BTN 014
Road Sign and Lighting Structures

05 June 2023
Version 2.3

Department of Transport and Planning

1. Scope and Application

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

DTP was formerly known as Department of Transport (DoT) and VicRoads. DTP documents include the relevant DoT and VicRoads documents which must also be complied with.

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 documents:

- AS/NZS 1170.2:2021 – Structural Design Actions – Part 2: Wind Actions
- DTP ITS Standard Drawings TC-2250 - TC-2319
- AS 5100 – Bridge Design
- DTP's Standard Sections
- Network Technical Guideline – Supplement to Austroads Guide to Road Design – Part 6.

Other than as stated in this document and the relevant DTP Standard Sections, the provisions of the AS 5100 Bridge Design series must apply. Where this document differs from the AS 5100 series, its requirements override those of the AS 5100 series.

2. Scope

The requirements set out in this BTN apply to all the structures listed in Clause 23.1 of AS 5100.1. In addition to these structures, 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 attached to gantry/cantilever structures or bridge components are required to comply with this BTN.

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

3. Definition

Sign structure/gantry - a structure that supports and carries the forces induced by attached road signs, traffic signals, tolling systems, variable message signs, or other equipment. It may be ground-supported or be mounted onto another structure.

Gantry - a frame that supports various signs and other equipment and includes both portal and cantilever structures that typically span over the roadway.

High-mast light structure - a column that supports luminaires with a nominal mounting height of more than 15 m.

Nominal mounting height - the vertical distance between the bottom of the baseplate and

a) For lighting poles with outreach arms: a horizontal line at the highest level of the outreach arm centreline, excluding the luminaire fixing spigot; or

b) For light poles without outreach arms: the highest point of the lighting pole, excluding the luminaire fixing spigot.

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 10 mm over the design life.

4.2. Mounting

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

Where signs or sign structures are to be mounted on bridges or bridge barriers, the signs/sign structures must be designed to meet the following requirements:

- The bottom edge of the sign and supporting elements must be at least 200 mm above the bridge soffit and up to a maximum height of 6.0m above the road surface.
- The top edge of the sign must be at least 200 mm below the top surface of the barriers.
- The sign must have a minimum horizontal clearance of 200 mm from the near face of the barrier to facilitate inspection of both the bridge and sign structure.
- Safety cables must be provided to secure the sign to structural members with a minimum factor of safety of 5.0 to resist the self-weight of the sign. The safety cable's length must be designed to ensure that if the sign connections become loose, the sign does not fall more than 600 mm vertically.

No part of the gantry is to be mounted on barriers on structures (i.e. bridge, major culvert, retaining wall and RSS wall, etc).

Where it is necessary to mount gantries on a bridge, the mounting point must be independent of the bridge barriers.

All elements of the gantry and lighting column must be located outside of the barrier working width in accordance with Network Technical Guideline – Supplement to Austroads Guide to Road Design – Part 6. 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 roadside 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 and across the road must be evaluated. The more adverse of the two terrain categories must be adopted for the computation of wind forces.

AS/NZS 1170.2:2021 Table C.3 provides 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 Tables C.4 and 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 the 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 Appendix A).

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

Sign structures/gantries horizontal (arms) must be designed so that the 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 and be discharged efficiently (refer Appendix B). 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 prevents water travelling down and staining 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 DTP 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 DTP ITS standard drawings TC-2250 to TC-2319.

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.

DTP 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 BTN before any modifications are made.

Where there is no information of the material properties of the structure, materials testing must be performed to enable those properties to be incorporated in the structural assessment.

7. Fatigue Limit State Design

When choosing and designing connection details whilst configuring a structure, primary consideration must be given to ensuring 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 are 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 (herein referred to as “AASHTO [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 (herein referred to as “AASHTO [2]”). The calculation of fatigue loads must be in accordance with Section 7.3 below.

High-mast light poles that have the potential to 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 as specified in Clause 5.6.2.

Notwithstanding Clause 13.11.3 of AS/NZS 5100.6, steel fatigue assessment and design of all other sections and their connections must be based upon AS/NZS 5100.6, unless noted below. The fatigue requirements of AS/NZS 5100.6 are largely taken from the International Institute of Welding (IIW) recommendations as described in Recommendations for Fatigue Design of Welded Joints and Components (herein referred to as "IIW [3]"). IIW [3] provides a comprehensive and thorough explanation of the fatigue requirements in AS/NZS 5100.6 and Designers are advised to consult it.

AS/NZS 5100.6 must be amended as follows:

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

  AS/NZS 5100.6 equation 13.11.1(2) must be replaced by:

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

  AS/NZS 5100.6 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 [2], then modified by factors k_t and k_1 as required by AS/NZS 5100.6 and;

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

  AS/NZS 5100.6 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 $N > 10^7$

  AS/NZS 5100.6 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, AS/NZS 5100.6.

- 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 AS/NZS 5100.6, reference may be made to the categorised fatigue detail tables in AASHTO [1] and AASHTO [2].

Alternatively, the appropriate stress concentration factor to convert nominal stress range to geometric stress (also referred to as hot-spot stress) can be determined using CIDECT Design Guide for Circular and Rectangular Hollow Section Welded Joints Under Fatigue (herein referred to as "CIDECT [4]"). The application of CIDECT [4] is strictly limited to the specified connections in the design guide.

Where a preferred detail is not represented in AS/NZS 5100.6 or the AASHTO [1], AASHTO [2] or CIDECT [4], 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), the geometric stress can be determined using an elastic Finite Element (FE) analysis with approval from the DTP Chief Engineer - Roads.

The elastic FE analysis must be in accordance with DNVGL-CG-0127 Class Guideline on Finite Element Analysis (herein referred to as “DNVGL [5]”) and DNVGL-RP-C203 Recommended Practice for Fatigue Design of Offshore Steel Structures (herein referred to as “DNVGL [6]”).

The geometric stress must be calculated in accordance with DNVGL [6] or IIW [3]. The geometric 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] or AASHTO [2] or CIDECT [4], 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 AS/NZS 5100.6 or AASHTO [1] or [2] S-N fatigue curves and detail tables. Typically, robust and extensive full-scale physical testing regimes are required as 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 verified by rigorous physical testing carried out in accordance with international standards. Refer to Clause 13.5 of AS/NZS 5100.6 and Clause C.1 Appendix C of AASHTO [2].

7.3. Calculation of Fatigue Loads - General

AASHTO [2] provides values of equivalent fatigue-limit-state static wind pressure ranges without requiring consideration of the site-specific wind loading. The wind pressure ranges in the AASHTO [2] formulae must be adjusted where the 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 the concrete foundation and the underside of the levelling nut below the base plate must not exceed the rag bolt diameter.

The 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 C for grouting requirements.

9. Steel Grade

Further to AS/NZS 5100.6 Clause14.4, 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 an engineering consultant that is prequalified at Structures Complex Level in accordance with the DTP 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 DTP Prequalification scheme.

11. Additional Requirements for Cantilever Arms Longer Than 9 m

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

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 an engineering consultant that is prequalified at Proof Engineering level in accordance with the DTP 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. CIDECT Design Guide for Circular and Rectangular Hollow Section Welded joints under Fatigue Loading, 2001.
5. DNVGL. 2015. Class Guideline DNVGL-CG-0127 Finite Element Analysis, October 2015.
6. DNVGL. 2011. Recommended Practice DNVGL-RP-C203 Fatigue Design of Offshore Steel Structures, October 2011.

Contact Details

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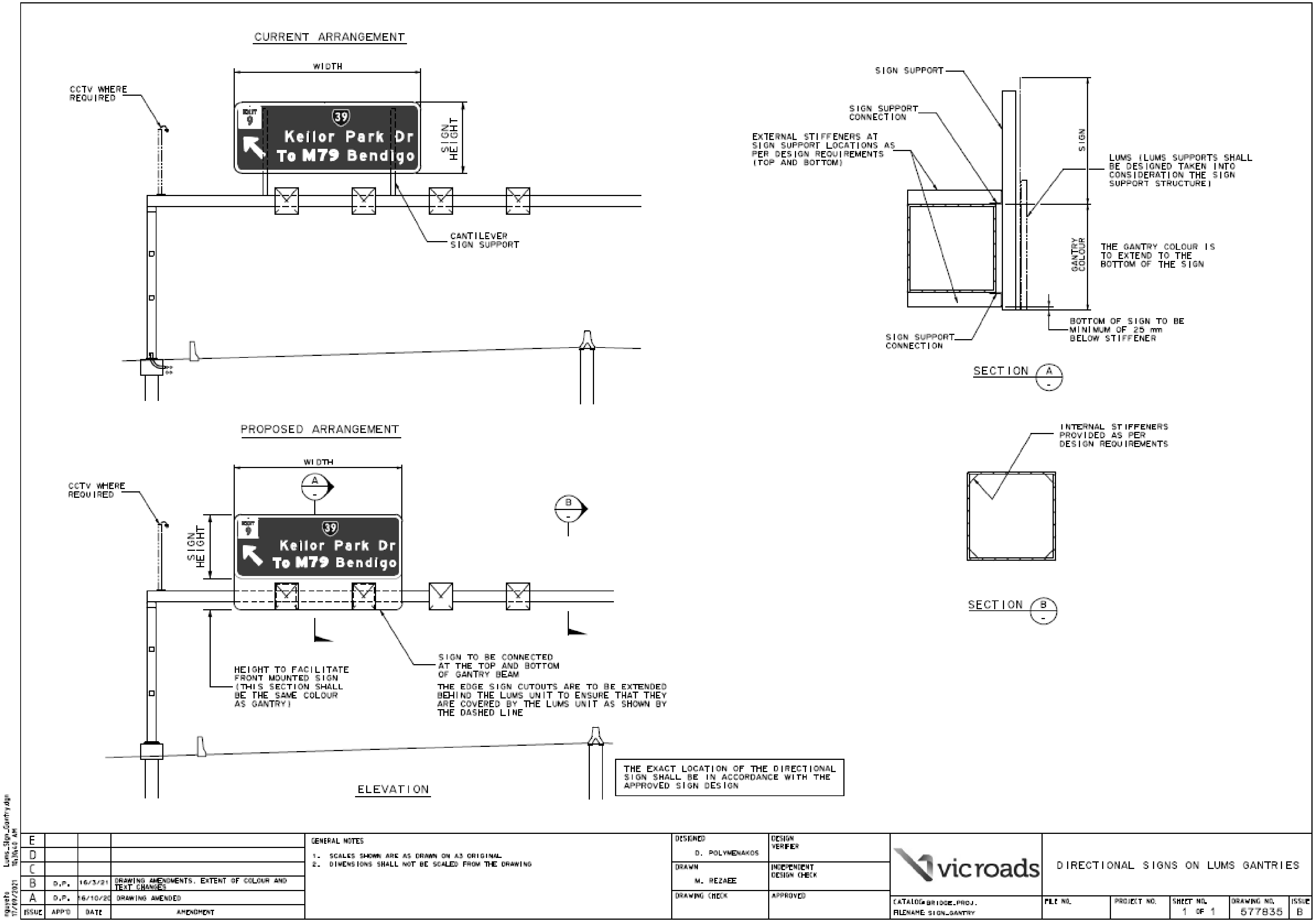
Bridge Technical Notes are subject to periodic review and may be superseded.

Document Control

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

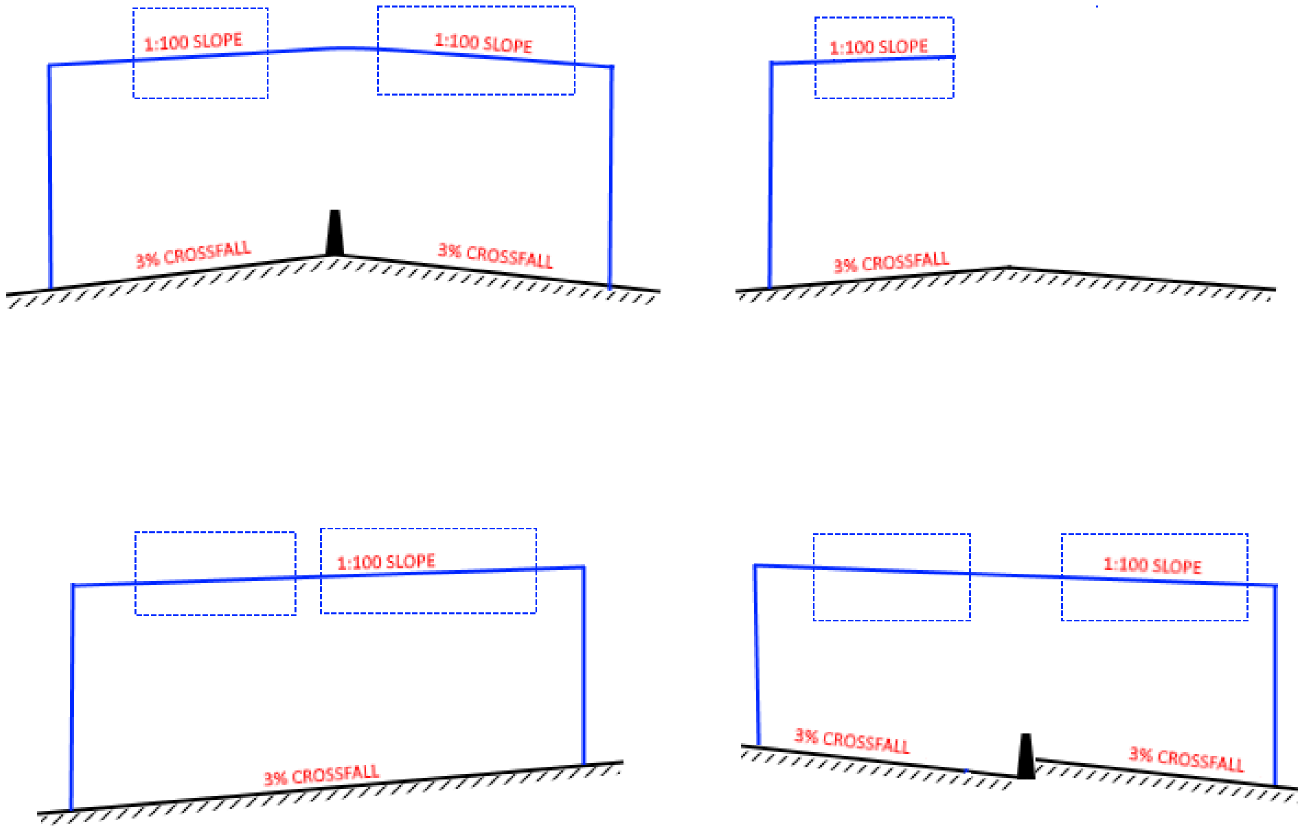
Note that for projects tendered prior to the revision date of this document, there are no retrospective implications of this document unless agreed otherwise with DTP.

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
2.3	Amended Section 1, 3 and 4.2 • Amended reference list • Amended high-mast light structure definition • Added additional requirements for mounting signs structures on bridge barriers	05 June 2023	Senior Manager – Roads Engineering



CURRENT ARRANGEMENT
WIDTH
CCTV WHERE REQUIRED
EXIT 9
39
Keilor Park Dr
To M79 Bendigo
SIGN HEIGHT
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
BOTTOM OF SIGN TO BE MINIMUM OF 25 mm BELOW STIFFENER
SIGN SUPPORT CONNECTION
SECTION A
INTERNAL STIFFENERS PROVIDED AS PER DESIGN REQUIREMENTS
SECTION B
GENERAL NOTES
1. SCALES SHOWN ARE AS DRAWN ON A3 ORIGINAL
2. DIMENSIONS SHALL NOT BE SCALED FROM THE DRAWING
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
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 B



Gantry slope requirement (signs to be installed level/plumb, minimum clearance to be maintained)

Appendix C

Construction

Installation of Rag Bolts

In accordance with Section 760, a double template system must be used to achieve correct positioning and alignment of the cast-in rag 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 rag bolts must be checked before and after pouring concrete for the foundation and after removal of the top template to ensure that the base plate fits the rag bolts.

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 Section 760 Clause 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.