designer that is prequalified at Structures Complex Level in accordance with the DoT Prequalification scheme.

All designs must be subjected to proof-engineering by a Proof Engineer that is prequalified at Proof Engineering level in accordance with the DoT Prequalification scheme.

11 Additional Requirements for Cantilever Arms Longer Than 9m

The length of cantilever arms of sign structures must not exceed 9m without the prior approval of the Chief Engineer – Roads of DoT.

To ensure adequate fatigue performance, the Contractor must perform continuous vibration monitoring of cantilever arms longer than 9m for a period of 12 months immediately following completion of the structure. As a minimum, vibration monitoring must be achieved by measuring variations in strain at the base-plate weld in order to establish that the strain range is less than the strain corresponding to relevant design fatigue strength.

Proposals for vibration monitoring together with the collection and interpretation of data must be subjected to proof-engineering by a company that is prequalified at Proof Engineering level in accordance with the DoT Prequalification scheme.

12 References

1. AASHTO. 2020. LRFD Bridge Design Specifications, 8th Edition. American Association of State Highway and Transportation Officials. Washington, DC.
2. AASHTO. 2015. LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition. American Association of State Highway and Transportation Officials. Washington, DC.
3. IIW. 2019. Recommendation for Fatigue Design of Welded Joints and Components, Second Edition. International Institute of Welding, A.F. Hobbacher, 2019.
4. DNVGL. 2015. Class Guideline DNVGL-CG-0127 Finite Element Analysis, October 2015.
5. DNVGL. 2011. Recommended Practice DNVGL-RP-C203 Fatigue Design of Offshore Steel Structures, October 2011.
6. CIDECT Design Guide for Circular and Rectangular Hollow Section Welded joints under Fatigue Loading, 2001.

Contact Details

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Document Control

This document is subject to periodic review and may be superseded. The revision date is listed in this BTN.

Note that for projects tendered prior to the revision date of this document, there are no retrospective implications of this document unless agreed otherwise with DoT.

Version	Description	Revision	Approved by
1.0	Original Publication	1 January 2018	Principal – Bridge Engineer
1.1	Amended Section 3 and Section 5	15 June 2018	Principal – Bridge Engineer
1.2	Amended Section 4	17 October 2018	Principal – Bridge Engineer
1.3	Amended minor errors	30 November 2018	Principal – Bridge Engineer
2.0	Fatigue design provisions	31 October 2019	Principal Engineer – Structures
2.1	Amended minor errors	20 November 2019	Principal Engineer – Structures
2.2	Amended Section 2, 3, 4, 5, 6, 7 and Section 8 • Improved definitions • Added addition design requirements for gantry design • Updated fatigue limit stage design requirements	21 October 2022	Chief Engineer - Roads

Appendix A

Construction

Installation of Anchor Bolts

In accordance with Section 760, a double template system must be used to achieve correct positioning and alignment of the cast-in anchor bolts and the bolt holes in the baseplate.

The area of templates must be kept as small as possible to avoid interference with concrete pour and reinforcement.

The anchor bolts must be checked before and after pouring concrete for the foundation and after removal of the top template.

Grout

Grout must be provided between the baseplate and pedestal and must comply with the requirements of Section 760. Dry-packed mortar must not be used.

Formwork

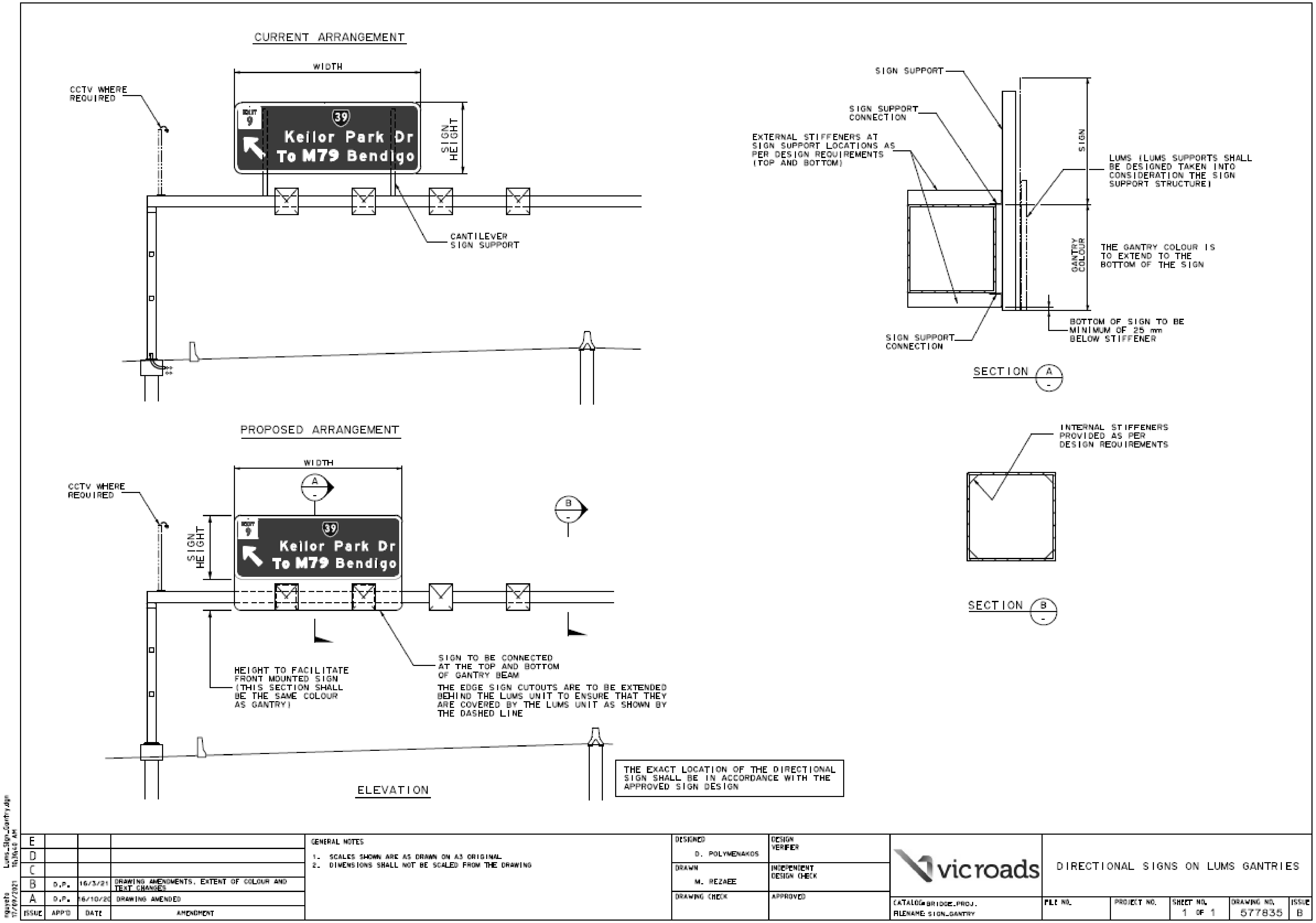
If formwork is not properly sealed, grout leaks may occur leading to the formation of voids under the baseplate and potentially to a heightened risk of corrosion of steel components. The following procedure is recommended in order to avoid the possibility of grout leakage.

Formwork Procedure

The design intent is to provide a layer of grout between the baseplate and foundation. Formwork must be set to ensure that the void under the base-plate must be filled to a level 10 mm above the underside of the base-plate as per Standard Specification 760.03.

The formwork or baseplate must be vibrated or tapped for 30 seconds. Grout must be cured in accordance with the manufacturer's instructions.

Appendix B



CURRENT ARRANGEMENT
WIDTH
CCTV WHERE REQUIRED
SIGN HEIGHT
EXIT 9
39
Keilor Park Dr
To M79 Bendigo
CANTILEVER SIGN SUPPORT
PROPOSED ARRANGEMENT
WIDTH
CCTV WHERE REQUIRED
SIGN HEIGHT
HEIGHT TO FACILITATE FRONT MOUNTED SIGN (THIS SECTION SHALL BE THE SAME COLOUR AS GANTRY)
SIGN TO BE CONNECTED AT THE TOP AND BOTTOM OF GANTRY BEAM
THE EDGE SIGN CUTOUTS ARE TO BE EXTENDED BEHIND THE LUMS UNIT TO ENSURE THAT THEY ARE COVERED BY THE LUMS UNIT AS SHOWN BY THE DASHED LINE
ELEVATION
THE EXACT LOCATION OF THE DIRECTIONAL SIGN SHALL BE IN ACCORDANCE WITH THE APPROVED SIGN DESIGN
SIGN SUPPORT
SIGN SUPPORT CONNECTION
EXTERNAL STIFFENERS AT SIGN SUPPORT LOCATIONS AS PER DESIGN REQUIREMENTS (TOP AND BOTTOM)
SIGN
LUMS (LUMS SUPPORTS SHALL BE DESIGNED TAKEN INTO CONSIDERATION THE SIGN SUPPORT STRUCTURE)
GANTRY COLOUR
THE GANTRY COLOUR IS TO EXTEND TO THE BOTTOM OF THE SIGN
SIGN SUPPORT CONNECTION
BOTTOM OF SIGN TO BE MINIMUM OF 25 mm BELOW STIFFENER
SECTION A
INTERNAL STIFFENERS PROVIDED AS PER DESIGN REQUIREMENTS
SECTION B
E
D
C
B D.P. 16/3/21 DRAWING AMENDMENTS, EXTENT OF COLOUR AND TEXT CHANGES
A D.P. 16/10/20 DRAWING AMENDED
ISSUE APP'D DATE AMENDMENT
GENERAL NOTES
1. SCALES SHOWN ARE AS DRAWN ON A3 ORIGINAL
2. DIMENSIONS SHALL NOT BE SCALED FROM THE DRAWING
DESIGNED D. POLYMENAKOS
DRAWN M. REZAEE
DRAWING CHECK
DESIGN VERIFIER
INDEPENDENT DESIGN CHECK
APPROVED
vicroads
DIRECTIONAL SIGNS ON LUMS GANTRIES
CATALOG: BRIDGE_PROJ.
FILENAME: SIGN_GANTRY
FILE NO.
PROJECT NO.
SHEET NO. 1 OF 1
DRAWING NO. 577835
ISSUE B

Appendix C

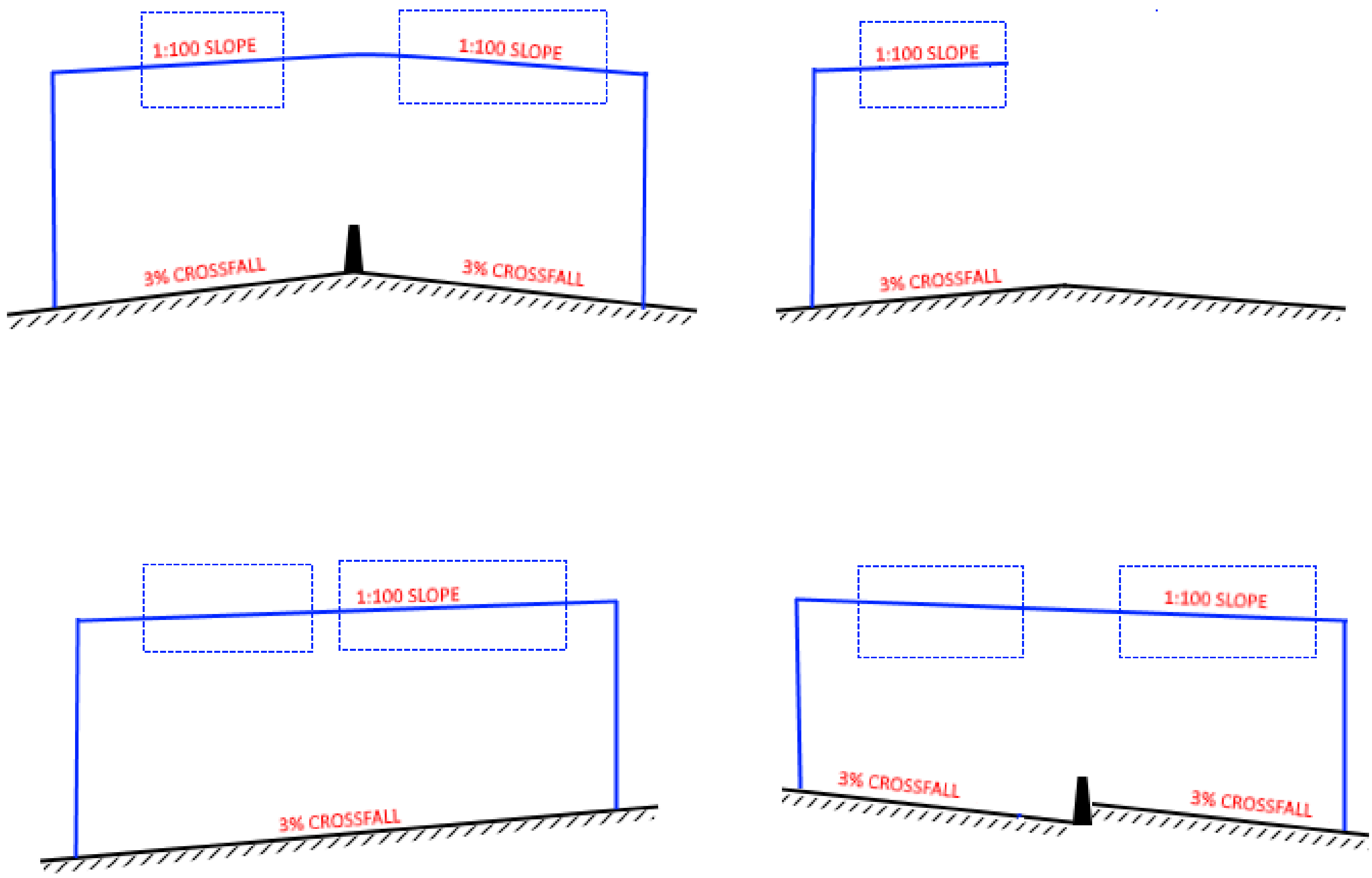


Figure C1 – Gantry slope requirement