Manual

Design Criteria for Bridges and Other Structures

August 2014

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Amendment Register

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3	1.3.6	Asbestos management and removal content update	DCE (Structures)	April 2014
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1 Design requirements for bridges

1.1 Reference documents

a) This set of design criteria complements AS 5100. Where this document and AS 5100 disagree, this document takes precedence.

b) AS 5100 is defined as: AS 5100:2004, the Supplements and the Amendments issued.

c) Amendments and corrections to AS 5100 are set out in Section 6 of this document.

d) At the start of each bridge design project, the additional requirements in Section 7 “Matters for Resolution to AS 5100” shall be either:

   i. Supplied by the principal to the designer, or

   ii. A proposal for the contents of Section 7 shall be prepared by the designer, and submitted to Deputy Chief Engineer (Structures) for modification (if necessary) and acceptance.

e) The design of prestressed concrete deck units shall also be based on Standard Drawing 2043 Design Assumptions for Transversely stressed standard Deck Units.*(Standard Drawing 2043 supersedes the Standard Drawing 1519 (11/10)).*

f) For design and construct contracts, construction shall be in accordance with Transport and Main Roads Specifications.

g) The Standard Drawings and Specifications referenced in this document are the latest version, which may be an Interim Version, published on the Department’s website www.tmr.qld.gov.au.

h) Transport and Main Roads *Bridge Design Drafting Manual*. All drawings shall be completed to the standards of detail, accuracy and completeness set out in the Transport and Main Roads *Drafting and Design Presentation Standards Volume 3 – Structures Drafting Standards*.

i) Transport and Main Roads bridge inspection and maintenance manuals. Where these standard manuals do not explicitly cover the inspection and maintenance of any bridge component or novel material or coating, the designer shall provide procedures (similar to the standard manuals) for inspection and maintenance for the novel aspects of the design.

j) Bridge Design Report. The template for the preparation of Bridge Design Reports is issued by Structures Section.

k) These criteria relate to Transport and Main Roads bridges. Bridges involving other authorities may have different requirements, for example:

   - Queensland Rail (clearances, structural form)
   - Utilities (communications, cables, and so on)
   - Local Authorities (water, sewerage pipes)
   - Mining development and power stations (specific load or dimensional clearances on associated roads).

l) The designer shall consult relevant authorities for their additional requirements if these are not explicitly included in Section 7 Matters for Resolution.

1.2 Bridges – scope

The scope of these design criteria is limited as below.

1.2.1 Standard bridges

This document covers the following types of bridge superstructure:

a) Standard small and medium span bridges including:

- Deck and kerb units as detailed on Transport and Main Roads Standard Drawings
- T girders and T-Roff girders
- I girders similar to AASHTO or NAASRA standard shapes for Prestressed Concrete (PSC) girders

Note: *Limited availability for this superstructure type, Director (Bridge and Marine Engineering) shall be consulted prior to commending the concept design.*

- Steel I girders for widening existing bridges with steel I girders. Acceptance to use steel girders in new bridges shall be obtained from Deputy Chief Engineer (Structures) prior to commencement of design.
- Insitu reinforced concrete decks on deck units, prestressed concrete and steel girders
- Transverse width of a concrete deck not exceeding 20 m. Additional criteria for limiting transverse concrete creep and shrinkage apply to wider bridges, and shall be included in a preliminary design report.

b) Small and medium span bridges of unusual geometry which require additional design and detailing (see Clause 1.2.1.1).

c) Medium span bridges such as box girders, or curved ramp bridges using box girders.

d) Footbridges of conventional design.

The standard substructure types covered are:

a) Prestressed concrete piles (Transport and Main Roads Standard Drawing 1500)

b) Cast-in-place piles in liners to MRTS63

c) Spread footings

d) Reinforced concrete abutments and piers.

1.2.1.1 Small and medium span, unusual geometry

a) Bridges with one or more of the following characteristics are not preferred and they require additional consideration in design to ensure the behaviour of the bridge in service does not create maintenance problems:

- Skews over 45°
- Horizontal curvature where the maximum distance between the arc and the chord over a span exceeds 600 mm
- Decks over 20 m wide, where transverse shrinkage and temperature movements shall be considered in the design, and the effects reduced as far as practical

- Continuous curved superstructure such as box girders, where the change in angle exceeds 30°. The effects of bearing placement, lateral restraint, thermal movements, and vertical differential temperature inducing torsional effects shall be considered in design.

b) The designer shall submit a detailed preliminary design report to the Principal on the additional design considerations undertaken and the reasons for the adopted design solutions, prior to submission of any preliminary design drawings for acceptance, typically at the 15% design completed stage.

1.2.1.2 Non-standard bridges

a) Non-standard bridges include:

- All bridges not included above
- All bridges outside the Scope of AS 5100
- Pedestrian access to railway platforms
- Bridges incorporating structural components made from novel or unusual materials
- Bridges incorporating novel or unusual structural form
- Concrete box girder bridges. AS 5100 does not adequately address shear and torsion in large concrete box girder bridges. The design criteria for such structures shall be accepted by Deputy Chief Engineer (Structures). AASHTO-Load and Resistance Factor Design (LRFD) shall be the basis of the acceptance.
- Steel box girders. AS 5100 does not adequately address the design requirements of this structural form.

b) This document does not cover the use and design requirements for non-standard bridges.

c) Any designer proposing the use of such bridge forms or materials shall submit a detailed proposal before design commences to the Deputy Chief Engineer (Structures), detailing:

- The reasons for use of such non-standard bridge forms or materials
- Proposed design standards and materials specifications to be used; the designer's experience in the use of the materials, structural forms and design standards; and evidence that the materials and components will have the specified design life
- One copy of every design standard and material specification, in English and fully legible
- Proposals for independent proof engineering of the design by experienced design consultants
- Proposals for independent testing for conformance to specifications of all unusual materials proposed in the design. Testing shall be done in Australia, witnessed by a departmental representative, all at no additional cost to the Principal.

d) Design shall not commence until full acceptance is given to use the non-standard designs and materials. Time taken by the Principal to assess such proposals shall be entirely at the designer's cost, and no project delay costs will arise.

1.2.1.3 Structural forms requiring approval

a) Integral structures

Bridges with “integral” substructure and superstructure may be considered in certain situations such as:

- Vertical alignment is constraint and an integral structure would achieve a higher vertical clearance
- Access to inspect and replace bridge bearings is severely restricted
- The foundation material is of competent quality to limit differential settlement of the abutments and piers to acceptable limits appropriate for the integral structure.

Integral structure design shall include the effects of additional earth pressure due to “racheting” of the abutment backfill based on geotechnical investigation and report, and *BA 42/96, The Design of Integral Bridges.*

Highly skewed and/or long integral bridges are generally considered unsuitable for integral structural form as it is outside the scope of AS 5100. These can result in “un-usual” effects from loads, detrimental effects on the pavement, and other effects causing maintenance issues. They need to be addressed and the design criteria established, during initial option studies for integral bridges and other structural forms.

Discussion and approval for the use of integral structures are required from Director (Bridge and Marine Engineering).

b) Substructure with single columns

In situations where geometric design constraints require a single column at a pier, the risk and consequences of vehicle/vessel impact on the column shall be assessed. AS 5100.1 requires sufficient redundancies to prevent collapse of the structure. The column shall be structurally robust to resist impact because there is no structural redundancy if the single column fails on impact. The column and foundation shall be designed to resist at least twice the structural ultimate limit state capacity required using AS 5100 design loads, in addition to the use of barriers for pier protection.

Discussion and approval for the use of single column substructure that can be impacted, is required from Director (Bridge and Marine Engineering).

1.2.1.4 Other structures

This criterion covers additional requirements for the design of other road-related structures:

- Pedestrian and cycle bridges
- Underpasses
- Sign support structures
- Retaining walls and other associated structures
- Drainage structures
- Noise barriers
- Fauna crossings and concrete arches

- Submerged structures
- Tunnels
- Bus stations and light rail stations
- Development applications adjacent to transport infrastructure.

1.3 Stage construction and provision for future widening

1.3.1 Future widening

a) Allowance shall be made for any future widening of bridges included in the design requirements. Couplers, ducts and other necessary details shall be provided and detailed on the drawings.

b) Breaking back of concrete to lap reinforcement is not permitted. Projecting exposed reinforcement is not permitted.

c) Wherever possible, the connections shall be detailed to minimise or eliminate the need for future modification of the bridge being designed. Details of the widening methodology, including outline drawings of the widening, the method of attachment, the loading code used and loading limits including the design Serviceability Limit State (SLS) and Ultimate Limit State(ULS) forces allowed for in the design of the bridge shall be included on any appropriate bridge drawings.

1.3.2 Stage construction

Details of minimum lane widths and minimum number of traffic lanes are in the road design criteria.

a) During the first stage of a bridge constructed by stage construction, the HLP 400 design load is not required, unless the first stage is 8 m wide or more. However, the completed bridge shall be designed for all stage loads, including HLP 400.

b) Permanent and/or temporary traffic barriers are required on the sides of the bridge. In one-lane operation, the traffic barrier shall be designed with due consideration of the traffic speed and distribution of vehicles.

c) Minimum lane widths and minimum number of traffic lanes are to be as detailed in Section 7 (Item S1) or elsewhere in the brief or Scope of Work and Technical Criteria (SWTC).

d) Where a longitudinal stitch pour is required to join reinforced concrete decks or other components subject to traffic movements or vibration, provision shall be made to ensure that stitch pour can be completed within a 48 hour period. During this period, provision for reducing or minimising the deflection, differential effect and vibration shall be made.

1.3.3 Widening an existing bridge

a) A bridge widening shall normally be done using the same cross-sectional profile of beams and decks or deck units as the original bridge, unless loading or hydraulic requirements require modifications.

b) When a bridge is widened, the new section of deck shall be made integral with the existing deck. A longitudinal joint in the roadway is not acceptable.

c) The existing bridge will have been designed to the current code of the time. Whilst it is desirable that the widened bridge fully conforms to AS 5100, where this is not reasonably practical or is uneconomic, the widened structure shall be designed to accommodate loading compatible with the original bridge and be equal in strength or structurally stronger than the existing bridge. For design traffic loads for widening existing bridges refer to Clause 3.2.4.

d) Footpath width shall desirably conform to AS 5100 requirements. For bridge rehabilitation, a lesser width footpath may be considered after taking into account the expected remaining life of the structure, traffic, and cost benefit of the conforming width and practicality of strengthening. The minimum width of the footpath shall be 1.8 m. Any variation from AS 5100 shall only be permitted with the written approval of the Deputy Chief Engineer (Structures). Design loading shall conform to AS 5100 and Section 6 of this document.

e) The footpath loads for an attached footpath shall be as per AS 5100. The addition of a footpath must not significantly reduce the traffic load capacity of the bridge. However, the traffic load capacity does not have to be increased but shall be reviewed for future demands and approved by the Deputy Chief Engineer (Structures).

f) Widening shall not reduce the structural stability or load capacity of the structure below the existing capacity of the bridge or culvert.

g) The expansion joint seals and Deck Wearing Surface (DWS) of the entire width of the bridge shall be replaced as part of the works.

h) Where a longitudinal stitch pour is required to join reinforced concrete decks or other components subject to traffic movements or vibration, provision shall be made to ensure that stitch pour can be completed within a 48 hour period. During this period, provision for reducing or minimising the deflection, differential effect and vibration shall be made.

1.3.4 Widening two bridges on separate carriageways

When a divided road is widened into the central median, the widened bridges shall remain separated to avoid the problems of an extra-wide deck and thermal movements. A minimum horizontal distance of 1.2 m shall be maintained between the two bridges for inspection and maintenance. Where this is not possible, the options shall be determined and referred to Deputy Chief Engineer (Structures) for advice.

1.3.5 Estimating residual life of existing bridge

Residual life is the remaining life of a structure, taking into account changes to the operating environment and its current condition.

1.3.5.1 Future operating environment

a) Factors that impact the operating environment are:

- Operating condition of the road, including usage as heavy vehicle route
- Hydraulics
- Location of widening on heavy vehicle route and the residual life of the original structure
- Difference between local authority roads, service roads and departmental roads.

b) Changes in land usage, from rural to urban for example, will significantly change the runoff in streams. Consideration shall be given in future land usage in determining if an existing structure has adequate waterway area, needs to have the waterway increased or needs to be replaced by a new bridge or culvert.

c) For design loads applicable to widened bridges or culverts refer to Clause 3.2.4.

1.3.5.2 Estimating operational residual life

a) Bridges are designed for a nominal design life of 100 years. Design life for culverts and other small drainage structures are as listed in Section 17 (prior to 2004, the nominal design life for culverts was 50 years).

b) The nominal residual life of the structure is the difference between the nominal design life and the age of the structure.

c) The residual operational life of the structure shall be determined. The residual operational life shall consider if initiation or propagation of deterioration has commenced, and whether current or future load increases or changes in environmental and exposure conditions will increase the rate of deterioration. Testing shall be done to determine whether the initiation or propagation phases are relevant to the structure.

d) The need to rehabilitate existing structures will either:

- be defined elsewhere in the Scope of Works and Technical Criteria, or
- be advised on completion of condition surveys and the assessment and calculation of the estimated operational residual life.

1.3.6 Working with asbestos in bridge rehabilitation works

1.3.6.1 Identification of the asbestos

These requirements for working with asbestos in bridge rehabilitation works should be undertaken in accordance with the Engineering and Technology (E&T) Asbestos Implementation Guideline which details the specific procedure and roles and responsibilities to be applied by E&T for the management of asbestos risk.

Designers shall investigate whether any permanent asbestos items have been used in an existing bridge prior to preparing the rehabilitation proposals. This investigation shall identify the locations and the type of the asbestos at the workplace.

Asbestos components shall be tested by Electron Microscopy with dispersive x-rays or equivalent to identify asbestos fibres as defined in Workplace Health and Safety Act 2011. Identification of fibres as asbestos using electron microscopy techniques can be undertaken in consultation with QUT. For further details email mr.techdocs@tmr.qld.gov.au. If asbestos is identified, a written asbestos management plan shall be developed by a qualified person in accordance with Workplace Health and Safety Queensland (WHSQ) - Work Health and Safety Regulation 2011.

Asbestos can occur in the following locations of existing bridges.

- Permanent formwork for in-situ deck slabs with girders including separated deck units;
- Suspended services (for example drainage pipes, water mains)
- Cast in services (for example conduits and drainage fittings)

- Buried services including ducts and pits
- Electrical and communication pits
- Miscellaneous packing and sealing products.

1.3.6.2 Asbestos removal and asbestos related works

Asbestos removal must only be done with specific care to minimise asbestos fibres becoming airborne. The following WHSQ guidelines shall be followed:

- *Safe Work Procedures techniques*
- *How to Safely Remove Asbestos Code of Practice 2011*
- *How to Manage and Control Asbestos in the Workplace Code of Practice 2011*
- *Work Health and Safety Regulation 2011*
- *Work Health and Safety Act 2011*.

Asbestos removal shall be carried out by an appropriately licensed asbestos removal contractor, unless exempted by WHS Relation 2011 for the size and class of the proposed asbestos work. The type of licence required shall be in accordance with WHS Regulation 2011 *Transport and Disposal of Asbestos Waste.*

Licensed asbestos removalists must ensure that asbestos waste is disposed to an authorised site in accordance with the guidelines provided in WHSQ Code of Practice *How to Safely Remove Asbestos*.

1.3.6.3 Clearance certificate

On completion of the licensed asbestos removal works, a clearance inspection shall be carried out by a licensed asbestos assessor or a competent person and a clearance certificate shall be issued in accordance with WHSQ guidelines to verify that the work place is safe for normal use.

All documentation must be given to the Asbestos Controller for uploading to the Central Asbestos Register.

1.4 Quality assurance in design documentation

1.4.1 Structural design objectives

a) Structural design shall conform to a high level of technical competence and shall be based on proven methods, materials and technology. All structures shall be designed in accordance with good engineering practice, relevant codes and incorporate safety in design principles. All structures must have an attractive appearance appropriate to their general surroundings and any adjacent structures. The design shall be practical and cost-effective to construct and maintain.

b) All bridges and other structures shall be:

- Designed and/or supervised by a structural engineer who is a Registered Professional Engineer of Queensland (RPEQ).
- Design-checked by an Engineer who is an RPEQ or supervised by an RPEQ. The engineer who undertakes the check shall be different to the designer, and shall do independent calculations.

- In all instances the design-checker shall be nominated from a team that is not involved in the design.

Depending on the complexity of the design, the design-checker may be either:

a) from the same office of the same firm

b) from a different office of the same firm

c) from a different firm or as defined in the Design Brief.

The design-checker must be nominated not later than at the 50% substantial completion stage and be approved by the Deputy Chief Engineer (Structures).

1.4.2 Conforming product, alternative product and innovation

a) "Conforming" materials and products are all materials and products detailed in the department's Standard Specifications, as amended by this design brief. Any other material or product is deemed to be "non-conforming" and shall only be used on bridges with the prior written permission of Deputy Chief Engineer (Structures).

b) Transport and Main Roads recognizes the need for innovation in design, material and products. An innovative product shall be equivalent to or exceed existing design, materials or products in all aspects of performance and be robust, that is, able to withstand normal and accidental loads in use without significant damage, and durable when exposed to the environment with an appropriate service life.

c) Innovations in structural design shall only be adopted for construction after appropriate testing and validation, and acceptance for safety, durability, future performance, constructability and maintenance by the department. It is suggested innovation is best undertaken outside a Contract. Experience has shown that acceptance of innovative design, material and products may take up to three years and involve extensive testing and development of specifications.

d) Transport and Main Roads specifications are conscious decisions of the department's structural engineers to provide long service life and minimum whole of life cost.

1.4.3 Review of drawings and scheme documents

a) Minimum scheme documents shall be Design Report, Supplementary Specifications and MRTS Annexures.

b) The drawings and scheme documents shall be reviewed and accepted for safety, durability, future performance, constructability and maintenance by the department's Structures Section.

c) Drawings shall be submitted at preliminary design (15%), 50% substantial completion (unchecked drawings), 85% complete (checked drawings) and for final acceptance.

d) The preliminary design submission (15%) shall involve a meeting and presentation of drawings. The drawings shall include all typical project details. The design shall not proceed until all issues are resolved.

e) Transport and Main Roads will provide comments that the designer must consider, and these shall be included in the design. If any comments are not acceptable to the designer, reasons shall be discussed with the department. A final position shall be reached, and the final version shall be subject to acceptance by the department before being adopted.

1.5 Bridge design report

1.5.1 Phases of report

a) A design report shall contain the following information, and shall be delivered at appropriate stages in the design development without unnecessary delay.

b) The first four phases are intended to manage information transfer, change requests and relevant acceptances. Hence they shall be as concise as possible, and the issues requiring resolution shall be suitably highlighted.

c) Where practical, bridge information shall be conveyed by drawings and sketches in preference to text.

d) Design non-conformances submitted for acceptance shall be suitably tabulated.

e) The design report shall be accompanied by the department's commissioning letter or design brief, including attachments. Subsequent design phase reports shall specifically note any of the conditions in the SWTC which are not being met, or changes requested.

1.5.2 Fixing report – bridge location determined

The fixing report is issued when sufficient information has been gathered and the exact location of the bridge can be determined in relation to the road geometry, waterway analysis, required clearances and any other restraints. In general, the bridge spans will be determined at this stage.

General arrangement drawings of the bridge shall be provided with the fixing report.

1.5.3 15% complete design report

a) At the 15% complete stage, all preliminary investigations have been completed, including structural design, hydraulics, geotechnical investigations, clearances and other requirements of relevant authorities. The spans, articulation, substructure and superstructure type have been selected, as have preliminary founding levels. Traffic barrier performance level, drainage, lighting and other service requirements have been agreed.

b) Departures from the department's Design Brief, SWTC and departmental specifications shall be listed in the design report for Transport and Main Roads review.

c) The general details shall be shown on draft drawings that include:

- general arrangement
- exposure classifications, concrete cover and concrete grade for each element
- abutment and pier drawings, and
- a superstructure cross-section.

d) It is expected that the major design parameters will not change during detailed design and drafting.

e) If major changes are subsequently made, a supplementary report shall be sent to Transport and Main Roads as soon as practical.

1.5.4 50% complete design report

50% complete stage design report shall be submitted for Transport and Main Roads review. This report shall include minimum of:

- Proposed design changes if any from 15% design submission
- Geotechnical and hydraulic report
- Durability report including thermal modelling results and recommendations if applicable
- Safety in design report.

50% detail design drawings shall be included.

1.5.5 85% complete design report

a) At the 85% complete stage, the design is effectively complete and a complete set of draft scheme documents and drawings shall be available for review by the department.

b) The Design Report shall highlight any non-conformance to the Design Brief, SWTC or any subsequent agreements or instructions issued subsequent to earlier design reports.

1.5.6 Final design report

a) The Final Design Report shall contain all the previous stage reports including final drawings, cost estimates, steel schedules, Electronic Project Model (EPM) and all the archival material required, as set out in the department's bridge design report template.

b) It lists all requests for changes to the Design Specifications, and a tabulation of the Matters for Resolution.

c) The final report contains all relevant information and shall highlight any non-standard construction materials, components or methods requiring action by the Construction Contractor, or by subsequent asset management processes (inspection and maintenance).

d) The design report shall include:

- Design code including date of publications and (any) amendments
- Date of referenced Transport and Main Roads Design Criteria for Bridges and Other Structures
- Statement for each item in Matters for Resolution by Authority, AS 5100.1 Appendix A
- A statement of design loads outlined in Clause 1.2 of AS 5100.2
- A statement to confirm the design model and analysis approach used
- Calculation of the barrier design loads – AS 5100.1 Appendix B – adjusted for minimum value specified by the department if applicable
- Other referenced documents
- Design criteria from other stakeholders/authorities
- The design methodology, durability, serviceability and ultimate loads
- Statement of design life of the bridge and each sub-element
- Other controls/limits/restrictions (for example shipping clearance, traffic clearance
- Construction methodology (for example T Girders composite at 100 days)
- Durability
- Robustness of design

- "Safety in design" considerations for construction, inspection, maintenance and operation. (Refer Clause 3.13)
- Design data for input into Bridge Information System
- Inspection and Maintenance Manual.

The report shall demonstrate conformance to the design brief. Any proposed variations from the design brief shall be discussed in terms of safety, durability, future performance, constructability and maintenance. Variations shall be submitted for acceptance by Transport and Main Roads Deputy Chief Engineer (Structures).

After approval, the variations may be incorporated into the design. All approved design variations shall be documented in the Design Report.

The final Design Report shall be submitted as part of the final scheme submission for Transport and Main Roads approval. For Alliance/ECI/Design and Construct type projects, the Design Report shall be approved by the Department prior to construction commencing.

1.6 Design certification

a) A geotechnical design report, certified by an RPEQ Geotechnical Assessor, shall be included in the Final Design Report for each bridge.

b) A structural design report, certified by an RPEQ Structural Engineer, shall be included in the Final Design Report for each bridge.

c) Design Certification is required for each retaining structure.

1.7 Innovative materials and components

Preparation of Inspection and Maintenance Procedures for innovative materials and component shall be as follows.

a) The designer shall assess all materials, coatings and components of the design to ensure they conform to the standard materials and procedures for in-service inspection and maintenance in the department's Bridge Inspection and Maintenance Manuals.

b) Novel and innovative designs, not covered by the standard inspection and maintenance procedures, shall have relevant procedures and information prepared and submitted with the final design report.

c) Where a procedure is required, it shall include the following details:

   - Inspection frequency, based on the risks which develop as the material/component degrades over time
   - Any special provisions for inspection access
   - Any tools, equipment, measurements, test procedures needed to assess the material/component insitu
   - Method of repair or replacement of a component and any diagrams necessary for safe working
   - Any routine maintenance required including cleaning, recoating, and so on

- A practical method of inspection and replacement for any bridge with bearings, with jacking points and loads shown on the drawings
- A detailed schedule for cleaning, preparation and recoating for any bridge with paint or similar protective coating. Repainting must be practical without significant interruption to traffic flow.

1.8 Construction handover documentation – bridges

a) Bridge construction handover documentation shall include:

- RPEQ certified "As constructed" drawings signed and dated by the Administrator
- RPEQ certification of all design changes
- Handover Report – Bridges.

b) The Contractor or Alliance shall provide "As constructed plans" stamped, certified and dated by an RPEQ engineer experienced in the relevant engineering disciplines of geotechnical, structural, civil, electrical, and so on. Where bridge schemes are constructed in accordance with the original drawings and specifications, the Contractor shall provide the original documents, stamped, certified and dated by the RPEQ engineer as confirmation.

1.8.1 "As constructed" drawings

a) "As constructed" drawings shall be certified by an RPEQ.

b) An RPEQ shall certify all design changes and include in "As constructed" drawings.

c) The Administrator must have documentation to prove "As constructed" details are true and correct, and shall sign the plans accordingly.

d) "As constructed" drawings shall contain but not be limited to the inclusions listed in Table 1.8.1.

Table 1.8.1 – "As constructed" drawings inclusions

Category	Details
Scour monitoring	• Bed levels at the time of original survey (including date of survey) and at the end of construction.
Actual foundation details	• Spread footing Ht • Cast-in-place pile founding level and length of socket • Pile bell details • Pile founding height • Pile splice Ht and details (where required) • Pile driving sets (last 25 mm) and hammer details • Pile liner toe Ht • Anchor toe Ht and details • Variation in level between design founding level and "as constructed" level shall be certified as meeting the design intent for load transfer, embedment and scour by RPEQ.

Category	Details
RPEQ certified variation/ modifications	• Reinforcement changes • Dimensional changes • Pre-stressing or post-tensioning changes • Backfill profile and materials used.
Works constructed outside tolerances (e.g. NCR table)	• Pile cap/pile head relationship (i.e. edge clearance) • Headstock/pile head relationship (i.e. edge clearance) • Headstock/bearing pedestal/bearing relationship • Earthworks profile • Abutment protection/toe wall, and • Associated Non Conformance Report (NCR) numbers.
Service /PUP locations	Show all services
Expansion joints and bearings	Installation details for expansion joints and bearings, including ambient temperature and dimensions (including joint widths at time of installation).

1.9 Construction handover report – bridges

The Construction Handover Report shall contain but not be limited to the inclusions listed in Table 1.9.

Table 1.9 - Construction handover report inclusions

Category	Elements	Details
Reports	Bridge Design Report	• As detailed in Clause 1.5 • Updated with construction information.
Asset Management	Bridge Information System records	• Structure and Design Inventory Verification Forms • Level 2 (and Level 3 if required) Inspection Records undertaken by the department's accredited inspector.
Quality Assurance(QA) system	Defects and lot diagrams	• Defect and Treatment log (NCRs) • Lot number diagrams.
Construction records for future maintenance and durability assessments	Details of proprietary bridge products	Manufacturer's name and model number (where appropriate) for all manufactured components, including (but not limited to): • Deck expansion joints • Bearings • Bridge rail pedestrian balustrade.

Category	Elements	Details
	Casting yard records	• Concrete test records • Concrete mix designs • Stressing records.
	Steel fabrication records	• Include material certificates and QA records. Provide fabrication inspection reports showing all product has been fabricated in accordance with MRTS78 and all hold points have been released by the Administrator.
	Cast-in-place piles capacity	• RPEQ Certification by a qualified Geotechnical Assessor for socket load carrying capacity of every cast-in-place pile.
	Waterproofing system	• Details of materials used
	Test results and construction records	• Testing certificates (including proprietary supplier testing results)Pile driving records, Pile Driving Analysis (PDA) reports and Case Pile Wave Analysis Program (CAPWAP) analysis Concrete test results (including a summary in electronic format)Post-tensioning and stressing records • Audit certificates • Annexures from specifications and technical standards • Shop drawings of all manufactured components (where available).
Learnings	System improvements	• Suggested specification or detail changes, or any problems encountered with current standards or details.

2 Bridge aesthetics

2.1 General

a) All structures must present smooth, clean lines and bridges shall have a minimum structural depth consistent with their spans and method of construction.

b) The design of bridges shall address the slenderness aspects of the structure and consider the effects of the parapets and all other elements of the structure in the determination of the apparent visual slenderness. Dominant horizontal lines shall be smooth and continuous.

c) Bridge proportions shall represent spanning and supporting requirements, and shall respond to the context of the individual bridge localities.

d) Length of spans shall be maximised where practical, within the context of the necessary bridge length.

e) Bridge structural elements such as piers, headstocks (including leading edges), sill beams and abutments shall be aesthetically integrated.

f) The bridge deck, kerb and barriers shall extend beyond the deck units by a minimum of 100 mm with 19 x 19 mm triangular drip groove to prevent water staining of the units and for aesthetics.

g) Columns with only two lines of symmetry (that is rectangular or elliptical) must have the longest edge transverse to the deck structure.

h) All superstructure elements must follow design vertical and horizontal profiles.

i) Spill-through abutments shall have a batter slope no steeper than 1:1.5.

j) On all exposed concrete surfaces on structures:

- the finishes and colour must be uniform
- tie holes must be aligned in a uniform pattern, and subsequently filled with mortar to achieve a smooth uniform coloured finish.

k) All structures must be of uniform colour and surface finish. Repair of defects and patching must match the appearance of the remainder of the surface.

l) RMS's Bridge Aesthetics: Design Guidelines to Improve the Appearance of Bridges in NSW shall be used as a guide to the basic minimum aesthetics standards.

2.2 Anti-graffiti coating

a) With the exception of rural areas, the accessible surfaces of all structures, noise-attenuating structures, walls, barriers, doors, louvers and other features must be treated with non-sacrificial anti-graffiti coating in accordance with the following requirements. Anti-graffiti coating shall not be applied on galvanised steelworks:

i. The anti-graffiti coatings must match the adjacent surface, and the colour appearance of the structure must not be altered by the application of the coating.

ii. Treatment of the surfaces must be to a minimum height of 3 m above the surrounding reinstated ground levels or any accessible footholds.

iii. Where part of an element of a structure requires treatment on the basis of the height criteria in sub-section (ii) above, then the whole element must be treated.

iv. To protect surfaces prior to applying the permanent anti-graffiti coating, the Designer and Contractor may use a sacrificial coating, provided that it in no way interferes with the adhesion of the permanent coating.

b) The design of all structures, tunnel linings, noise-attenuating structures, walls, barriers, doors, louvers and other features must consider and address the aesthetic impact of anti-graffiti coatings on the element, the structure and the family of structures.

c) Subject to Transport and Main Roads region requirements, it is acceptable to use water based paint to conceal graffiti. However, the paint shall match the colour of the adjacent surface, and appearance of the structure must not be altered by the application of the coating.

3 Bridge functional requirements

3.1 *Traffic capacity*

3.1.1 Number of lanes

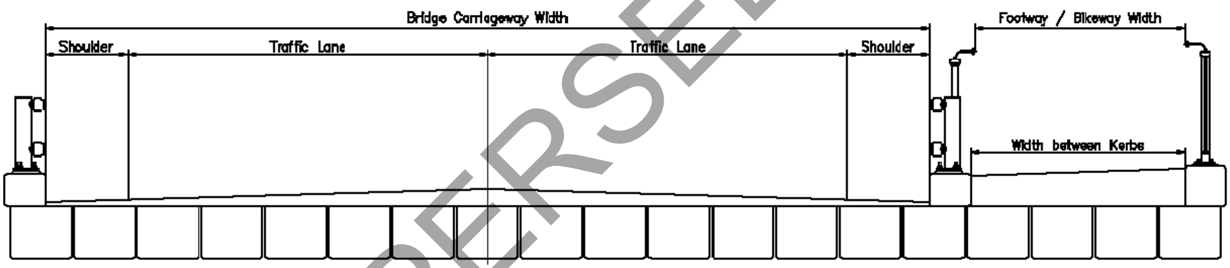
a) In general, the bridge will have the same number of lanes as the adjacent roadway. Bridges near intersections, or forming part of interchanges, may require additional lanes to achieve safe design weaving lengths for adjacent entry and exit lanes.

b) The lane layout shall be determined by the Road Designer prior to bridge design commencing, and the required lane geometry shall form part of the Bridge Design Brief.

c) Where future widening of a bridge is planned, and construction of the additional lanes will be expensive due to high traffic volumes on the associated roadways, the original design shall consider whether the widened bridge would be more economically and safely built in the first stage. The allowance for future widening may include substructure alone (ready for superstructure erection at a future date) or the complete structure.

d) For minimum bridge carriageway widths – refer to Table 3.1.1.

Table 3.1.1 - Minimum bridge carriageway widths



BRIDGE FOOTWAY / BIKEWAY WIDTHS

Footway Type	Minimum Footway / Bikeway Width	Notes
Pedestrian Only	**1.800**	1 The above widths are minimum widths and local factors are to be considered, for example close locality to schools, recreation facilities and important bus stops and so on.
One Way Cycling Only (Separate Bikeway)	**2.000**	2 The widths are clear widths between bridge barriers.
Two Way Cycling Only (Separate Bikeway)	**3.000**	3 Bicycle safety rails are only required on designated bikeways.
Cycling and Pedestrians (Dual Use)	**3.000**	

MINIMUM BRIDGE CARRIAGEWAY WIDTHS FOR FREEWAYS AND MOTORWAYS

Carriageway Type	Length (m)	AADT	Shoulder (minimum)	Traffic lane	Traffic lane	Shoulder (minimum)	Minimum Bridge Carriageway Width (Concrete Deck)	Minimum Bridge Carriageway Width (Deck Units with Cast Insitu Kerbs)
One Way, Multiple Lane	≤ 50	Any	Same as adjacent roadway	3.500	3.500	Same as adjacent roadway	**Dependant on number of traffic lanes**	**Dependant on number of traffic lanes**
	>50	Any	2.000	3.500	3.500	1.200	**Dependant on number of traffic lanes**	**Dependant on number of traffic lanes**
One Way, Two Lane Ramp (Single Lane at Nose)	Any	Any	1.000	3.500	3.500	1.000	**9.000**	**9.200**
One Way, Single Lane Ramp	Any	Any	2.000	4.000		1.000	**7.000**	**7.360**

MINIMUM BRIDGE CARRIAGEWAY WIDTHS FOR NATIONAL NETWORK & STATE STRATEGIC ROADS

Carriageway Type	Length (m)	AADT	Shoulder (minimum)	Traffic lane	Traffic lane	Shoulder (minimum)	Minumum Bridge Carriageway Width (Concrete Deck)	Minimum Bridge Carriageway Width (Deck Units with Cast Insitu Kerbs)
One Way, Two Lane	Any	Any	2.000	3.500	3.500	1.000	**10.000**	**10.400**
Two Way, Two Lane	≤ 20	< 3000	1.500	3.500	3.500	1.500	**10.000**	**10.400**
		3000-5000	2.000	3.500	3.500	2.000	**11.000**	**11.000**
		> 5000	2.500	3.500	3.500	2.500	**12.000**	**12.200**
	> 20	< 3000	1.100	3.500	3.500	1.100	**9.200**	**9.200**
		3000-5000	1.100	3.500	3.500	1.100	**9.200**	**9.200**
		> 5000	1.200	3.500	3.500	1.200	**9.400**	**9.800**

MINIMUM BRIDGE CARRIAGEWAY WIDTHS FOR OTHER ROADS

Carriageway Type	Length (m)	AADT	Shoulder (minimum)	Traffic lane	Traffic lane	Shoulder (minimum)	Minimum Bridge Carriageway Width (Concrete Deck)	Minimum Bridge Carriageway Width (Deck Units with Cast Insitu Kerbs)
One Way, Two Lane	≤ 20	Any	2.000	3.500	3.500	1.000	**10.000**	**10.400**
	> 20		1.000	3.500	3.500	1.000	**9.000**	**9.200**
Two Way, Two Lane	Any	< 1000	0.800-1.050	3.250-3.500	3.250-3.500	0.800-1.050	**8.600**	**8.600**
	≤ 20	1000-3000	1.100-1.350	3.250-3.500	3.250-3.500	1.100-1.350	**9.200**	**9.200**
		3001-5000	2.000	3.500	3.500	2.000	**11.000**	**11.000**
		> 5000	2.500	3.500	3.500	2.500	**12.000**	**12.200**
	> 20	1000-3000	0.800-1.000	3.250-3.500	3.250-3.500	0.800-1.000	**8.600**	**8.600**
		3001-5000	1.100	3.500	3.500	1.100	**9.200**	**9.200**
		> 5000	1.200	3.500	3.500	1.200	**9.400**	**9.800**

MINIMUM BRIDGE CARRIAGEWAY WIDTHS FOR SINGLE LANE RURAL BRIDGES

Carriageway Type	Length (m)	AADT	Shoulder (minimum)	Traffic lane	Shoulder (minimum)	Minumum Bridge Carriageway Width (Concrete Deck)	Minimum Bridge Carriageway Width (Deck Units with Cast Insitu Kerbs)
Single Lane	Any	Any	0.700	3.500	0.700	**4.900**	**4.900**

* AADT: Average Annual Daily Traffic

3.1.2 Clearances and shoulder width

3.1.2.1 Long bridges

a) The design shall include an assessment of the width required for safe inspection and maintenance activities while maintaining traffic flow at reduced speed.

b) Expanding on the requirements in Clause 7.10 Bridges and Clearances of the *Road Planning and Design Manual*, the width of all bridges, including long bridges, shall be increased to include:

- bicycle lanes where they are required on the approach roads, or
- adequate safety for cyclists where they are expected to ride on the shoulders of the approach roads.

c) The designer's attention is also drawn to the *Road Planning and Design Manual* regarding stopping sight distances.

3.1.2.2 Spans for overbridges

a) A bridge spanning a major roadway shall provide full clearance and shoulder widths on the road beneath. Allowance for the longitudinal drainage, services and maintenance operations shall be considered and provided where necessary.

b) Allowance for future widening of the road beneath shall be included if this is planned or likely in the next 100 years.

3.1.2.3 Clearances in design brief

The design brief should specify clearances. If not, the designer must consult with Transport and Main Roads prior to commencing detailed design.

3.1.2.4 Height clearances for bridges over roads

a) The minimum vertical clearances for bridges over roads are specified in Table 3.1.2.4.

Table 3.1.2.4 - Minimum vertical clearances for bridges over roads

Description of road beneath bridge	Preferred minimum	Absolute minimum
Very High Clearance Routes (where no suitable convenient alternative is available)	6.5 m [1, 2]	6.0 m [3]
Highways and Motorways	6.0 m [2]	5.5 m [2,3]
Declared Roads	5.5 m [2]	5.5 m [2]
Other Arterial and Main Roads	5.5 m [2]	5.5 m [2]
Other Local Authority Roads	5.3 m [2]	4.8 m [4]

[1] Generally either 6.5 m clearance or a suitable convenient alternative route (for example via entry and exit ramps or heavy vehicle bypass roads) should be available on the motorways and highways that are the major through freight routes (for example Port of Brisbane, Gateway, Logan and much of the Pacific Motorways, and most highways).

[2] Heights provide 300 mm resurfacing or pavement strengthening to the major road, and 100 mm to "Other Roads".

[3] The absolute minimum vertical clearance for "Very High Clearance Route" and "Highways and Motorways" has no allowances for overlays. It should only be adopted where a pavement with a long design life has been used. For example HILI (High Intervention, Low Intensity) pavements, pavements with a 40 years design life.

[4] Although the legal height of livestock and vehicle carrying vehicles is 4.6 m, to reduce the risk of accidental impact and damage, the minimum clearance required is 4.8 m.

b) The minimum clearance for footbridges over declared main roads is 6.5 m. For footbridges over local authority roads, the clearance shall conform to the local authority requirement, subject to departmental acceptance of these values. Footbridges must have 1 m greater clearance than any adjacent road bridge structures on the road link.

c) For the existing bridges with a height clearance less than in Table 3.1.2.4, the existing clearance (as measured on site) is to be maintained. This includes the provision of additional lanes under these bridges.

d) For additional requirements for existing bridges or new bridges to be designed with a height clearance less that in Table 3.1.2.4 with the approval of Transport and Main Roads Director (Bridge and Marine Engineering), refer to Clause 7 Item 44.

e) Any special clearances shall be in accordance with Section 7 (Item S2).

3.1.3 Geometry, design speed

a) Special consideration shall be given to any bridge which does not conform to the design speed of the rest of the road link. Sudden increase in curvature on a bridge or bridge approaches can significantly increase the risk of vehicle roll-over that could result in a vehicle going over the edge of a bridge. If the geometry cannot conform to adjacent speed characteristics (which may be above posted speed limits), then additional warning signage and increased bridge barrier capability must be provided.

b) For bridges on interchanges, the design speed shall not be less than the adjacent through road design speed, less 20 kph. (That is, for a road with a design speed of 120 kph and posted speed limit of 100 kph, an interchange bridge shall have a minimum design speed of 100 kph and a posted speed limit of 80 kph).

c) The designer's attention is also drawn to Stopping Sight Distance requirements.

3.2 Load capacity – freight efficiency

3.2.1 Design loads and construction sequence

The design loads and any construction sequence limitations shall be shown on the drawings and specifications for all bridges in accordance with AS 5100.

3.2.2 Design traffic loads for new bridges

a) The design traffic live loads for new bridges are SM1600, W80, A160 and HLP 400 in accordance with AS 5100. Refer to Section 6 "Additional Requirements to AS 5100 Bridge Code" for specific design requirement for placement of HLP Loads.

b) These design loads apply to all new road bridges and new culverts on declared main roads, except in unusual circumstances that have been accepted in writing by the Deputy Chief Engineer (Structures).

c) These conditions shall also apply to any overbridge across a declared main road which is likely to be travelled by a HLP which cannot fit beneath it and is likely to go across the overbridge.

3.2.3 Design traffic loads for widening/strengthening an existing bridge or culvert

The cost of widening/strengthening should be compared against the cost of a bridge replacement. If a new bridge to current loads is more economic, a new bridge should be constructed.

The design lane excluding HLP shall comply with AS 5100. HLP position shall comply with Clause 6 (Additional requirements to AS 5100 Bridge Code) of this document.

<u>Other loading design parameters shall be as follows</u>:

• Load factor for dead loads and superimposed load	As per AS 5100
• Ultimate load factor for traffic loads (excluding HLP)	2.0
• Ultimate load factor for HLP	As per AS 5100 for speed
• Dynamic load allowance:	
a) for cranes and AB triple, AAB quad, HML semi, at speed	0.4, at speed
b) Vehicles specified in AS 5100	as per AS 5100 at speed
c) Vehicles at crawl	Zero
• Accompanying lane factors	As per AS 5100
• Other parameter	As per AS 5100

3.2.3.1 Design traffic loads for simply support spans of less than 50m

Design traffic loads for simply support spans of less than 50 m shall be as shown in the Table 3.2.3.1. Figure 3.2.3.1 shows the details of 6 axle semi, AB Triple and AAB Quad.

Table 3.2.3.1 - Design traffic loads for simply supported spans of less than 50 m

<table>
<tr><th>Road classification/name</th><th>Design vehicle</th><th>Accompanying vehicle</th></tr>
<tr><td>Any bridge constructed since 2004</td><td colspan="2">SM 1600 and HLP 400 to Transport and Main Roads Bridges and Other Structures Design Criteria, or 48 t or 79.5 t crane plus coexisting vehicle to AS 5100</td></tr>
<tr><td>Any bridge constructed between 1976 and 2004</td><td colspan="2">Design criteria will be the greater of
1. Original design load, or
2. Load specified below.</td></tr>
<tr><td rowspan="2">Minimum for Gateway Arterial, Logan Motorway, Ipswich Motorway, Pacific Motorway (excluding Captain Cook Bridge to Gateway Motorway), Western Corridor, Warrego Highway east of Toowoomba, Bruce Highway, Capricorn Highway, Dawson Highway and all Port Access Roads)</td><td>• Multiple T44's with a 3 m (stationary) or 6 m (moving)** minimum headway between vehicles, located for maximum load effects, or
• HML AB triples T1 road train (4.4 m axle group spacing), or
• HML AAB quad T2 road trains (4.4 m axle group spacing) or,
• 48 t crane in lane at speed, or
• 79.5 t crane in lane at speed.</td><td>• HML AB triples T1 road train (4.4m axle group spacing), or
• HML AAB quad T2 road trains (4.4m axle group spacing)</td></tr>
<tr><td>• HLP 320 (+/- 1.0 m centre of 2 marked lanes) at speed</td><td>For HLP vehicles only, accompanying vehicle only used in other lanes when 3+ design lanes exist.
Half of (HML AB triples T1 road train (4.4m axle group spacing), or HML AAB quad T2 road trains (4.4 m axle group spacing))</td></tr>
<tr><td>Minimum for National Highways, B double routes and Type 1 road train routes (Excluding Gateway Arterial, Logan Motorway, Ipswich Motorway, Pacific Motorway, Western Corridor, Warrego Highway east of Toowoomba, Bruce Highway, Capricorn Highway, Dawson Highway and all Port Access Roads)</td><td>• Multiple T44's with a 3 m (stationary) or 6 m (moving)** minimum headway between vehicles, located for maximum load effects, or
• HML AB triples T1 road train (4.4 m axle group spacing), or
• HML AAB quad T2 road trains (4.4 m axle group spacing) or,
• 48 t crane in lane at speed.
• HLP 280* (+/- 1.0 m centre of 2 marked lanes) at speed</td><td>• HML AB triples T1 road train (4.4 m axle group spacing), or
• HML AAB quad road trains (4.4 m axle group spacing)
For HLP vehicles only, accompanying vehicle only used in other lanes when 3+ design lanes exist.
Half of (HML AB triples T1 road train (4.4 m axle group spacing), or HML AAB quad T2 road trains (4.4 m axle group spacing))</td></tr>
</table>

Road classification/name	Design vehicle	Accompanying vehicle
Minimum for Pacific Motorway (Captain Cook Bridge to Gateway Motorway)	• Multiple T44's with a 3 m (stationary) or 6 m (moving)** minimum headway between vehicles, located for maximum load effects, or • 48 t crane in lane at speed, • 48 t crane at **crawl** on centreline.	Multiple T44's with a 3 m (stationary) or 6 m (moving)** minimum headway between vehicles, located for maximum load effects
Minimum for Type 2 Road train routes and any other road not specified above	• HML AB **triples** T1 road train (4.4 m axle group spacing), or • HML AAB quad T2 road trains (4.4m axle group spacing) or, • 48 t crane **at crawl** on centreline.	Bridges greater than 30 m long HML AAB quad T2 road trains (*4.4 m axle group spacing*) Bridges less than 30 m long **Two** HML semitrailers with a 4 m minimum headway between vehicles, located for maximum load effects.
	• HLP **240*** (+/- 1.0m centre of 2 design lanes) **at crawl**	**Nil**

* Similar geometry to HLP 320 with axle weight proportionally reduced.

** Distance between axles of the leading and following vehicles.

Figure 3.2.3.1 - Details of 6 axle semi, AB triple and AAB quad

- Overall width and tyre patch as per T44 loading from Austroads Bridge Design Code 1992.
- All axles except 6T axle are tandem axles.

3.2.3.2 Design traffic loads for simply supported spans over 50 m and continuous spans

Special criteria apply – refer to Deputy Chief Engineer (Structures) for criteria of each bridge. Design must consider worst effect due to 6 axle semi, AB triple or AAB quad and design vehicles.

Additional criteria:

1. Maximum spacing between axle groups can vary between 4.4 m and 6.0 m for continuous bridges to create the worst load effect.
2. Minimum spacing between following vehicles is 3.0 m for stationary and 6.0 m when moving. Maximum spacing is the dimension to create the worst load effect considering pattern loading of spans.

3.2.3.3 Design traffic loads for local authority bridges and culverts

The load rating of a Local Authority bridge or Local Authority culvert shall be as specified by the Local Authority but not less than H20-S16.

3.2.4 Design traffic loads for damaged bridges

For bridges damaged in service, the damaged section shall be reinstated to the design load existing prior to the vehicle impact. If the bridge is required to be replaced, the new superstructure shall be designed to the criteria for new bridges if possible. If this cannot be obtained, the design loading shall not be less than T44, A14 and HLP 320.

3.2.5 Heavy load platforms

a) Heavy Load Platforms (HLP) represent actual configuration of vehicles that travel on the road network, not design simplifications.

b) On road projects associated with major infrastructure (mines, power stations and so on), there may be a requirement for a heavier HLP in bridge design. Designers shall consult the relevant authorities before detailed design commences. Typically, a heavy load platform can “safely” carry much higher loads (up to 50 tonne/axle) than normally allowed on bridges (25 ton/axle).

3.2.6 Abnormal loads

Any requirements for abnormal loads shall be defined in accordance with Section 7 (Item S2).

3.2.7 Special conditions for footbridges

For the design of a stand alone footbridge, lateral loads (AS 5100.2, Clause 9) are a critical load case. For new structures the minimum lateral load is 500 kN.

For footbridges over waterways and navigable channels, ‘ship’/navigational vessel impact shall be taken into account. AS 5100 does not address ship impact, however, Transport and Main Roads Design Criteria for Bridges and Other Structures covers this issue in Section 7.

3.3 Load capacity – environmental and construction loads

3.3.1 Mining subsidence

a) Mining is one of the most common activities that can have a considerable impact on the design of a bridge. Assessment of mining impacts requires close liaison with the relevant statutory authority and the mining company, if mining has occurred or is already in progress.

b) Maps of designated mine subsidence areas are produced by relevant state authorities. Bridges constructed in those areas must be designed for anticipated ground movements resulting from past and future mining activities.

c) The design parameters for ground movements are usually prepared by the mine subsidence authority using geotechnical models, and include vertical displacement and the orientation and degree of the ground slope. The ground slope results from the transition from the original ground levels to the subsided ground levels. It moves as a 'wave' through an area as mining progresses, and hence differential movements and rotations may occur over the length of the bridge.

d) The need to accommodate mine subsidence movements may require:

- The use of simply supported spans as opposed to continuous spans to accommodate rotations
- Additional fixings or restraints to ensure spans do not move enough to fall off their bearings/supports
- The provision of measures to accommodate movements at abutments by using precast curtain walls to facilitate movements
- The use of bearings that will allow free movement at piers and abutments. For example, the use of guided slide pot bearings with removable side guides will allow movements without damaging the bearing.
- The use of bedding material under spread footings that will allow rotations to occur without damaging the substructure
- Special considerations to remove part of the bridge to accommodate movements. For example, provisions to remove a span on a pedestrian bridge when the ground movements cannot be accommodated by the structure.

e) Detailed procedures of action required in the event of mine subsidence being imminent must be shown on the drawings, together with the design parameters used.

f) Confirmation in writing must be obtained from the mine subsidence authority that parameters used in the design are still appropriate for the actual movements being recorded.

g) The design report must include full details of provisions for mine subsidence and any advice (including the confirmation mentioned above) from the mine subsidence authority.

3.4 Hydraulic investigation, flood loadings and levels

3.4.1 Hydraulic investigation

The hydraulic investigation shall be undertaken by one of the following three options.

<u>Option 1</u>

The consultant must perform a hydraulic study for each bridge including:

a) Serviceability effects of afflux and increased stream velocity on adjacent properties and the stability of the adjacent road embankment – 100 years Average Return Interval (ARI) flood; and

b) Ultimate Limit state of bridges, major drainage structures and major retaining walls – 2 000 years ARI flood.

The study shall be carried out to the requirements of the department's *Hydraulic guidelines for Bridge Design.*

Option 2

The hydraulic investigation report shall be supplied to the consultant.

Option 3

Hydraulics investigation is not required in this project.

3.4.2 Minimum hydraulic forces on bridges

a) The minimum hydraulic force on a bridge pier shall be 75 kN per pier. The minimum stream velocity for calculating hydraulic forces in accordance with AS 5100 shall be 1.5 m/s.

b) Minimum debris depth:

   i. Where flood forces act on superstructure, the depth of debris mat shall be the greater of 3.0 m minimum or the structural depth of the superstructure in elevation (solid) plus 1.5 m.

   ii. Where flood forces act on substructure only, the depth of debris mat shall be 3.0 m minimum.

3.5 Construction loads

3.5.1 Incrementally launched prestressed concrete bridges

When designing incrementally launched prestressed concrete bridges, the standards detailed in Table 3.5.1 must apply during the launching stage:

Table 3.5.1 - Construction loads: prestressed concrete bridge launching

Loading	Criteria
Dead load	As per AS 5100.2
Launching live load	0.5 kPa on all deck surfaces (minimum)
Differential temperature	70% of AS 5100.2 values
Wind Load	70% of AS 5100.2 values, with no launching to be carried out during strong winds.
Differential settlement and construction tolerance allowances between bearing levels	As specified in design (must be monitored and controlled during construction)
Load factors, limit states	As per AS 5100.2

The criteria for other types of incrementally launched bridges shall be subject to written agreement by Transport and Main Roads Deputy Chief Engineer (Structures).

3.6 Construction loads all bridges

The following loads shall apply during construction except for the launching phase of an incrementally launched bridge.

Table 3.6 - Construction loads: all bridges (except launching)

Loading	Criteria
Dead load	As per AS 5100.2
Construction live load	0.5 kPa on all deck surfaces (minimum). The designer can specify a higher value. Small span components such as formwork over Super T Girder voids shall be designed for a minimum of 5 kPa, representing over thickness in concrete while placing.
Differential temperature	90% of AS 5100.2 values
Wind Load	During construction, various elements of the bridge may be more susceptible to wind loads than when the bridge is completed. The return interval for the design wind during construction shall be determined by the equation: R = 100N where R is the return period and N is the duration of construction in years. The minimum value of N is 2 years.
Differential settlement and construction tolerance limits between bearing levels	As specified by design (must be monitored and controlled) during construction
Load factors, limit states	As per AS 5100.2

3.7 Sustainability

3.7.1 Design life – new bridges

a) All bridgeworks and retaining walls must be designed and detailed to ensure an operational design life of 100 years, without major maintenance requirements. Painting of steel structures is considered normal maintenance. Repainting must not cause significant traffic disruption.

b) Design life for Sub-elements of bridges which are less than 100 years and design life of other related structures are as follows:

- Expansion joints 40 years
- Rubbers in expansion joints 20 years
- Drainage systems(replaceable elements only) 50 years
- Steel bridge traffic barrier, safety screens and fencing 50 years
- Light poles and signs on side of bridge 40 years
- Bearings with provision for simple replacement 40 years
- Bearings with no practical means of replacement 100 years
  (For this application, stainless steel pot bearing is mandatory)
- Noise barriers - refer Transport and Main Roads Standard Specification MRTS15
- Abutment and Pier scour protections 50 years
- Median slabs 50 years

c) The design life shall be interpreted such that there is a 95% probability that during the design life the structure or element:

- will not require major maintenance or replacement of elements
- will be fully functional
- will require minimal maintenance, and
- will blend and harmonise with the existing surrounds and planned landscaping.

3.7.2 Design life for drainage structures

Refer Section 17 for design life for drainage structures

3.7.3 Design life – remedial works

Design life for remedial works shall be approved by Deputy Chief Engineer (Structures) or Director (Bridge and Marine Engineering) prior to the commencement of the design.

3.8 Durability – bridges

3.8.1 Steelwork

All steelwork shall be hot dip galvanised to AS 4680, with a minimum coating in accordance with Table 1 of AS 4680. Material with a silicon and phosphorous content less than the following will need to be whip blasted to create a surface profile prior to galvanising.

%Si < 0.04%

%Si+(2.5x%P) < 0.09%

These requirements shall be included on the drawings.

3.8.2 Fitments material

a) The durability of the materials used for fitments (includes anchor bolts, traffic barrier connections, anchorage points, bearing bolts, machine screws and so on) must be considered in light of the exposure conditions. In marine conditions, the use of stainless steel fitments will reduce long-term maintenance costs and offset higher initial costs. The cost of replacement may be disproportionately high compared to the extra cost of the more durable material.

b) Fitments shall be hot dipped galvanised cast-in ferrules or sockets, however stainless steel cast-in ferrules or sockets shall be used in marine or corrosive environments.

3.8.3 Painted steel structures

3.8.3.1 General

a) Painting as the primary corrosion protection will only be accepted when hot dip galvanising is not practical or cost-effective.

b) Paint systems shall be selected on the basis of the longest practical service life before recoating. Recoating in the field must be practical, without the need to grit blast to remove the original paint if sound.

c) Structures over roadways shall be detailed with appropriate access platforms, and so on, which will allow easy inspection and repainting, and clearances shall be provided so that traffic is not significantly interrupted during repainting. Access must be practical during daylight hours.

d) Surface coatings require the analysis of whole-of-life costing for inspection and repainting, and the cost of road closures necessary for painting shall be included. Night closures must consider dew point temperatures and paint sensitivity to moisture.

e) Duplex coatings may be required to achieve the design life and reduce/remove the need for repainting.

f) Prior approval shall be obtained from Deputy Chief Engineer (Structures) for the painting system.

3.8.3.2 Protective coatings – assumed life for costing analysis

a) Galvanising and proper careful detailing can give a 'maintenance free' life of 50 to 70 years. At that stage, once the galvanising has weathered away, painting will be required.

b) Shop painting and proper careful detailing shall give a life to first repaint of up to 30 years. Field-applied coatings, if done before full breakdown of initial paint system, may be assumed to last up to 15 years.

3.8.3.3 Detailing for durability

When detailing a structure to be painted for durability:

a) Avoid bolts and nuts wherever possible (always early corrosion starters), use welding wherever practical. All edges shall have a minimum radius of 2 mm. These requirements shall be included on the engineering drawings.

b) Welding shall be smooth or ground smooth, and all splatter shall be removed before painting.

c) Sharp re-entrant angles shall be avoided. All surfaces must be accessible to inspect, clean, sand back or other preparation, and repaint. Large surfaces meeting at angles of less than 45° are a future maintenance problem.

d) Rain shall wash all surfaces clean. Places where water and dust/mud can collect and accumulate must be eliminated by careful detailing.

e) Judicious use shall be made of non-corroding material, for example stainless steel bolts, bearings and other details.

3.8.4 Durability for concrete

3.8.4.1 Components with 100 year design life

a) For road bridges and footbridges with 100 year design life, exposure classification shall be determined in accordance with AS 5100.5. The minimum exposure classification shall be B2 to AS 5100.5, except for reinforced concrete decks in remote areas where the appropriate concrete strength shall be selected after discussions with the region and potential suppliers.

b) In addition to (a) above, Table 3.8.4(a) for brackish saltwater and marine applications and Table 3.8.4(b) for Potential Acid Sulphate Soil (PASS) and/or Acid Sulphate Soil (ASS) environments shall also be met.

Table 3.8.4(a) - Concrete exposure classifications for components in brackish, saltwater and marine applications

Location	Chloride content of water	Exposure classification
Brackish water permanently submerged or zones subject to repeated wetting or drying	2000 ppm to 8000 ppm	B2
Permanently submerged in marine or saltwater	Above 8000 ppm	C
Spray zones in marine or saltwater	Above 8000 ppm	C
Tidal splash zones or zones subject to repeated wetting and drying in marine or saltwater	Above 8000 ppm	C2

Notes:

1. Tidal Splash Zone is the zone 1.0 m below Lowest Astronomical Tide (LAT) to 1.0 m above Highest Astronomical Tide (HAT)
2. Spray Zone is the zone from 1.0 m above HAT where the structure is exposed to permanently to salt spray or built over the sea.
3. Soffits of bridges and other structures which are in occasional contact with saltwater shall be exposure classification C

Table 3.8.4(b) - Concrete exposure classifications for concrete elements in PASS/ASS

SO4 in groundwater (mg/l or ppm)	Acidity (pH)			
	< 3.5	≥ 3.5 to < 4.5	≥ 4.5 to < 5.5	≥ 5.5
< 1500	C2	C1	C	B2
≥ 1500 to < 3000	C2	C1	C	B2
≥ 3000 to < 6000	C2	C2	C	B2
≥ 6000	C2	C2	C2	C

Note:

1. Full isolation of the concrete surface exposed to the environment by either protective coating, membrane or use of controlled backfill is also required for exposure classification C2.

c) Cover to reinforcement shall be as defined in AS 5100.5 except for the following exceptions:

- For exposure classification C2 in salt water or marine applications as defined in Table 3.8.4 (a) – 70 mm with rigid forms and intense vibration.
- For exposure Classifications C, C1 and C2 for PASS/ASS as per exposure classification C in AS 5100.5
- For driven prestressed concrete piles, minimum cover to reinforcement shall be 50 mm for exposure classification B2 to AS 5100. For all exposure class C applications including C, C1 and C2 the minimum cover shall be 70 mm with rigid formworks and intense vibration.

d) Structural design for control of cracking shall be carried out, taking into consideration the exposure classification of AS 5100.5 Clause 4.3 and the minimum area of reinforcement in tensile zones according to AS 5100.5 Clause 8.6.

e) Cast in place piles shall have permanent steel liners, and concrete shall be placed in the dry, where possible, and properly compacted. In marine or tidal applications, steel liners shall extend to a level 2.0 m below Highest Astronomical Tide (HAT).

f) Bridge deck shall be waterproofed in accordance with MRTS84.

g) The requirement of proprietary high performance waterproofing membrane for special circumstances listed below shall be identified during the concept design stage to enable sufficient time for product evaluation. Such evaluation shall be undertaken outside a contractual situation.

If a requirement of proprietary high performance waterproofing membrane has been identified at the concept design stage, the proposal to use such system shall be informed in writing to the Director (Bridge and Marine Engineering) for review and acceptance.

The examples of special circumstances where proprietary high performance waterproofing membrane system shall be required are listed below:

- Transversely stressed deck unit bridges
- Rehabilitation of transversely stressed deck unit bridges
- Where bridge decks are suffering from high Alkali reactivity
- Rehabilitation of decks where the deck reinforcing steel has been damaged or exposed
- Bridge decks in salt spray susceptible areas.

h) Rail bridges shall conform to the rail authority requirements.

3.8.4.2 Components with 50 year design life

Exposures classifications and cover to reinforcement for components with a 50 year design life shall be as defined in AS 3600. The minimum exposure classification shall be A2.

3.8.4.3 Additional requirements to MRTS70

Concrete shall be to MRTS70 Concrete. In addition to the requirements of MRTS70, following shall apply:

a) Minimum 28 days characteristic concrete strength and maximum aggregate size for relevant exposure classification shall be as follows.

- For exposure classification A2 and B1 to AS 3600, S32 to MRTS70
- For exposure classification B2 to AS 3600 and AS 5100, S40 to MRTS70
- For exposure classification C, C1, C2 and U (marine, tidal, saltwater or PASS/ASS conditions) to both AS 3600, AS 5100 and this Standard, 50 MPa to MRTS70.

The maximum aggregate size shall be 20 mm unless shown otherwise on the Drawings.

b) Concrete for exposure classifications A2, B1 and B2 to AS 3600 and B2 to AS 5100 the following additional requirements for S32, S40 and S50 concrete mixes shall be met.

- Minimum total cementitious content and maximum water cementitious ratio to be as per MRTS70.

- Cementitious material to be a blend compliant with either of the following criteria with the combined total adding to 100%. Blend tolerances to be as per AS 1379:
  - 65% to 75% GP cement, 25% to 35% fly ash, or
  - 50% to 55% GP cement, 20% to 25% ground granulated blast furnace Slag, and 25% to 30% fly ash, or
  - 65% to 71% GP cement, 4% to 8% amorphous silica, and 25% to 31% fly ash

Maximum chloride ion content of hardened concrete to be 0.8 kg/m³.

c) Concrete for aggressive environments of exposure classifications C1, C2 to AS 3600 and C, C1, C2 to AS 5100 following additional requirements for S50 concrete mixes shall be met.

- Maximum chloride ion content of hardened concrete to be 0.4 kg/m³.
- Minimum total cementitious content and maximum water cementitious ratio for C exposure classifications to be as per MRTS70. For C1 and C2 exposure classifications minimum total cementitious content to be 500 kg/m³ and maximum water cementitious ratio to be 0.4.
- Cementitious material to be a blend compliant with either of the following criteria with the combined total adding to 100%. Blend tolerances to be as per AS 1379:
  - 50% to 55% GP cement, 20% to 25% ground granulated blast furnace slag, and 25% to 30 % fly ash, or
  - 65% to 70 5 GP cement, 4% to 8% amorphous silica, and 25% to 30% fly ash.

3.9 Buried components (no inspection, maintenance practical)

Currently there are no additional requirements for durability of Buried Components however this will be a requirement in the future.

3.10 Aggressive environments

3.10.1 Sulphate reducing bacteria

a) Different types of sulphate reducing bacteria (SRB) are located in many environments. The SRB most critical to steel bridge substructures are located in the rocks and soils of tropical Australia and Asia. The bacteria produce acid that attacks steel in the tidal range and within the soil, depending on the structural arrangement. The collapse of the Adelaide River Bridge in the Northern Territory has been attributed to sulphate reducing bacteria, which corroded steel piles at the mud line under water.

b) The Austroads Bridge Technical Review Panel is currently investigating SRB and is preparing technical advice on the subject.

c) Steel H piles are not normally permitted for bridge foundations. However, in dry western areas of Queensland, steel piles may be permitted in overflow bridges (not the main channel) where there is no permanent water and the ground is too hard for driven prestressed concrete piles. The use of steel piles must be accepted by Deputy Chief Engineer (Structures). Acceptance will be based on safety, constructability (hard driving conditions), maintenance, coatings and durability. Steel liners of cast-in-place piles are considered as temporary form work with no long-term structural capacity.

d) The use of temporary steel piles for structural capacity is permitted for a maximum of five years.

3.10.2 Stray currents from electric railway or other sources

Bridges carrying electric railway or in close vicinity to an electric railway, shall be protected from stray current using a system accepted by the department and any related authority (for example rail service provider).

3.10.3 Marine environment

For cast in-situ concrete, in salt water tidal zones or zones subject to repeated wetting or drying salt water (chloride content above 800 ppm), except where stainless steel reinforcement (refer Standard Specification MRTS71A) is used, all bridge components “below a level which is 3 m above high water spring tides” shall have a suitable outer layer of stainless steel reinforcement and an inner layer of carbon steel reinforcement with excess cover. Cover to stainless steel reinforcement shall be provided similar to the carbon steel in accordance with AS 5100.5. A 70 mm minimum clear gap between stainless steel bars and the carbon steel reinforcement shall be maintained. Carbon steel shall have provision for possible future cathodic protection and assessment of all concrete piles, pilecaps, headstocks and piers. This must include providing electrical continuity of all non-stressed and stressed reinforcement, fitments and anchor plates. Anchors for metal items with a large exposed surface area must be electrically isolated from the remaining reinforcement. The electrical continuity must be able to be demonstrated for all concrete piles, pilecaps, headstocks and piers. The electrical continuity shall be tested in accordance with AS 2832.5: Cathodic Protection of Metals-Steel in Concrete Structures. These requirements shall be included on the appropriate drawings.

This clause is not generally applicable to prestressed precast concrete piles or other precast items.

3.10.4 Cracks in concrete at the end of construction

a) In non-aggressive areas, any finished concrete with a crack more than 0.3 mm wide but less than 0.5 mm wide shall be:

- Inspected by the designer (who shall be an RPEQ) who shall certify that the crack is non-structural or structural
- Non-structural cracks shall be injected with epoxy to seal the crack by a means accepted by the department
- Cracks certified as structural shall be referred to Deputy Chief Engineer (Structures) who shall determine whether the crack shall be repaired or the member replaced.
- Concrete elements with cracks greater than 0.5 mm shall be rejected.

b) In aggressive areas, any finished concrete with a crack more than 0.15 mm wide but less than 0.3 mm wide shall be:

i. Inspected by the designer (who shall be an RPEQ) who shall certify that the crack is non-structural or structural

ii. Non-structural cracks shall be injected with epoxy to seal the crack by a means accepted by the Department

iii. Cracks certified as structural shall be referred to Deputy Chief Engineer (Structures) who shall determine whether the crack shall be repaired or the member replaced.

iv. Concrete elements with cracks greater than 0.3 mm shall be rejected.

3.10.5 Thermal cracking in large sections – modelling in design

Any concrete section with a thickness or minimum dimension greater than 1 m shall be thermal modelled by a recognized method to determine thermal gradient and maximum temperature due to heat of hydration. The modelling shall be undertaken by a recognized method. The maximum temperature of the concrete shall not exceed 75°C, and the thermal gradient from centre to surface shall not exceed 25ºC. Thermocouples shall be placed in the structure to monitor the actual temperature. Where the temperature determined by thermal modelling is likely to exceed 75ºC, the designer must submit a proposal for controlling the concrete temperature for Deputy Chief Engineer (Structures) approval.

3.11 Economy

3.11.1 Minimum whole-of-life costs

a) All structures shall be designed for a minimum whole-of-life cost. The minimum whole-of-life cycle cost includes:

i. Initial construction cost

ii. Inspection cost

iii. Routine maintenance

iv. Scheduled maintenance

v. Special maintenance.

b) The concept of building a cheap initial cost with high maintenance cost is not “value for money” and will be rejected.

3.11.2 Design details for economy

The design shall be economically efficient. Economically efficient design shall be achieved by meeting one or more of the parameters such as lowest whole of life cost, lowest operating and maintenance cost, longest life span and so on.

3.11.3 Constructability

The construction process assumed in the design shall be reviewed at the pre-construction phase and reported. This review is to identify obstacles before the project actually commences in an attempt to mitigate or prevent errors, delays, cost overruns and to ensure safety in design.

3.11.4 Maintainability

a) “Safety in design” considerations mean that the designer shall make provision for inspection and maintenance operations as part of the design process.

b) Maintenance shall consider the bridge’s future operating environment. As it is difficult to obtain closures of bridges carrying busy roads and railways, the design shall limit the range of materials to reduce the need for closures.

3.12 Protection against scour

3.12.1 Minimise increase in velocity and afflux

a) In urban areas, the main restraint on hydraulic design is to minimise afflux when this would adversely affect adjacent upstream properties.

b) Where afflux is not a restraint, care shall be taken to ensure velocity increase through the bridge opening is kept to levels consistent with the erosion protection of abutments, stream bed and banks downstream.

3.12.2 Minimise scour at abutments and piers

a) The scour potential at abutments and piers shall be minimised. The design shall take this into account, and design the abutment and pier protection accordingly. The design life for abutment/pier protection in streams subject to scour is 50 years. The design must provide for replacement of the scour protection at the end of its service life or after a flood event.

b) Piers and abutments shall be aligned with the expected flood flow directions. If at bed level, pile caps shall be detailed to provide minimum disturbance to the flow.

c) Scour at abutments and piers shall be designed for the worst velocities for floods with an ARI between one and 100 years, and shall consider situations such as:

- overtopping bridge and embankment
- effects of local catchments and along road drainage
- scour analysis based on actual particle size of bed material and bed shear stress. (In sand, scours to more than 5 m are common.)

3.12.3 Handling drainage from adjacent road

Road-side drains must be designed and detailed to prevent erosion of the approach embankment and abutments. Road drainage must be moved away from the bridge where possible. Steep gradients into the stream must also be avoided where possible, or fully protected with lined channels and energy dissipaters when required.

3.12.4 Scour on drawings

Expected and acceptable levels of scour shall be shown on the design drawings.

3.13 Safety in design, construction and maintenance

Safety in design shall conform to:

1. Workplace Health and Safety Act
2. Workplace Health and Safety Regulations
3. Safe Design of Structures, Code of Practice, July 2012, Safe Works Australia. This Code of Practice is yet to be approved by Queensland but is best practice in the absence of a local Code of Practice.
4. Legislative guide – designer written report for structure (LG-DR1): www.worksafe.qld.gov.au

3.13.1 Safe access to site

a) The design shall address safety in the construction, inspection, maintenance and operation phases.

b) The design shall consider the future requirements for safe access for inspection and maintenance, including areas adjacent to the bridge where staff can safely park and load/unload equipment. This will require the designers of the adjacent roadway to include safe pull-off areas for vehicles.

3.13.2 Safe access for inspections (stairs, ladders, hatches, anchorage points)

a) On major bridges, the design must include the provision of access gantries for future maintenance.

b) On smaller bridges, the installation of support points to support future maintenance activities such as repairing must be provided.

c) Other access requirements include:

- platforms at abutments to allow safe inspection of bearings
- stairways to access locations and on batter slopes to access abutments
- ladders, fixed where this is appropriate, or attachments to stabilise temporary ladders
- hatchways to provide access and prevent unauthorised entry
- anchorage points for inspection scaffold or safety harness.

d) Eyelets shall be cast into the sides of abutment headstocks for attachment of safety lines for inspections and maintenance. Eyelets shall be hot-dipped galvanised, however stainless steel eyelets shall be used in marine or corrosive environments. Eyelets shall be made of 16 mm diameter steel minimum.

3.14 Bridge security (when specified)

Bridge security considerations (where specified) may need to include the following:

- high security access to the inside of box girders and hollow piers (heavy duty galvanised steel (6 mm thick) doors and high security padlock systems)
- considerations of the redundancy of members and in spans
- installation of security cameras
- restricted access to site, typically around abutments.

3.15 Bridges over/in the proximity to railway

a) In addition to AS 5100, bridges over railway shall be designed in accordance with the current versions of:

- MCE-SR-001 Queensland Railways – Requirements for the Design of Road Overbridges
- MCE-SR-002 Queensland Railways – Requirements for Work In and About Property Occupied by QR
- MCE-SR-003 Queensland Railways – Requirements for Work Adjacent to Overhead Line Equipment

- MCE-SR-007 Queensland Railways – Barrier Selection
- MCE-SR-012 Queensland Railways – Protection of Supporting Elements Adjacent to Railway Bridges, and
- QR Standard Drawings.

b) MCE-SR-007 shall be amended as follows:

i. The requirements of the guideline are in addition to AS 5100 and AS 3845.

ii. Where a railway embankment has a vertical retaining wall, a traffic barrier shall be provided, between the wall and the roadway where the height of the retaining wall is in excess of 2 m. The barrier must not impart loads to the wall unless the wall is designed for such loads. Where there is no barrier, the retaining wall shall be designed to withstand vehicle impact in accordance with AS 5100.

iii. Barriers on the edges of elevated retaining walls shall conform to the same criteria as bridges.

iv. Where road and rail bridges are parallel, the rail bridge superstructure could be subject to vehicle impact where it is less than 5 m from the road bridge barrier. In such cases, the bridge barrier shall be designed to prevent vehicle rollover. Consideration shall also be given to a rolling vehicle impacting the bridge substructure.

v. Table 5 in MCE-SR-007 shall be replaced by Table 3.15 which follows:

Table 3.15 - Bridge barrier heights and performance levels

Road Status	**Bridge Barrier Height (m) and Barrier Performance Level to AS 5100**				
1A	2.0 (Special)*	1.5 (Special)*	1.5 (Medium)	1.1 (Medium)	1.5 (Special)
1B	1.5 (Special)*	1.5 (Medium)*	1.1 (Medium)	1.1 (Regular)	1.5 (Medium)
1C	1.5 (Special)	1.5 (Medium)	1.1 (Medium)	1.1 (Regular)	1.5 (Medium)
2A	1.5 (Special)	1.5 (Medium)	1.5 (Medium)	1.1 (Medium)	1.5 (Medium)
2B	1.5 (Special)	1.5 (Medium)	1.1 (Medium)	1.1 (Regular)	1.1 (Medium)
2C	1.5 (Medium)	1.1 (Medium)	1.1 (Regular)	1.1 (Regular)	1.1 (Medium)
3	1.1 (Regular)	1.1 (Regular)	1.1 (Regular)	1.1 (Regular)	1.1 (Regular)
Rail Status	MPE	MC & DG	SP	L	C

Note:

1. (Regular) denotes the barrier is 1100 mm high, measured from the edge of the adjacent road lane pavement level, with a barrier performance level "Regular".
2. Special* is 1000 kN in accordance with Table 6, while Special is 750 kN.

3.16 Special conditions or requirements

Any special conditions, including aesthetics for the bridge design, are detailed in Section 7 (Item S1).

4 Bridge component design requirements

4.1 Foundations design

Geotechnical requirements in foundation design including design methodology, geotechnical investigations, design documentations, pile testing and so on, shall be in accordance with Transport and Main Roads *Geotechnical Design Standards-Minimum Requirements*. In addition to that, requirements stated in this document shall also be met.

4.1.1 Driven piles – structural design

a) Structural design of driven piles shall be carried out in accordance with AS 5100 "Bridge Design".

b) PSC piles shall be designed with concrete strength at transfer greater than or equal to 35 MPa, and less than or equal to 40 MPa.

c) Driven reinforced concrete piles are not permitted, except as part of very long PSC piles where the RC section is buried at least 15 m below ground surface.

d) Driven prestressed concrete piles shall conform to Standard Drawing 1500. Pile splices shall conform to departmental standards. Pile splices shall be located in a low moment zone at depth and are not permitted in Reinforced Soil Structure (RSS) blocks.

e) For abutment piles, displacement restraint and rotational restraint at the pile head must be minimised to reduce the internal pile forces (bending moments, shear forces) induced by lateral soil movement. Down drag (negative skin friction) effects due to settlement on piles must be allowed for in the design of such piles, together with methods to reduce such effects.

f) Lifting points for PSC piles shall be designed and RPEQ certified in accordance with MRTS73 by the designer.

4.1.2 Cast-in-place piles – structural design

4.1.2.1 Cast-in-place piles for traffic bridges

a) The minimum internal diameter of cast-in-place piles for traffic bridge foundations shall be 900 mm for those that do not require a safety shield for inspection and certification, and 1200 mm for all other applications.

b) Some cast-in-place piles require anchoring. Passive anchors (for example, reinforcing bars grouted into holes) are preferred. Active anchors (prestressed ground anchors) are not the recommended option. The preferred method of installing the reinforcing bar in the drilled hole of a passive anchor is for installation prior to placing the concrete.

c) The subsequent drilling of anchors from the surface through the concrete of the pile is NOT permitted because:

- the condition of the drilled hole (for example, clean or full of debris) cannot be determined
- any water ingress may adversely affect the quality of grout

- the integrity of the grout over the length of the pile cannot be guaranteed
- the reinforcing bar cannot be located centrally in the hole unless specialised fitments of proven performance are used.

d) The steel liners shall be ignored in the durability assessment of the concrete piles.

4.1.2.2 Design outputs shown in drawings

The designer shall calculate the following critical design loads for each pile for both serviceability and ultimate load conditions, and these shall be clearly marked on the foundation drawings. For simplicity in construction, the maximum design effects in a pile group may be listed for all piles in the group instead.

- Axial compression
- Axial tension (if applicable)
- Bending moments (in two directions)
- Impact loads or lateral shear forces
- Scour – design assumptions on maximum depth
- Moment fixity in rock if required
- Minimum penetration of the pile into the founding strata.

4.1.2.3 Design foundation levels

The designer shall consider the borelogs and geotechnical report, and shall include on the drawings adequate information to guide the construction supervisors. This shall include:

- Minimum depth/penetration of pile
- Most probable founding level considering scour, axial and moment effects
- The founding layer or strata as described in the borelogs
- The likely geological requirements to achieve required bearing capacity (service and ultimate).

Foundations are to be assessed on site by an RPEQ geotechnical engineer.

4.1.3 Spread footings – structural design

Structural design of spread footings to be in accordance with AS 5100. Where spread footings are used as the abutment foundation, the requirements stated in Clause 4.5.3 shall also be met.

4.2 RSS walls

Refer Section 13: *Retaining Structures for RSS wall design requirements*. Where RSS walls are used as the front face of the bridge abutment, the requirements stated in Clause 4.5 shall also be met.

4.3 Pile types not accepted by Transport and Main Roads

Bored piles (without steel or concrete liners), pile constructed with bentonite or polymer slurry, driven reinforced concrete piles, continuous flight auger piles, precast concrete piles manufactured by spinning or rolling and steel screw piles are not permitted for bridge foundation. Any designer, who believes the use of such piles is cost effective and will achieve the strength and durability required, may prepare a written submission for Deputy Chief Engineer (Structures). Delays in assessing such submissions, and any consequent costs are entirely the responsibilities of the Designer.

4.4 Pier designs

4.4.1 Headstocks

a) The use of inverted "T" headstocks is not a preferred option. The use of "thin" bearing shelves designed as corbels is not permitted.

b) The use of precast headstocks or abutments is not permitted unless the design is as robust and durable as a cast-insitu design and is accepted by the Deputy Chief Engineer (Structures).

4.4.2 Durability

Refer to Section 3.8 for durability of components of the bridge piers.

4.4.3 Pier protection of overbridges from traffic impact

Refer to Section 6 of this document: PART 2: Design Loads: Clause 10.2.

4.5 Abutment designs

4.5.1 Spill-through abutments

4.5.1.1 Batter slope

Spill-through abutments shall have a batter slope no steeper than 1:1.5.

4.5.1.2 Access for inspections (walkways, stairs, ladders, hatches, anchorage points)

a) A 750 mm minimum width shelf shall be incorporated at or near the top of the batter slope to allow access to inspect and maintain bearings.

b) On major bridges, the design shall include the provision of access gantries for the future maintenance. On smaller bridges, the installation of support points to support future maintenance activities shall be considered. Other access requirements include:

- stairways to access locations and on batter slopes
- ladders
- hatchways to provide access and prevent unauthorised entry. Hatchways shall be a minimum width of 750 mm.
- anchorage points for inspection scaffold.

c) Eyelets shall be cast into the sides of abutment headstocks for attachment of safety lines for inspections and maintenance. Eyelets shall be hot dipped galvanised, however marine grade stainless steel eyelets shall be used in marine or corrosive environments.

4.5.1.3 Abutment slope protection

4.5.1.3.1 Abutment protection for widened bridges

The abutment protection of a widened bridge shall be similar in style and materials to the existing bridge, provided the original protection is in reasonable condition. If the existing protection is in poor condition or has failed, a complete new protection shall be provided.

4.5.1.3.2 Abutment protection – all bridges

a) Abutment slope protection shall be provided for all bridges, except where the abutment is founded on a non-friable rock cutting.

b) Abutment slope protection for road overbridges shall be provided at least over the area directly beneath the superstructure, and over sufficient of the embankment sides to prevent erosion and undermining.

c) Abutment height shall be considered in determining the length of a bridge. High abutments result in large retaining structures and embankments with inherent stability issues both in terms of the surcharge load to underlying materials causing risk of excessive settlement, and the consequent long-term structural issues, including rotations and horizontal deflections. Instances have occurred where vertical and horizontal displacements at high abutments in soft soils have resulted in structural distress to the abutment and consequent jamming of expansion joints.

d) The material for the abutment slope protection shall:

- blend in and harmonise with the existing surrounds and proposed landscaping and urban design
- require minimal maintenance over the service life of the bridge
- be structurally stable and resistant to weathering, and
- have a uniform plane surface and suitable neat appearance.

e) The material selection shall be considered in context with the landscape concept and other surrounding elements.

f) Abutment slope protection shall be designed in accordance with the minimum standards of MRTS03.

4.5.1.4 Abutments designed for soil settlement and movement

a) Where the bridge approaches overlie soft compressible layers of soil, the permissible total in service settlement (within the first 40 years in service) shall be in accordance with the Table 1: Settlement Criteria specified in Transport and Main Roads *Geotechnical Design Standards - Minimum Requirements*.

b) Raked piles shall not be used unless a full analysis of long-term ground movements confirm that the abutment pile forces are within safe limits.

4.5.2 Reinforced soil structure (RSS) walled abutments

a) Where RSS walls are used as the front face of the abutment, the designer shall incorporate in the design a primary support system for the abutment headstock (such as PSC or cast- in-place piles) with a design life of at least 100 years.

b) Where the abutment headstocks are designed to be tied back into the RSS block, the designer shall provide supporting information demonstrating that the tie-back straps for the headstock have 100 years design life with the proposed backfill material as required by the RSS supplier's specification.

c) A walkway shall be provided between the abutment headstock and the RSS wall for bridge inspections and maintenance. The RSS wall shall extend a minimum of 1100 mm above the top of the walkway surface to provide protection for users of the walkway. Alternatively a balustrade with a minimum height of 1100 mm shall be provided. The walkway shall have a clear width of 1200 mm between the front of the headstock and the back face of the RSS wall panel or the balustrade. The vertical head clearance shall be 2000 mm minimum between the soffit of the girders or deck units and the top of the walkway.

Both ends of the walkway shall be secured with robust locked gates to prevent unauthorised entry. A path shall be provided at both ends of the walkway connecting the bridge approach to the walkway. Balustrades shall be provided along the path.

The designer shall consider access limitations and the method of providing materials and equipment for bridge maintenance and bridge jacking.

4.5.3 Abutment spread footings

Abutments that are supported on spread footings shall be founded on competent rock *(shall be reviewed by Transport and Main Roads Director (Geotechnical))*, and not on rock or soil that is strengthened by rock/soil anchors or by other means. Abutments shall be founded on piled foundations in the absence of competent rock for spread footings.

4.6 Bearings

Refer Section 3.7.1 for the design life of bearings.

The minimum edge distance between the end of a girder or deck unit and the bearing or support plate shall be 75 mm.

4.6.1 General

Articulation of a widened bridge shall be consistent with the existing bridge articulation.

4.6.1.1 Widened bridges

The bearings on widened bridges shall be similar to the existing type in the bridge. Steel components of pot bearings shall be hot dip galvanised to AS 4680 or stainless steel. Bridge substructures must be designed for load effects of deck jacking to replace bearings.

4.6.1.2 New bridges

The following changes apply to the bearing arrangement for deck unit bridges:

a) All bridges consisting of deck units with insitu deck shall have a bearing under each end of the deck units.

b) For transversely stressed deck units with spans 21 m or greater, each end of the deck unit shall be supported on a suitable bearing.

c) For transversely stressed deck units with spans less than 21 metres, the deck units may be supported on either mortar pads or bearings.

d) All other superstructure types shall be supported on bearings.

e) Where transversely stressed deck unit bridges are designed on skew of 30 degrees or greater, longitudinal shear must be addressed in the design including consideration for shear keys.

4.6.2 Provision for jacking and bearing replacement

a) Bridge superstructures and substructures must be designed to allow for their jacking up in the future to replace bridge bearings. Diaphragms shall be provided at each end of every span for all girder bridges. End diaphragms shall be designed to carry the self weight of the span and emergency vehicles through jacking devices positioned on headstocks. The gaps between bottom of the end diaphragms and top of headstock shall be a minimum of 200 mm (nominal). The location points and the associated maximum jacking loads must be addressed and detailed in the design documentation. The designer shall submit a comprehensive Maintenance Procedure detailing the equipment and the methods to replace the bearings. The jack capacity shall be twice the design working load. Fasteners on bars in shear are not permitted.

b) Bearing pedestals shall be constructed using concrete or accepted proprietary mortars developed specifically for installation of bearings. Bearing pedestals shall be a minimum depth of 150 mm. Bearing pedestals shall be reinforced.

c) Girder bearings shall be on continuous or on discrete pedestals 150 mm deep (nominal). The width of headstocks shall be sufficient to accommodate jacking devices for direct jacking of girders or deck units.

d) All girder bearing pedestals shall be reinforced cast-insitu concrete with a minimum depth of 150 mm and a plan area that provides an edge clearance that ensures bearing forces intersect the vertical reinforcing bars. These shall be cast separately to the bearing shelf. All fasteners shall be anchored within the pedestal rebar grid and any restraint angles must have at least the minimum edge clearance described above. Typically the concrete strength shall be a minimum of 50 MPa, but load effects must be checked. Normally, a 10 mm aggregate would be used to allow a grid of small diameter bars at relatively close centres.

e) The provision of pedestals allows much greater control of line and level and a means of compensating for errors in headstock construction line, level and planarity.

4.6.3 Restraint of elastomeric bearings

Elastomeric bearings shall be in accordance with AS 5100. Elastomeric bearings including strip bearings shall be restrained from creeping in any direction. This can be achieved either by:

- placing the bearings or strips in 10 mm deep recesses in the headstock or reinforced concrete pedestals. The recesses shall be initially constructed to a greater depth and then filled with epoxy mortar to achieve 10 mm deep recess for the bearings. Recesses into mortar seatings are not permitted. Concrete cover to headstock reinforcements shall be measured from the bottom of the recess, or
- installing steel bearing restraint plates attached to the underside of girders.

4.6.4 Unacceptable types of bearings

Disc bearings (utilizing proprietary plastic type discs) and spherical bearings are not permitted.

4.6.5 Design for hog during construction

4.6.5.1 PSC deck units on elastomeric bearings

A layer of epoxy putty with a thickness not greater than 5 mm shall be placed on top of the elastomeric bearings to accommodate rotation due to beam hog. This shall be applied insitu during deck unit erection just prior to lowering the deck unit onto temporary packers adjacent to the bearing. Notes to this effect must be included on the drawings.

4.6.5.2 PSC girders, including T girder bridges

a) For T girder bridges, tapered plates shall be used between the bearing and girder to accommodate the effect of hog in the PSC girders. The minimum thickness of plates shall be 16 mm. The plates shall be fully dimensioned and detailed on the drawings.

b) To ensure uniform bearing between the tapered plate and the girder, a plate with minimum thickness of 16 mm shall be cast into the underside of the girder. The plate thickness may need to be increased to provide anchorage of studs to anchor the plate.

c) The use of a layer of epoxy putty or mortar on top of elastomeric bearings, in lieu of a tapered steel plate, is not permitted.

4.7 Main superstructure elements

4.7.1 Positive connection required

a) Superstructures of all bridges shall be positively connected to the substructure by means such as restraint angles or holding-down bolts. Floating superstructures on bearings relying on friction are not permitted.

b) Bridge decks integral with the abutment are not permitted for any temporary or permanent works, unless the bridge is designed and detailed as a portal frame.

c) Drilling into PSC units or coring into PSC girders and deck units is not permitted. Provisions for restraints must be detailed on the drawings and cast-in when the units are cast.

d) Provision for effective lateral restraints to resist lateral movement during jacking for bearing replacements shall be made for all bridges.

4.7.2 External post-tensioned concrete superstructure

Permanent external prestressing is not permitted.

4.7.3 PSC deck units

4.7.3.1 PSC deck unit ligatures

a) The ligatures in PSC deck units are placed on top of the bottom layer of prestressed strands and in contact with the underside of the second row of strands. The exception is the sets of ligatures at the ends of the deck units, where the ligatures enclose all the prestressed strands, including the bottom layer of strands.

b) The reason for requiring ligatures to be placed in this location is that the strands provide support, and assist with maintaining the correct concrete cover at the bottom of the deck unit. This reduces durability issues and provides significant time saving for manufacturers.

c) Designers shall be aware that the effective depth used in torsion and shear calculations would need to be reduced accordingly.

d) Ligatures that are not in accordance with a), must have some other positive means of support detailed so that they do not settle under intense vibration during casting.

e) Strands located in corner of ligatures shall not be debonded.

f) The maximum pretension force in a tendon at transfer shall not be greater than 75% of the minimum breaking load of tendons.

4.7.3.2 Maximum skew angle

a) Deck units shall not be cast with skews exceeding 45 degrees. This requirement relates to practicality of manufacture.

b) Note: When the skew of the superstructure exceeds 45 degrees, this can be achieved by installing the deck units on the actual skew, but ends of the precast girders shall be detailed at 45 degrees (acute angle of the girder ends).

c) The ligatures shall be fanned at the ends and transition to be perpendicular to the deck unit longitudinal axis.

4.7.3.3 Voids in PSC deck units

Maximum void length in PSC deck units shall be 2.0 m. A minimum of 60 mm cover is required between the void and strand and/or horizontal reinforcing steel to ensure the flow of concrete around the void.

4.7.3.4 Transfer strength of PSC deck units

PSC deck units shall be designed with concrete strength at transfer greater than or equal to 35 MPa, and less than or equal to 40 MPa.

4.7.3.5 Lifting of PSC deck units

Lifting points for PSC deck units shall be designed and RPEQ certified in accordance with MRTS73 by the designer.

4.7.3.6 Waterproof membrane

A waterproof membrane in accordance with Standard Specification MRTS84 shall be provided for the entire bridge deck for all deck unit bridges.

4.7.3.7 In-fill sheets

In case the deck units are spaced apart, the permanent form work for deck slab shall be in accordance with Clause 4.11.5.11.

4.7.4 PSC I girders

4.7.4.1 Transfer strength of PSC I girders

PSC I girders shall be designed with concrete strength at transfer greater than or equal to 35 MPa, and less than or equal to 40 MPa.

4.7.4.2 Maximum tendon force at transfer

The maximum pretension force in a tendon at transfer shall not be greater than 75% of the minimum breaking load of tendons.

4.7.4.3 Diaphragms

I girder superstructures shall be designed with a diaphragm between girders at each pier and abutment to ensure uniform distribution of loads during jacking to replace bearings. In addition, intermediate diaphragms shall be provided between girders to resist impact loads from excessive height vehicles or high marine vessels. For road overpasses, intermediate diaphragms shall be aligned with the centre of the marked traffic lanes on the carriageway below.

4.7.4.4 Lifting of PSC I girders

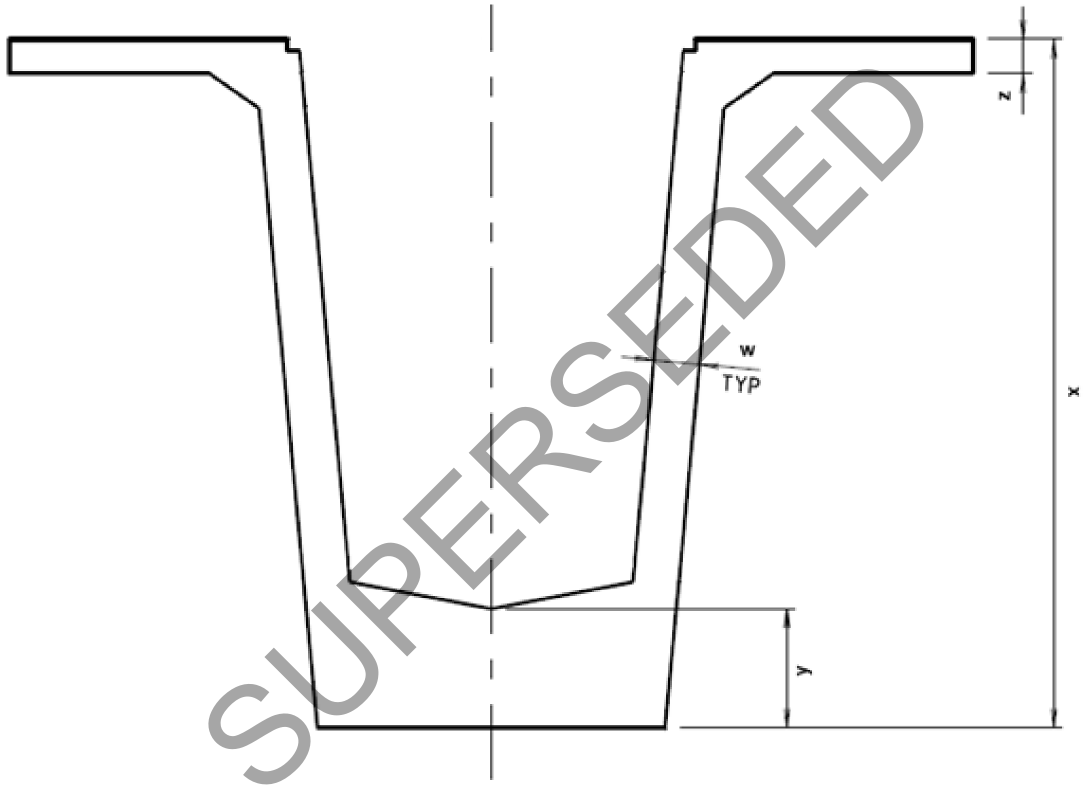
Lifting points for PSC I girders shall be designed and RPEQ certified in accordance MRTS73 by the designer.

4.7.5 PSC T girders

4.7.5.1 T girder dimensions

- T girders shall have diaphragms and the maximum void length between diaphrams shall be 5.0 m.
- T girder dimensions and void arrangements shall be in accordance with Figure 4.7.5.1 and Table 4.7.5.1 respectively.

Figure: 4.7.5.1 - Dimensions of the T girders



	Standard T-Roff Dimensions							
	Option 1				Option 2			
w (mm)	120	120	120	120	120	120	120	120
x (mm)	1000	1200	1500	1800	1025	1225	1525	1825
y (mm)	240	260	260	325	265	285	285	350
z (mm)	75	75	75	75	100	100	100	100

Table 4.7.5.1 – Void arrangement of T girders (Indicative only)

Nominal Length (m)	T girder void arrangement			Nominal Length of End Blocks (mm)	Nominal Actual Girder Length (mm)
	No. of 5 m Voids	No. of 2.5 m Voids	No. of Internal Diaphragms (150 mm)		
20	3	0	2	2325	19950
21	3	0	2	2825	20950
22	3	1	3	2000	21950
23	3	1	3	2500	22950
24A	3	1	3	3000	23950
24B	4	0	3	1750	23950
25	4	0	3	2250	24950
26	4	0	3	2750	25950
27	4	1	4	1925	26950
28	4	1	4	2425	27950
29	4	1	4	2925	28950
30	5	0	4	2175	29950
31	5	0	4	2675	30950
32A	5	0	4	3175	31950
32B	5	1	5	1850	31950
33	5	1	5	2350	32950
34	5	1	5	2850	33950
35	6	0	5	2100	34950
36	6	0	5	2600	35950

4.7.5.2 End diaphragms

a) T girder superstructures shall be designed with a diaphragm at each pier and abutment to ensure uniform distribution of loads during jacking to replace bearings.

b) T girder diaphragms or cross girders shall be poured separately from the reinforced concrete deck because the diaphragms provide stability during pouring of the concrete deck. The diaphragms shall be poured and the concrete cured before the deck is poured. This shall be detailed on the drawings.

c) Because the diaphragms provide stability during pouring of the concrete deck, they shall be poured and the concrete cured before the deck is poured.

4.7.5.3 Maximum skew angle

a) Concrete trough and "Super Tee" girders shall not be cast with skews exceeding 45 degrees. This requirement relates to practicality of casting yards.

b) Note: When the skew of the superstructure exceeds 45 degrees, this can be achieved by installing the T girders on the actual skew, but ends of the precast girders shall be detailed at 45 degrees (acute angle of the girder ends).

c) The ligatures shall be fanned at the ends and transition to be perpendicular to the girder longitudinal axis. Refer Transport and Main Roads *Drafting and Design Presentation Standards Manual*, Chapter 14 for typical reinforcement arrangement at the skew ends of the girders.

4.7.5.4 Half-joints not permitted

Stepped or half-joints shall not be used in bridge girders.

4.7.5.5 Sacrificial formwork for T girders

The sacrificial formwork for the insitu reinforced concrete deck over T girders and between the flanges of T girders shall comply with the following requirements:

4.7.5.5.1 Design loads

a) The design loads to be applied to the formwork are:

- self weight, and
- construction loads.

b) The limit state design requirement for strength, stability and stiffness (deflection) shall be in accordance with AS 3610 Table 4.5.1

4.7.5.5.2 Construction loads

The construction loads on the formwork shall be considered in two stages. Stage 1 is prior to the placement of the concrete deck and Stage 2 is during the placement of the concrete deck.

a) Stage 1 loads:

- Concentrated load that shall be in accordance with AS 3610 – 1995 Formwork for Concrete. This load shall be multiplied by 1.25, which is the recommended impact factor.
- This load can be due to construction materials, such as bundles of reinforcing steel and construction foot traffic.

b) Stage 2 loads:

- Wet concrete, and
- Concentrated load which shall be in accordance with AS 3610 – 1995 Formwork for Concrete.

Wet concrete and concentrated load shall be multiplied by 1.25 (dynamic impact factor). These loads take into account the placement of the concrete. They also take into account the loads generated by construction foot traffic and the equipment used in the placement of the concrete.

4.7.5.5.3 Edge support of formwork

The minimum edge support dimension shall be 25 mm continuous along four sides of the formwork. The strong direction of the formwork shall span across the T girders.

4.7.5.5.4 Acceptable deflection

The deflection shall be determined in conjunction with the combinations specified in AS 3610 “Formwork for Concrete” Table 4.5.1 and the addition of the concentrated load. The maximum allowable deflection for all stages of construction shall be span/360 for all products.

4.7.5.5.5 In-service stress

The maximum ultimate limit state stresses during all stages of construction shall be less than the specified flexural strength of the material.

4.7.5.5.6 In-fill sheets

a) Fibre Cement (FC) In-fill Sheets

   Fibre cement sheet is an accepted material for in-fills to T girders. The design criteria for the FC sheet shall satisfy the following:

   - The deflection shall be in accordance with the acceptable deflection criteria, and
   - The ultimate design stresses shall not exceed the flexural strength of the panels.

b) Material Not Permitted as In-fill Sheets

   The following materials are not permitted as in-fill sheets in T girders:

   i. Plywood and wood-based panel products because moisture ingress degrades the material, which may then block drainage of the cells in the girder.

   ii. Cold-formed steel sheet sections (for example, Bondek or similar) are not permitted due to deformation of profile during loading.

c) Alternative Products

   i. Any product except those listed under (b) above as In-fill Sheets may be considered an alternative product.

   ii. The product shall satisfy the following:

      - Resist the design loads
      - Be durable for 100 years
      - Satisfy the deflection criteria outlined above, and
      - The cross-sectional shape shall not change when the formwork is loaded. Testing may be required to verify the section does not change shape.

   iii. The product shall be selected by the Designer, and detailed clearly on the deck drawings.

4.7.5.6 Transfer strength of PSC T girders

PSC T Girders shall be designed with concrete strength at transfer greater than or equal to 35 MPa, and less than or equal to 40 MPa.

4.7.5.7 Debonding of strands

Strands located in corner of ligatures shall not be debonded.

4.7.5.8 Maximum tendon force at transfer

The maximum pretension force in a tendon at transfer shall not be greater than 75% of the minimum breaking load of tendon.

4.7.5.9 Lifting of PSC T girders

Lifting points for PSC T girders shall be designed and RPEQ certified in accordance MRTS73 by the designer.

4.7.6 PSC box girders

4.7.6.1 Segmental superstructure construction

a) The preferred option involving precast segmental sections is that all joints between precast sections must have an insitu concrete connection and must be a minimum of 400 mm wide with lapped reinforcement.

b) Match-cast segmental superstructure construction may be used only in exceptional circumstances, subject to departmental acceptance by Deputy Chief Engineer (Structures). The criteria listed in Clause 4.11.6.2 shall be used as the basis of a submission to use match cast precast concrete boxes.

4.7.6.2 Design criteria

4.7.6.2.1 General

a) All permanent prestressing shall be internal.

b) Grouting of internal prestressing ducts shall be in accordance with MRTS89.

c) The dimensional tolerance of wide units is critical, as large differences in thickness can result in cracking. As large dimension units can cause instability, the maximum dimension of a precast box shall be 14 m.

4.7.6.2.2 Durability

a) A multi-redundant system shall be used to ensure that there is no water ingress resulting from the use of match cast systems.

b) All concrete shall be cured in accordance with Standard Specification MRTS70. No reduction in curing standard will be permitted.

c) All faces between match cast units shall be coated with wet-to-dry epoxy.

d) All prestressing ducts shall be in accordance with Clause 7.1.6 of Standard Specification MRTS89. (Steel ducts are not permitted).

e) A proprietary seal shall be used on all ducts at each match cast joint.

f) The entire width of the top surface of the deck shall have a 20 mm x 20 mm recess joint between the match cast boxes and sealed with a waterproof joint after stressing.

g) The entire top surface shall be sealed with a high performance waterproof membrane with a grit to ensure grip of the DWS. Bituminous waterproofing to Standard Specification MRTS84 is not permitted.

4.7.6.2.3 Design

a) The standards which shall be used in the design of PSC box girders are listed in Table 4.7.6.2.3(a).

b) There will be a residual compression of 1 MPa for ALL serviceability load cases.

c) Tapered shear keys shall be used on each match cast joint.

Table 4.7.6.2.3(a) - PSC box girders design standards

Design Standard	Section	Description
AS 5100.2	All sections	Design loads and combinations
AS 5100.5	All sections	Concrete Design
AS 5100.5	Appendix B	Design of Segmental Bridges

d) The standards which shall be used during the erection stage of match cast concrete box girders are listed in Table 4.7.6.2.3(b)

Table 4.7.6.2.3(b) - PSC box girders loading criteria

Loading	Criteria
Dead load	As per AS 5100.2
Erection live load	0.5 kPa on all deck surfaces (minimum)
Differential temperature	70% of AS 5100.2 values
Wind load	70% of AS 5100.2 values, with no launching to be carried out during strong winds.
Differential settlement and construction tolerance allowances between bearing levels	As specified by designer (must be monitored and controlled during construction)
Load factors, limit states	As per AS 5100.2

e) The criteria for other types of incrementally launched bridges shall be subject to written agreement by Transport and Main Roads Deputy Chief Engineer (Structures).

4.7.6.3 Additional segmental bridge design standards not covered in AS 5100.

a) AS 5100 and the previous criteria shall be the main reference for design. However, where this standard does not specifically address match cast box girders, AASHTO LRFD may be used.

b) The standards which shall be used for segmental bridge design and construction of prestressed concrete segmental bridges are listed in Table 4.7.6.3

Table 4.7.6.3 - Segmental bridge design standards

Design Standard	Section	Description
AASHTO LRFD	Section 4.6.2.9	Analysis of Segmental Bridges
AASHTO LRFD	Section 5.14.2	Segmental Construction

i) AASHTO LRFD Section 4.6.2.9

- Specific requirements for the analysis of time dependent effects

- Specific requirements for transverse analysis of box sections
- Specific requirements for erection analysis

ii) AASHTO LRFD Section 5.14.2

- Specific requirements for construction analysis
- Definition of minimum construction loads (out of balance segments, erection equipment, and so on)
- Specific requirements for limiting stresses during construction
- Construction load combinations
- Considerations for provisional post-tensioning ducts and future deflection adjustment
- Specific requirements for minimum section dimensions
- Specific requirements for seismic design
- Specific requirements for segmental joints (precast and insitu joints)
- Specific requirements for balanced cantilever construction
- Specific requirements for force effects due to construction tolerances
- Segmental bridge design detailing requirements
- Specific requirements for segmental bridge substructures.

4.7.6.4 Precast segmental bridge deck analysis

The method of analysis for precast segmental bridges is specifically covered in AASHTO LRFD Section 4.6.2.9. The following issues are to be considered in addition to those required for standard precast girder decks:

- Shear lag (effective flange widths)
- Construction stage analysis
- Prestress stage analysis
- Analysis for time-dependent effects, in particular the concrete segment creep and shrinkage properties which vary with time
- Residual creep effects
- Torsional and distortional warping for box sections and so on
- Construction.

4.7.6.5 Construction

All construction shall be in accordance with Standard Specifications MRTS70, MRTS71, MRTS72, MRTS73 and MRTS89.

4.7.6.6 Lifting of PSC box girders

Lifting points for PSC box girders where applicable shall be designed and RPEQ certified in accordance with either MRTS72 or MRTS73 as applicable by the designer.

4.7.7 Steel I beams

Steel I beams are less durable than prestressed concrete unless regularly painted and maintained. They are acceptable when widening an existing steel beam bridge, and shall be galvanised where possible.

For new bridges, painted girders are generally not acceptable because of the ongoing costs of regular inspection, cleaning and painting, including the cost of traffic control and disruption to traffic.

4.7.8 Steel box girders

Steel box girder construction may be used only in exceptional circumstances, subject to departmental acceptance by the Deputy Chief Engineer (Structures). Steel box girder superstructures can only be used under the conditions detailed in Clause 4.11.9.

4.7.8.1 Cost benefit analysis

The choice of design option is based on the option's whole-of-life cost as well as on the constraints that may prevent using concrete girders. Prior to acceptance of a steel box girder by the Deputy Chief Engineer (Structures), the designer shall submit the whole-of-life cost for this option and an alternative non-steel option (for example, concrete box girder option). The use of a steel box girder shall be accepted by the Deputy Chief Engineer (Structures) prior to commencing the design.

4.7.8.2 Design standards

Steel bridges are to be designed in accordance with AS 5100, except that for the design of steel box girders, the standard detailed in Table 4.7.8.2 must apply during the erection stage:

Table 4.7.8.2 - Steel bridge design standards

Loading	Criteria
Dead load	As per AS 5100.2
Erection live load	0.5 kPa on all deck surfaces (minimum)
Differential temperature	70% of AS 5100.2 values
Wind load	70% of AS 5100.2 values, with no launching to be carried out during strong winds.
Differential settlement and construction tolerance allowances between bearing levels	As specified by design (must be monitored and controlled during construction)
Load factors, limit states	As per AS 5100.2

4.7.8.3 Maintenance access

a) Any steel box girder over a road, rail or shopping corridor shall be provided with a maintenance gantry attached to the structure. The design of the maintenance gantry shall be such that when the maintenance gantry is in use, it will not intrude into the clearance envelope of all surrounding corridors.

b) The boxes shall be large enough to allow easy internal inspection, maintenance and painting. A minimum size of 1.6 m internal depth x 1.2m wide is required.

c) There must be sufficient clearance beneath the bridge to allow inspection and painting without interruption to the traffic underneath.

d) Rails for an access gantry must be included in the design, and drawings of a fully detailed access gantry must be supplied.

e) All steel box girders must have access holes suitable for inspection and maintenance access. Access holes must be located in the bottom flange in areas of low stress, and must be fitted with hinged doors and provided with locks.

f) Access holes must be provided in all diaphragms.

g) Access holes must be large enough to permit maintenance personnel access.

h) Access provisions must comply with the Workplace Health and Safety Act and the Workplace Health and Safety Regulations which include, but are not limited to, the provisions for the design of confined spaces.

4.7.8.4 Ventilation and drainage

a) Provision must be made for ventilation and drainage of the interior of all box sections.

b) All outside openings in steel box sections must be screened to exclude unauthorised persons, birds and vermin.

4.7.8.5 Durability

a) All steelwork, including internal faces, shall be protected by hot dip galvanizing to AS 4680. Refer additional requirements in Clause 3.8.1 for steel with low silicon and low phosphorous contents.

b) All steel surfaces are to be protected from corrosion.

c) Internal areas too small to paint (including maintenance repainting) must be sealed and filled with either an inert gas or a water-absorbing product such as Corroless. Sealed sections shall be pressure tested prior to inserting the gas or water absorption products. Bolts must be provided with inspection tabs to monitor internal conditions for all sealed sections.

d) The interior of all steel box sections must be painted with a light colour.

e) The coating system shall be shop applied.

f) Coating systems must be capable of being repainted by brush. A trial test panel must be undertaken before repainting steel box girder bridges.

g) Coating systems must be applied in accordance with the manufacturer's specifications and Transport and Main Roads Technical Standards.

h) The coatings shall have a 25 year design life. Paint coating system shall include the recoating procedure for maintenance.

4.7.8.6 Handover (where applicable to design, construct and operate/maintain contracts)

At the time of handover, the proponent must ensure that:

a) There is no loss of structural section in any steel girder bridges, and

b) All surfaces have a complete coating system that complies with departmental specifications, of which no coating film is older than 18 months. This requirement applies to the coating system in its entirety and to each coat that makes up the coating system.

4.7.9 Steel composite bridge deck

a) The method of analysis for steel composite bridges is covered in AS 5100.6 Section 7B.4, the analysis method being selected according to Table 4.7.9

Table 4.7.9 - Steel composite bridge analysis method

Limit State	Method of Analysis
Serviceability Limit State	Linear Elastic
Ultimate Limit State	Two Dimensional "Grillage" Analysis for Global Effects Three Dimensional Finite Element Analysis

a) The following issues are to be considered in the analysis of steel composite girder decks:

- Shear lag (effective flange widths)
- Ratio of elastic modulus between concrete and steel
- Concrete cracking (in particular over pier supports for continuous bridges)
- Torsional and distortional warping for box sections
- Plate slenderness limits (compact vs non-compact sections)
- Element buckling
- Member buckling (for example lateral torsional buckling)
- Construction stage analysis.

4.8 Decks and deck wearing surface

4.8.1 Crossfall, gradient and drainage

a) The drainage system must be designed so that a minimum amount of water flows across deck joints. All drainage structures must be readily accessible for cleaning and maintenance purposes.

b) Bridge drainage over streams shall satisfy the requirements of the Environmental Management Plan (EMP). In general, collection and treatment of drainage water is not required unless specified in the EMP. Where drainage pipes are required, they must be able to be cleaned effectively, and placed between beams or behind an edge skirt to maintain clean lines on the bridge profile.

c) To prevent structural overloading from flooding due to leaks and breakages in the pipe, stormwater pipes shall not penetrate into the voided cell of T girders and deck units unless a 100 mm diameter drain hole is detailed in the bottom flange of the cell containing the pipe. Drain pipes inside any cell or box girder shall be galvanised (hot dipped) steel pipe.

4.8.1.1 New bridges

The crossfall on all new bridges shall be compatible with the geometric road design. The minimum cross fall on new bridges shall be 2.5%.

If the bridge is submersible then zero longitudinal gradient is acceptable. This will minimise undesirable turbulence effects when the bridge is progressively inundated.

4.8.1.2 Widened bridges

a) The crossfall for widened bridge decks shall be reviewed. The minimum crossfall shall be similar to the existing bridge deck. The preferred minimum crossfall is 2.5%.

b) The existing DWS on all bridges subject to widening, including bridge approaches where required, shall be milled off to a sufficient depth to allow for a new asphaltic concrete (AC) DWS. Milling shall not damage the concrete deck. Milling shall be in accordance with Standard Specification MRTS84A.

c) For existing bridges having a one-way crossfall of less than 2%, the DWS may be increased in thickness to result in a crossfall of 2%, provided the load rating is not too adversely affected.

d) Where the proposed crossfall has a significant adverse effect on load rating, the proposal shall be submitted to Director (Bridge and Marine Engineering) for agreement.

4.8.2 Waterproof membrane

a) A bituminous waterproof membrane in accordance with Standard Specification MRTS84 shall be provided for the entire bridge deck of all bridges.

b) For bridges with a footway raised above the concrete deck using fill, the bituminous waterproof membrane on the deck shall extend under the raised footway areas to protect the bridge deck from corrosion. Stabilised sand shall be used where fill is required under raised footway areas on bridge decks to eliminate moisture being retained on the top of the deck.

4.8.3 Deck wearing surface

a) The DWS (where applicable) on all road bridges must be asphaltic concrete and must have a minimum design life of 20 years.

b) The DWS must comply with MRTS30 or MRTS31 whichever is specified for the project.

c) The DWS on PSC deck unit bridges without a cast insitu deck shall consist of a DG10 corrector course followed by the waterproof membrane and a surfacing layer. The corrector course shall have a minimum thickness of 25 mm in any trafficked lane. The corrector course shall not be less than 10 mm at the kerb. Where the surfacing layer consists of open graded asphalt, the maintenance requirements need to note that the waterproof membrane may be removed during resurfacing and it has to be reinstated during resurfacing.

d) The DWS on bridges with a cast insitu deck shall consist of the waterproof membrane and a surfacing layer. Where the surfacing layer consists of open graded asphalt, an additional layer of dense graded asphalt shall be placed over the waterproof membrane to protect the deck and waterproof membrane during removal of the open graded asphalt.

e) The minimum thickness of DWS (excluding bituminous waterproof membrane and corrector course as noted above) on bridges must comply with MRTS30 or MRTS31 as appropriate.

f) For design purposes, an allowance of 70 mm shall be made for the minimum depth of DWS at the kerb of PSC deck unit bridges without a cast insitu deck except that, where the bridge has a uniform cross fall, the allowance shall be 85 mm.

4.9 Barriers

4.9.1 Bridge traffic barriers

4.9.1.1 Structural design

All new bridge traffic barriers shall conform to AS 5100 and the further criterion detailed in Section 6 Additional Requirements to AS 5100 Bridge Code. The minimum design load for barriers on new bridges shall be "regular" level to AS 5100. For details for bridge widening and replacement of existing barriers, refer to Section 7 “Matters for Resolution”.

4.9.1.2 Functionality and appearance

a) The primary function of a traffic barrier is to contain or redirect vehicles.

b) Features of a barrier system that are designed to limit injury to vulnerable road users shall be documented. These features may include some or all of the following:

- A smooth unbroken surface without openings or sharp edges
- Lack of points that might snag
- Protection against impact with posts
- Locating attachments, such as reflectors, where they are less likely to be impacted
- On terminals, the vertical slope on a road traffic barrier shall be no steeper than IV to 10H. Frangible attachments, defined as having a maximum section size of 90 mm round with 3 mm wall thickness, shall have a maximum slope of: 1 (V) to 2(H).

c) These features shall be part of the basic design or obtained by fitting additional components.

4.9.1.3 Post and rail traffic barriers

Steel (posts and rails) bridge traffic barrier shall be used on streams, creeks and rivers with a flood immunity of less than ARI 2000 years to reduce afflux, if this is a design constraint.

4.9.1.4 Concrete barriers

a) Concrete traffic barriers shall be used on overpass bridges. Details of cover plates at expansion joints are provided in Clause 4.14.

b) The following methods for constructing concrete traffic barriers on bridges are not permitted:

- Slip forming of concrete traffic barriers and median barriers
- Extruding concrete barrier.

c) Concrete traffic barriers and median barriers on bridges shall be cast integral with the bridge deck using reinforcing steel. The traffic barrier loads shall be transferred to the deck using reinforced concrete design methodology.

4.9.1.5 Precast concrete barriers

Precast concrete traffic barriers shall conform as follows:

a) Reinforcing bars connecting the barrier to the deck are to be uniformly spaced – approximately 150 mm apart.

b) Precast barriers fixed to the bridge deck with only concrete stitch pours or joints are not acceptable. A precast outer face with a cast insitu concrete inner face (each part 100 mm minimum thick) to full height of the barrier is acceptable. The cross-section shall enable easy vibration of the concrete to the full depth of the barrier.

c) Grouting reinforcing bars in small holes does not guarantee quality. Hence, these designs are not acceptable.

d) Recessed holes are not acceptable.

e) Where a bridge is to be widened on one side and the existing barriers are substandard by current design requirements, the need to modify or replace the old barrier (on the non-widened side) shall be clarified in Matters for Resolution Section 7 in the design brief.

f) In addition to the requirements in this document, precast barriers shall be designed to MRTS72 where applicable including requirements for lifting.

4.9.1.6 Transition between road and bridge barriers

The transition from road barriers to bridge barriers must ensure:

a) There is no snagging hazard to stop the errant vehicle moving between the two types of barrier.

b) The entire length of the road barrier, transition and bridge barrier must be smooth and continuous to support an errant vehicle's passage along the carriageway.

c) The stiffness of the barrier must ensure pocketing does not occur. Bridge transition barriers are detailed in Transport and Main Roads Standard Drawings.

d) Refer to Section 6 Additional Requirements, of this document for further details.

The approach rail shall not direct an errant vehicle into a hazard on the bridge (for example kerb). Similarly the exit shall not direct a vehicle onto a hazard. The layout must also address cross-over crashes/incidents. The approach barrier also stops an errant vehicle from travelling down embankments, into creeks or onto a road beneath the bridge. The design method of road barriers is based on risk assessment. Details of the method, including determining the length of approach barriers, are listed in Section 8 of the *Road Planning and Design Manual*.

The balustrade will narrow the footpath width. Additionally, a balustrade may pose a hazard to cyclists.

4.9.1.7 Retrofit of barriers

For any retrofits of barrier and new barriers on existing bridges and approaches, the following shall apply:

a) Balustrades are on the outside of footpath.

b) Traffic barriers are on either side of a bridge to restrain errant vehicles.

c) Balustrades shall not be installed on the road side of a footpath/bikeway on new works. Traffic barrier plus safety rail shall be used in these applications.

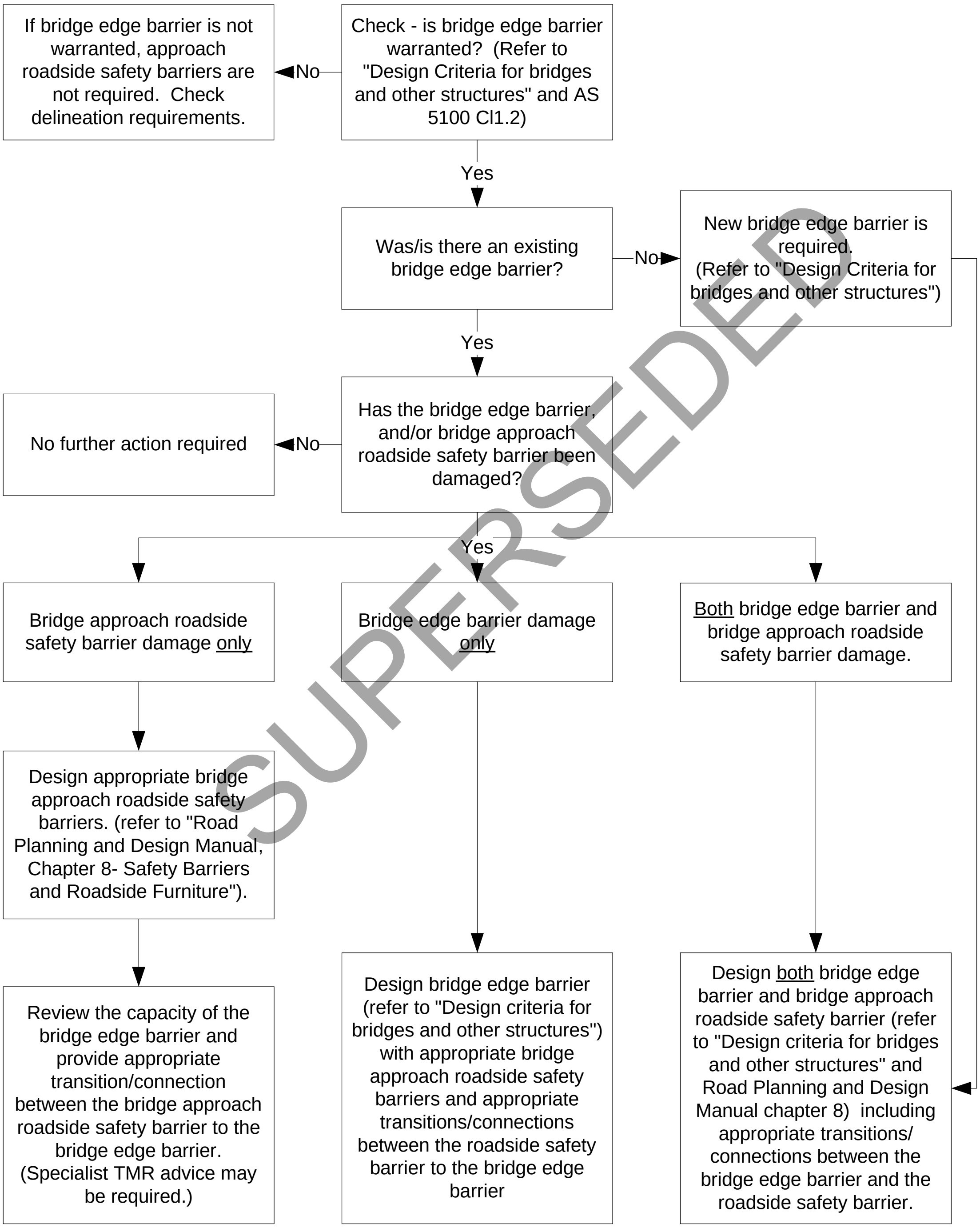
d) Historically, balustrades may have been installed between road and footpath to stop pedestrians and cyclists falling off the footpath on to the road where there is a large vertical drop to the road or where the footpath is narrow. Vehicle impact of balustrades poses a hazard to road users and pedestrians.

e) On existing bridges with balustrades next to the road, the balustrade may be allowed to remain in place if the speed limit is 70 km/h or less and Commercial Vehicles are less than 5% traffic volume. All other applications shall be removed and replaced by conforming barriers.

f) Traffic rails/barriers MUST NEVER be connected to the end of a balustrade.

For the assessment process refer to Figure 4.9.1.7.

Figure 4.9.1.7 - Flow chart for assessing bridge barriers and transition to roadside safety barriers



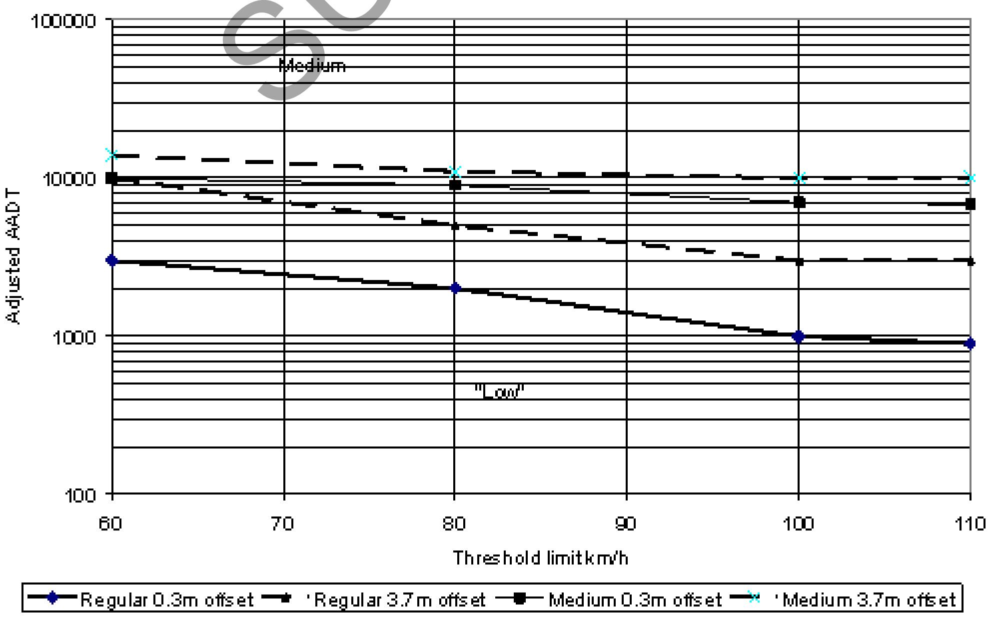
4.9.1.8 Temporary barriers – worker protection during construction

When workers and/or work areas are behind the barrier both the contractor and the designer have Safety in Design obligations under legislation. Additionally, due to Safety in Design considerations, the designer has a duty to ensure that there is no foreseeable risk to the workers during construction. Temporary barriers shall be designed to comply to the provisions in accordance with AS 5100.1 Appendix B except Figures B5 to B8 are replaced by Table 4.9.1.8 and Figure 4.9.1.8 below.

Table 4.9.1.8 - Complying criteria for temporary barriers to AS 5100 to protect workers – 45 t semi-trailer and 68 t B double

Threshold Limit (km/h)	Adjusted AADT 0.3 m offset	Adjusted AADT 3.7 m offset	Barrier level
	< 3000	< 10000	Low
60	> 3000 and < 10000	> 10000 and < 14000	Regular
	> 10000	> 14000	Medium
	< 2000	< 5000	Low
80	> 2000 and < 9000	> 5000 and < 11000	Regular
	> 9000	> 11000	Medium
	< 1000	< 3000	Low
100	> 1000 and < 7000	> 3000 and < 10000	Regular
	> 7000	> 10000	Medium
	< 900	< 3000	Low
110	> 900 and < 6800	> 3000 and < 10000	Regular
	> 6800	> 10000	Medium

Figure 4.9.1.8 - Deemed-to-comply temporary barriers to AS 5100 to protect workers – 45 t semi-trailer and 68 t B double



4.9.2 Wire rope barriers

In general, wire rope barriers are not suitable as bridge barriers. In certain circumstances, wire rope barriers may provide adequate safety and meet other design constraints. These include:

a) For rehabilitation of existing bridges, the location shall conform to the requirements of AS 5100.1 Clause 10.5.1 and barrier performance level shall conforms to either Clause 10.5.2 or 10.5.3.

b) For new bridges, the bridge conforms to requirements of AS 5100.1 Clauses 10.5.2 or 10.5.3.

c) A wire rope barrier is required for safety reasons on the bridge approaches.

d) Where bridges are close to houses or other flood-sensitive structures, and the lowest practical afflux is required, and concrete kerbs should be avoided.

e) Where the new bridge is relatively short and is constructed full formation width (minimum 11 m wide for 2 lane bridges) and the wire barrier is placed at least 1 m in from the edge of the bridge.

f) Where the use of a wire rope barrier is put forward at the 15% design report, and is accepted by Deputy Chief Engineer (Structures).

4.9.3 Noise barriers, safety screens and electrical protection barriers on bridges

a) Where noise barriers, safety screens and electrification barriers must be continuous across the bridge, it is a requirement that the noise barrier panels and posts and electrification barriers shall be located on the outside of the bridge behind the top horizontal face of the concrete traffic barrier to avoid being impacted by traffic.

b) The requirement for and design criteria for safety screens must be in accordance with the following departmental documents:

- Technical guidelines for the treatment of overhead structures – objects thrown or dropped, and
- Policy – reduction of risk from objects thrown from overpass structures on to roads.

4.10 Expansion joints

4.10.1 General

a) Expansion joints design shall conform to AS 5100 and the additional requirements below.

b) Abutment stiffness. If expansion joints are provided at an abutment, the design must include raked piles or stiffer cast-in-place piles to prevent earth pressure moving the abutment forward and closing the joint.

c) Bearing replacement. Where bearings are used at abutments, a joint must be provided to enable jacking for bearing replacement.

d) Expansion joint replacement. Expansion joints shall be designed to be replaced during the life of the bridge. Where the joint is secured by bolts, the bolts and sockets shall be corrosion resistant stainless steel, of two different grades to prevent thread locking on tightening.

e) Waterproof. All types of joints shall be waterproof, with adequate seals and drainage to prevent road runoff from staining piers and abutments, or causing corrosion damage to bearings or restraints.

f) Joint seals. Joint seals on all bridges (including bridge widenings) must be continuous across the width of the bridge and any edge upturns.

g) Constructability. Joints must not inhibit the proper placement and compaction of deck concrete.

h) Maintenance. Joints must have adequate access for inspection and maintenance.

i) Surface flatness. The surface flatness of joints must not deviate by more than 3 mm when measured with a 3 m straightedge. This includes the adjacent surface seals and cover plates.

j) Bolted-in extruded aluminium expansion shall only be used when the road surface is asphalt. Cast-in extruded aluminium expansion joints shall be used only when the road surface is concrete.

4.10.1.1 Safety of pedestrians and cyclists

The surface of joints must not present a hazard to any road user. Joints on roadways shall be detailed to be safe for narrow bicycle wheels. Joints on footpaths/cycleways shall have no gaps that can trap a bicycle wheel, and must not present a slippery surface when wet.

4.10.1.2 Noise

Joints must be selected and detailed to minimise noise produced by traffic crossing the joint.

4.10.1.3 Modular joints

Modular joints shall be designed in accordance with Transport and Main Roads Standard Specification MRTS90 and AS 5100. Modular joint design shall provide adequate space in the void beneath the joint to permit easy access for inspection, maintenance, and replacement of critical wearing components of the joint. The overall bridge design shall include safe access to the space beneath the joint.

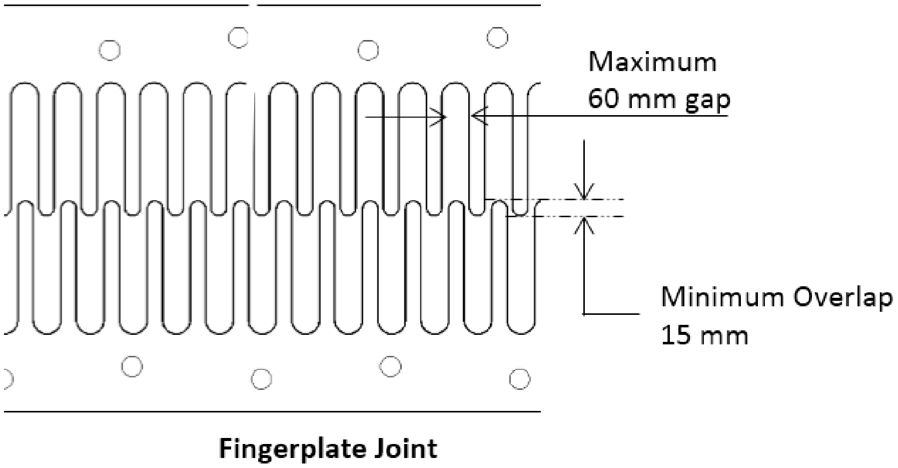
4.10.1.4 Finger type expansion joints

Finger type joints such as fingerplate or saw tooth expansion joints shall be designed in accordance with Transport and Main Roads Standard Specification MRTS82A and AS 5100.

Gap width of fingerplate joints shall be as follows.

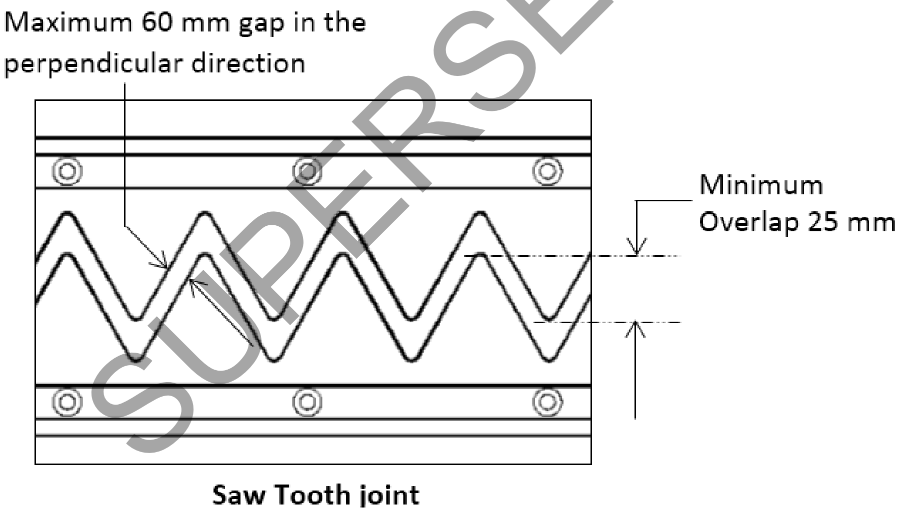
- For fingerplate joints, the gap width specified in AS 5100.4 Clause 17.3.5 shall be amended, as the maximum opening between fingers between adjacent fingers on the same side of the joint shall be 60 mm and minimum overlap of the fingers on the opposite side of the joint shall be 15 mm. This is as shown in the Figure 4.10.1.4A below.

Figure 4.10.1.4A – Gap width of fingerplate expansion joints



- For saw tooth joints, the maximum perpendicular opening between adjacent saw teeth on the opposite side of the joint shall be 60 mm at the ultimate movement limit and the minimum overlap of the saw teeth on the opposite side of the joint shall be 25 mm. This is as shown in the Figure 4.10.1.4B below.

Figure 4.10.1.4B – Gap width of saw tooth expansion joints



4.10.2 Non-conforming joints

a) The following joints inclusive do not conform to departmental requirements, and shall not be used in any bridge design:

   - Multiplex TM and WABOFLEX joints are not acceptable due to the high noise level produced on previous departmental projects.
   - Flush seals shall not be used for alu-strip expansion joints with a skew greater than 20 degrees.
   - Bonded steel plate/rubber type joints.
   - Simple open joints, as they are not waterproof.

b) If there is evidence, supported by design change, in-service performance and independent assessment and testing, a designer may submit such information before the 85% complete design report, to request acceptance to use any of the joints listed in (a) above.

4.10.3 Joints to be detailed on drawings

Expansion joints shall be fully detailed on the Drawings submitted at the 85% complete design report, and are subject to acceptance by the Deputy Chief Engineer (Structures).

4.10.4 Cover plates at joints

a) Stainless steel cover plates with a minimum thickness of 6 mm shall be provided on concrete traffic barriers at expansion joints, where the maximum opening in the barrier is greater than 150 mm but less than 900 mm under the worst serviceability limit state condition (widest opening). Where the maximum opening in the barrier is less than 150 mm, steel cover plates with a minimum thickness of 3 mm shall be provided.

b) The opening is measured parallel to the longitudinal axis of the bridge.

c) Steel cover plates must cover the inside face and top of the barrier.

d) The faces of the barrier shall be recessed so the cover plate is flush with the barrier surface except that recesses in the faces of the barriers are not required for 3 mm thick plates.

4.10.5 Access for maintenance

Access for safe maintenance of the expansion joint system is a part of the design development process. This requirement needs to be addressed at the concept design stage and reviewed through the detail design. The principle method adopted by the design to address safe maintenance shall be to reduce or eliminate maintenance requirements.

4.10.6 Open joints

Open joints are prohibited.

4.11 Relieving slabs

a) Relieving slabs shall be provided at both ends of road bridges in accordance with Transport and Main Roads Standard Drawing 1505 (3 m) to prevent settlement of the road surface adjacent to the structure.

b) Relieving slabs shall be fixed to the bridge abutment, with the typical detail in Standard Drawing 1505 which allows limited rotation under settlement.

c) Design change of grade over the length of the relieving slab due to differential settlement during design life of the road pavement shall be limited to 0.5%.

d) Where there are very high embankments (typically > 6.0 m) and/or residual future settlement, relieving slabs shall be provided in accordance with Transport and Main Roads Standard Drawing 1506 (6 m).

4.12 Stay cables

a) For cable stayed bridges provisions must be made for the replacement of the stay cables in the long term. To facilitate this requirement the bridge must be designed to allow any one cable to be removed without exceeding any serviceability limit states.

b) A detailed procedure for the replacement of stay cable shall be included on the drawings, noting any live load restrictions required, and all jacking loads and precautions.

4.13 Services, lighting, miscellaneous

4.13.1 Provision of utility services on bridges

The design must satisfy the requirements of all relevant authorities to accommodate and provide for existing and proposed future services acceptable to the department within and/or on the bridges.

The service ducts in the footpath may be placed in the cavity spanned with precast reinforced concrete panels, or alternatively the cavity may be filled with weak concrete.

4.13.2 Fixings for services

Fixings cast into bridge concrete shall have a high level of durability. The minimum level of durability is hot-dip galvanised fittings, except that in marine environments the fittings shall be marine grade stainless steel.

The criterion needs to address durability, load and performance during an extreme event. Parameters to be addressed include:

- drilling into prestressed or post-tensioned members is not permitted
- the attachment point for services shall be adequately anchored into the bridge
- the services are positioned above the soffit of the superstructure to ensure there is no additional blockage of the stream and to maintain clean lines of the bridge
- where the services are positioned exposed to the flooding, they shall be designed to ensure they can sustain impact from the flood debris and water flow
- services shall be supported on the abutment or extend behind the abutment.

4.13.3 Chemical anchors in tension

a) Chemical anchors in tension are not permitted (example – suspending a pipe underneath a bridge deck).

b) Permanent fixtures must be cast into concrete for service support. Chemical anchors are acceptable for fixings loaded in shear.

4.14 Footbridges and bikeways

4.14.1 Special conditions for short span, narrow footbridges not over road or rail corridor

The individual spans of foot and/or bicycle path bridges that do not pass over a road corridor (including clear zone, or rail corridor), and have

- spans less than 10 m, and
- width less than 3.4 m

may be designed for bored piles or cast in place piles with a minimum diameter of 600 mm in accordance with MRTS63A.

4.14.2 Maximum gradient

The maximum gradient of pedestrian bridges shall conform to Transport and Main Roads Technical Note 38 *Longitudinal grades for footpaths*.

4.15 Paint systems

4.15.1 Initial application to be compatible with future recoating

a) Any paint system specified must include details of how the coating shall be repainted in the future. The recoat system must be practical and compatible with normal operating systems, for example:

- Abrasive blasting on site is difficult and undesirable
- The closure of some lanes for repainting is not possible on highly trafficked roads. Similar conditions shall apply to other transport corridors
- All coatings shall be able to be applied by Airless Spray, Brush, Roller, and Air. The first coating system must be applied in the shop. Recoats would be field applications.

b) Any painted steelwork (for example gantry or bridge) over a road, rail or shopping corridor shall be provided with a maintenance gantry attached to the structure. The design of the maintenance gantry shall be such that when the maintenance gantry is in use, it does not intrude into the clearance envelope of all surrounding corridors.

c) All bolts, rivets and edges shall be stripe coated. All paint shall be applied in accordance with MRTS88.

4.15.2 Medium exposure (C3 to AS 2312 and AS 4312)

In a medium (C3 to AS 2312 and AS 4312) exposure application and a 25 year coating life, acceptable paint systems for fabricated steelwork over a transport corridor as well as for repainting steel bridges are listed in Product Information for Bridges and Other Structures.

4.15.3 Very high marine exposure (C5M to AS 2312 and AS 4312)

In a very high marine exposure (C5M to AS 2312 and AS 4312) application where a 25 year life is required, acceptable paint systems for fabricated steelwork are listed in Product Information for Bridges and Other Structures.

4.15.4 Structural steel

Structural steel material shall meet the following requirements:

- All cold formed structural steel hollow sections to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel
- Steel members fabricated from rolled plates with seam welds need to be designed taking into account the tolerance of rolling in the design. The tolerances are outlined in MRTS63. Rolled plates shall be manufactured in accordance with MRTS63 using Grade XXXL15 material to AS/NZS 3678 where XXX is the grade of the steel. All of these welds shall be 100% ultrasonically tested.
- All hot rolled steel plates shall be to AS/NZS 3678
- All structural steel hot rolled sections shall be to AS/NZS 3679.1
- Structural steel welded sections shall be to AS/NZS 3679.2
- Minimum steel thickness for structural steel members shall be 2.5 mm except for external steel members exposed to weather where the minimum steel thickness shall be 3 mm

- Structural steel water pipe manufactured to AS 1579 is not permitted unless it is tested along the longitudinal axis to AS/NZS 1163 and is Grade xxx L0 where XXX is the grade of the steel.

Spirally wound fabricated circular hollow sections are not permitted.

5 Bridge construction requirements

5.1 Specifications

For Design and Construct and Alliance type projects, the construction shall be in accordance with departmental construction specifications and standards.

5.2 Date plates and survey marks

A date plate (Transport and Main Roads Standard Drawing 1063) and a survey mark shall be detailed in the documents to be supplied and affixed to each bridge

5.3 Frequently requested variations to standard specifications

a) Transport and Main Roads specifications are conscious decisions of departmental structural engineers who require a long service life and minimum whole of life cost.

b) The following options are unacceptable innovations to the department:

- Reduction in stripping times in formwork
- Reduction in curing of concrete.
- Reduction in durability standards for any material or component.

5.4 Inspection of bridges

5.4.1 Inspection during construction for multi-span bridges

On multi-span bridges the Level 2 inspection shall be undertaken after construction of a few spans to identify issues early and avoid repetition of errors on the remaining spans.

5.4.2 Inspection on completion of construction

a) The new bridge construction work shall have a Level 2 inspection by a qualified inspector in accordance with the Department's *Bridge Inspection Manual* and the results entered into the department's Bridge Information System.

b) The Level 2 inspection shall be undertaken prior to placing of DWS while the top of the deck units or reinforced concrete decks are accessible for inspection.

c) These requirements shall be included in the documentation.

6 Additional requirements to AS 5100 bridge code

In this section, the clause number refers to AS 5100

PART 1 : SCOPE AND GENERAL PRINCIPLES

Amendment 1 of AS 5100.1:2010.

This amendment shall be adopted.

Clause 9.5 Edge clearances for bridges with walkways:

In addition to the requirements of Clause 9.5 for bridges without walkways, the minimum edge distance is 600 mm for bridges unless a greater width is required in Tables 9.4(A) and 9.4(B).

Clause 10.5.2

Replace this clause with the following:

For certain bridge sites, conditions may be such that traffic barriers may constitute a higher risk than not providing any barrier. Similarly, traffic barriers need not be provided on low-level bridges subject to frequent flooding. Traffic barriers may be omitted where ALL the following conditions apply:

- The bridge is less than 1.5 m above the ground or low flow water levels
- Traffic volumes are less than 150 vehicles per day
- Radius of curvature of the bridge is such that the road approaches have a sight distance greater than the minimum stopping distance for the design speed of the road
- The width between kerbs is not less than 8.4 m for a two-lane bridge or 5.2 m for a single lane bridge
- The edge of the bridge is at least 1.0 m from the edge of traffic lanes
- The location is without anticipated pedestrian traffic
- Any water beneath the bridge is normally less than 1.2 m deep
- The provision of barriers would prevent the passage of debris or the barriers would be frequently damaged by heavy debris or both
- Where a risk assessment has been undertaken and it has been agreed with the Deputy Chief Engineer (Structures) that barriers are not to be provided.

Clause 10.6.3

A smooth face and tensile continuity shall be maintained throughout. Exposed bridge traffic barrier ends, posts and sharp changes in the geometry of the barrier components, kerbs, and the like, shall be avoided or transitioned out with a maximum taper of:

- 1 in 10 in the horizontal plane
- 1 (v) to 10 (h) in the vertical plane

for the barrier components, and a maximum taper of 1 in 20 for kerb discontinuities. Frangible attachments are defined as having a maximum section size 90 mm round with 3 mm wall thickness shall have a maximum taper of:

- 1 in 10 in the horizontal plane
- 1 (v) to 2 (h) in the vertical plane.

Clause 11.4 Ship collision with bridge piers

Paragraph 2 of this clause is deleted.

Clause 2.1(d) Height of Balustrades:

This clause states that the balustrade shall be 1.3 m above the kerb.

Austroads Guide to Road Design Part 6A: Pedestrian and Cyclist Paths, Clause 7.7. states that the balustrade shall be 1.4 m (minimum 1.2 m) above the riding surface.

In order to conform to both documents, a minimum height of 1.4 m must be used. A kerb is required under the balustrade to stop material falling off the bridge.

PART 1 : SCOPE AND GENERAL PRINCIPLES	
	Appendix B, Figure B1 On the left side, third box from bottom: “Figures B3.3.1 to B3.3.4” shall be amended to read “Figures B5 to B8”.

PART 2 : DESIGN LOADS	
	Amendment 1 of AS 5100.2:2010 is accepted excluding the amendment to Clause 7.3 which is not accepted by Transport and Main Roads. The remaining clauses shall be adopted.
	Clause 6.3 Heavy Load Platform Loads. The design loads for bridges are the W80, A160, SM1600 and HLP400. The lateral placement of the HLP400 is: a) <u>Two marked-lane bridge, 2 way traffic rural bridge</u> b) ±1.0 m either side of centreline of the bridge, or c) One lane ramp d) Shall be positioned on a one lane ramp as located by the designer. The tolerance on lateral position shall be specified. The minimum lateral tolerance shall be ±1.0 m. Consideration shall be given to the most likely path of the vehicle, or e) <u>All other situations, excluding (a) and (b) above</u> (for example, three or more marked lanes, 2 way traffic, and two or more lanes, one way traffic, non-rural roads). f) The HLP shall be placed ±1.0 m either side of the centre of any two adjacent lanes. g) In order to provide safe traffic movement of load platforms in area with high traffic volumes, the lateral position of the HLP within the carriageway must be considered in the context of road user safety. A HLP will generally travel in the outmost left-hand lanes, except at merges and departures. However, a HLP cannot easily change lanes in heavy traffic without endangering the safety of the driver and escort of the HLP as well as other motorists. As such, consideration shall be given to the most likely path of the vehicle. The code co-existent half SM1600 loading in the adjacent lane/s shall be applied to create the worst effect. h) In the case of widening of an existing bridge, the minimum structural capacity of the <u>existing part</u> of a widened bridge shall be HLP 320. If this cannot be achieved through economical strengthening, then it may be necessary to build a replacement structure for HLP 400 loading on priority mass routes. i) The designed location of the HLP 400 shall be shown on the General Arrangement drawing.
	Clause 6.7.3(ii) The clause shall be amended to read: 0.1 for a cover depth of 2 m or more for all loads excluding S1600. (S1600 is a stationary load and has no impact. Table 6.7.2 states that S1600 has zero dynamic load allowance).
	Clause 7 <u>Any</u> pedestrian and/or bicycle-path on a bridge with a pedestrian and/or bike-path width between kerbs greater than 3.5 m shall be designed for the live loads in Clause 7 <u>PLUS</u> consideration of how inspection and maintenance will be undertaken. If the inspection and maintenance is required to be taken from the bridge, the minimum inspection and maintenance truck loading is a M13.5 truck as defined in Figure A8 of AS 5100.7. The truck live loading shall conform to AS 5100.2. All other footbridges/footpaths and/or bicycle-paths shall be designed in accordance with Clause 7 live loads. The balustrade for the maintenance truck shall be designed for panic crowd loads 3.0 kN/m and the deflection requirements of AS 5100.2 Clause 11.5.
	Figure 7 ‘For walkways attached to the road or railway bridge superstructure’ shall be interpreted as: 1. “Attached walkway load” shall be designed with simultaneous traffic loads, and

PART 2 : DESIGN LOADS

2. "Independent walkway load" shall be designed with no traffic load.

Clause 8.5.1, 2nd paragraph, 2nd line

'8.5.4' shall be amended to '8.5.5'.

Clause 10.2

The existing clause is deleted and replaced by the following clause.

10.2 Glancing collision load from road traffic

The supports for a bridge or other structure within a road reserve shall be designed to resist a minimum equivalent static load of 2000 kN which is assumed to act in any direction in a horizontal plane. The load shall be applied 1.2 m above ground level. The contact length of the load is the smaller of the contact length (e.g. width of pier) or 2.4 metres This load, in conjunction with the ultimate design dead loads on the structure, shall be considered at ultimate limit states, with a load factor of 1.0.

As this load does not represent a head on collision load, the supports that are within the clear zone of not less than 10 m shall be protected against direct impact from a vehicle travelling at an angle of less than 15° from the direction of the road centre-line passing under the bridge. Unless approved otherwise by the Authority, this protection shall comprise TL5 rigid road barrier to AS 3845 for speeds greater than 80km/h and TL4 rigid road barrier to AS 3845 for speeds less than or equal to 60km/h complying with the requirements of Clause 11.2 with appropriate approach treatment. The barriers shall be designed so as to not transmit the barrier design load to the bridge supports.

A rigid barrier is refined as is defined as having zero or extremely limited deflection, movement or yielding deformation when impacted by an errant vehicle. Examples of rigid barrier are extruded or cast in-situ concrete barrier restrained at the base. A Precast Concrete Barrier is not a rigid barrier.

Abutment walls comprising reinforced soil shall be protected from collision or shall be provided with sufficient redundancy so that the bridge that it supports shall not collapse in the event of a collision. If the RSS wall is located outside the 10 m clear zone, no additional protection from impact is required.

The clear zone clearance is measured from the lane line (the white line).

Note that the above Clause 10.2 stipulates that all bridge supports within a road reserve shall be designed for the minimum impact of 2000 kN regardless of the location of the bridge support.

<u>WORKING WIDTH</u>

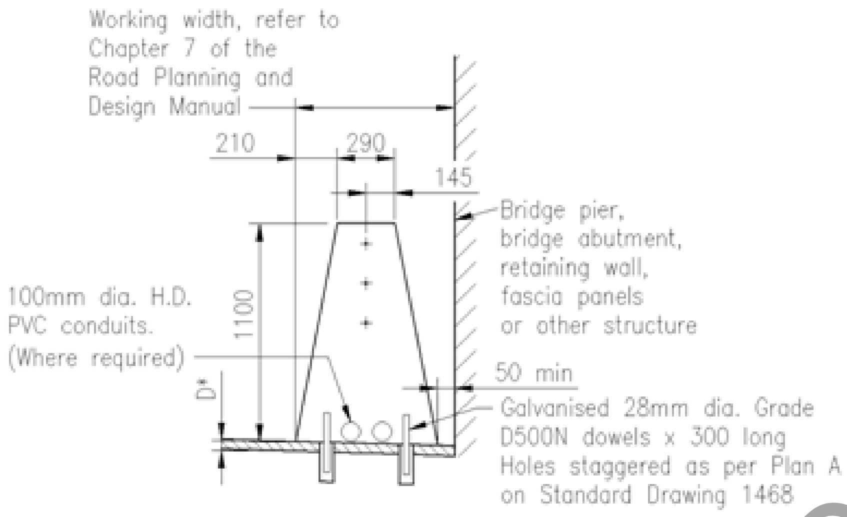
Working Width conditions are specified in *Road Planning and Design Manual*, Chapter 7.

The working width behind the barrier front face corresponds to the region where an impacting vehicle may extend during an impact (zone of intrusion) as described in AASHTO *Roadside Design Guide.*

The motorway cross section and alignment should be adjusted if necessary to satisfy the above conditions.

The rigid TL5 barrier are to be separated from the structure by a clear gap that is large enough to ensure the barrier collision load is not transmitted to the structure. Figure 1 shows an acceptable arrangement of extruded concrete barrier. Figure 1 supersedes Section Views "Cast against Walls/Piers" and "Offset from Walls and Piers" in Standard Drawing 1468 (3/04). The minimum distance detailed is only applicable for rigid barriers.

PART 2 : DESIGN LOADS



WORKING WIDTH AT STRUCTURES

The TL5 barrier shall be extended beyond the ends of bridge substructure, for at least the minimum lengths determined, as described in *Road Planning and Design Manual* Chapter 8, or connected to the roadside barriers by a transition barrier if necessary.

The flare rate of the barrier (angular deviation) to the traffic lanes shall not exceed 1 in 20. The minimum width of the horizontal section at the top of the barrier shall be 150 mm for single slope concrete barrier on one face, or 200 mm for single slope concrete barrier on both faces.

The bridge pier, bridge abutment or sign gantry shall be designed for a Glancing Collision Load in accordance with the department's *Design Criteria for Bridges and Other Structures, Part 6 Additional Requirements to AS 5100 Bridge Code.* If the existing bridge piers and abutments consist of column type structures they may require retrofitting with reinforced concrete "infilling" between individual columns to provide a blade structure for robustness and structural adequacy for impact resistance.

Protection of Bridge Supports within the 10 m clear zone

Also note that supports that are within the clear zone of not less than 10 m shall be protected using a TL5 rigid road barrier for speeds greater than 80 km/h and TL4 road barrier for speeds less than or equal to 60 km/h as a minimum barrier requirement. However the design barrier performance level shall be determined using the barrier selection method in AS/NZS 3845 and the department's *Road Planning and Design Manual*. The design performance level of the barrier may be greater than TL5, depending on the results of the barrier selection method.

A rigid reinforced concrete barrier shall be used unless there are drainage considerations that requires an open steel rail and post barrier. Appropriate foundations shall be used to limit deflections of the barrier to prevent transmission of the barrier design load to the bridge supports.

Guardrail, W beam and wire rope barriers are not permitted.

Existing bridge supports may require retrofitting with reinforced concrete "infilling" to provide a blade structure for robustness and structural adequacy for impact resistance.

Protection of Bridge supports outside the 10 m clear zone

Acceptable barrier types are extruded concrete barriers, structural steel rail and post or G9 (Modified) Thrie Beam (AS/NZS 3845) barriers for the protection of bridge supports that are located more than the clear zone of 10 m.

The selection of barrier type is subject to the results of a risk analysis taking into account the modification factor for horizontal curve, slopes etc in Chapter 8 of the *Road Planning and Design Manual*. The minimum acceptable barrier is the G9 (Modified) Thrie Beam.

Wire Rope barriers shall not be used to protect bridge supports from vehicle impact.

PART 2 : DESIGN LOADS

For road safety requirements, the barrier alignment and total length of barrier shall be in accordance with the department's *Road Planning and Design Manual*.

Clause 11.2.1

First sentence is ambiguous. Replace first sentence by:

'The design criteria, including loads and geometric requirements, provided in this Clause 11 (AS 5100.2) and in AS 5100.1, Clause 10 shall be used for the following:'

Clause 11.2.2

The last paragraph shall be replaced by:

Concrete barriers are rigid barriers whilst post and rail barriers are semi-rigid. All loads on concrete traffic barriers shall be applied 50 mm below the top face of the traffic barrier. Where the barrier height is increased due to electrification, anti-throw and/or fire protection requirements by increasing the height of the concrete barrier, the additional barrier height is not to be modelled in the above traffic impact analysis, as it is not required for vehicle redirection. All rails on a post and rail barrier shall have the same size. All loads on rail and post type barriers shall be applied for the greater effect of:

- equal load on each rail
- the centroid of the load is greater than or equal to the minimum effective height in Table 11.2.3.

The distribution of the longitudinal loads to posts shall be consistent with the continuity of rail elements. Distribution of transverse loads shall be consistent with the assumed failure mechanism of the barrier system.

Table 11.2.3

Delete existing table and replace by:

Barrier performance level	Minimum effective height (H_c) mm
Low	500
Regular	800
Medium	1100

Clause 11.5 Pedestrian Railing Design Loads

The design of pedestrian railing loads without panic loads shall conform to either:

a) Clause 11.5, or

b) Transport and Main Roads standard drawings for steel and aluminium balustrade.

Clause 14

AS 1170.4 – 1993 shall be used in conjunction with AS 5100.2 – 2004.

Figure 15.2.1

On horizontal axis, right end, '0.2' shall be replaced by '2000'.

Clause 15.2.2

Include, Serviceability Limit State load factor shall be 1.0.

Figure 16.3.3

Replace 'Drug' on vertical axis caption by 'drag'.

Figure 17.3

The structure depth 'd' shall be replaced by 'D'.

PART 3 : FOUNDATIONS AND SOILSUPPORTING STRUCTURES	
	Amendment 1 of AS 5100.3:2010. This amendment shall be adopted.
	No requirements.

PART 4 : BEARINGS AND DECK JOINTS	
	Amendment 1 of AS 5100.4:2010. This amendment shall be adopted.
	Clause 12.6.8(c) c) For plain pads and strips:' shall be amended to read: For plain pads and strips the value of the compressive strain(ε_c) to be used in deriving the compressive deflections (d_c) shall be determined as follows:'
	Clause 14.2 2nd paragraph 'AS 1449' shall be amended to read 'ASTM A240/A240M-03b'

PART 5 : CONCRETE	
	Amendment 1 of AS 5100.5:2010. This amendment shall be adopted.
	Amendment 2 of AS 5100.5:2010. This amendment shall be adopted.
	Additional requirements to AS 5100.5 for prestressed members • Maximum compressive stress at transfer: $0.6f_{cp}$ (in accordance with Clause 8.1.4.2) • Maximum compressive stress at all other times: $0.4f'_c$
	Equation 8.1.4.1(2) The correct equation is: $\frac{A_{st}}{bd} \geq 0.22\left(\frac{D}{d}\right)^2 \frac{f'_{cf}}{f_{sy}}$
	Table 6.3.1 The strands referenced in Table 6.3.1 shall be replaced by AS 4672.1 – 7 wire – 12.7 – 1870 – Relax 2, and AS 4672.1 – 7 wire – 15.2 – 1750 – Relax 2 The stressing bars detailed in Table 6.3.1 shall be replaced by bars from AS/NZS 4672.1.
	Equation 8.1.6(1) Shall be amended to read: $\sigma_{pu} = \sigma_{p.ef} + 6200 \times \frac{(d_p - k_u d)}{L_{pe}}$
	Clause 8.3.4(a) The clause shall be amended to: Torsional reinforcement is not required if: i) $T^* < 0.25\phi T_{uc}$; or …8.3.4(1)

PART 5 : CONCRETE

(ii) $\frac{T^*}{\phi T_{uc}} + \frac{V^*}{\phi V_{uc}} \leq 0.5$; or …8.3.4(2)

(iii) $\frac{T^*}{\phi T_{uc}} + \frac{V^*}{\phi V_{uc}} \leq 1$ and the overall depth of the beam is not greater than 250 mm or half the width of the web .8.3.4(3)

where T_{uc} and V_{uc} shall be calculated in accordance with Clauses 8.3.5 and 8.2.7, respectively and T^* shall be calculated taking into account the effect of cracking on the torsional stiffness.

Clause 8.6.1(a)

Delete and replace with:

(a) The minimum area of reinforcement in a tensile zone of a beam shall comply with Clause 8.1.4.1.

Clause 8.6.2 (a) to (b)

Clause 8.6.2 (a) and (b) are deleted and replaced by:

The crack control for flexure in prestressed beams shall be determined as follows:

a) Monolithic beams. Flexural cracking in a prestressed beam shall be deemed to be controlled if under the serviceability limit state load combinations, the resulting maximum tensile stress in the concrete is not greater than $0.25\sqrt{f'_c}$ and $0.25\sqrt{f'_{cp}}$ as appropriate or, if this stress is exceeded, reinforcement or bonded tendons, or both, near the tensile face shall be provided and either-

   i) The calculated maximum flexural tensile stress under the serviceability limit state load combination, including transfer shall be limited to-

   $0.5\sqrt{f'_c}$ or $0.5\sqrt{f_{cp}}$; or …8.6.2

   ii) In the case of HLP 400 loading only, the increment in steel stress near the tension face shall be limited to 200 MPa as the load increases from its value when the extreme concrete tensile fibre is at zero stress to the serviceability limit state load combination values. The centre-to-centre spacing of reinforcement, including bonded tendons shall be limited to 200 mm.

b) Segmental members at unreinforced joints. Under all serviceability limit state load combinations, the residual compression shall be not less than 1 MPa.

Clause 10.7.3.1 (a) (iii)

A. With reference to Clause 10.7.3.1 (a) (iii) of AS 5100.5, when columns have been designed with N* < 0.5 ØNu, "full" lateral restraint of longitudinal bars does not have to be provided. In such cases, columns designed with N* < 0.5 ØNu must be provided with the following minimum lateral restraints.

   At least every sixth longitudinal bar must be restrained in accordance with Clause 10.7.3.2 to 10.7.3.4 of AS 5100.5 and the horizontal distance between laterally restrained bars must not exceed 1000 mm

   All bundled longitudinal bars must be laterally restrained in accordance with Clause 10.7.3.2 of AS 5100.5.

   The vertical spacing of lateral restraints must not exceed 600 mm.

B. The provisions of Clause 10.7.3.5 of AS 5100.5 for earthquake resistance take precedence over and may override the above requirements.

Clause 13.3.2 Third Paragraph

Replace "0.1Lp" by 0.1Lpt".

Appendix H Figures H1(B) and H1(C)

On all cross sections, the bottom flange thickness is denoted as 1b. It shall be replaced by t_b to be consistent with Tables H2(B)(1) & H2(B)(2)

PART 6 : STEEL AND COMPOSITE CONSTRUCTION

Amendment 1 of AS 5100.6:2010.

This amendment shall be adopted.

Amendment 2 of AS 5100.6:2010.

This amendment shall be adopted.

Table 3.2, Items (c) and (c) (i) of Amendment 1.

Delete existing Items (c) and (c) (i) and replace as follows:

(c) Connections Connection component other than bolt, pin, rivet or weld	12.3.6	0.90
(i) Bolted connections:		
- bolt in shear	12.5	0.80
- bolt in tension	12.5	0.80
bolt subject to combined shear and tension	12.5	0.80
- ply in bearing	12.5	0.90
- bolt group	12.5	0.80

Clause 5.1.8.3(b)

'hydrid' shall be amended to 'hybrid'.

Equation 5.6.1.1(2)

The version in the standard is:

$$\alpha_s = 0.6\left[\sqrt{\left(\frac{M_s}{M_{oa}}\right)^2 + 3 - \left(\frac{M_s}{M_{oa}}\right)}\right]$$

The correct formula is:

$$\alpha_s = 0.6\left[\sqrt{\left[\left(\frac{M_s}{M_{oa}}\right)^2 + 3\right]} - \left(\frac{M_s}{M_{oa}}\right)\right]$$

Equation 5.6.1.2(1)

The version in the standard is:

$$M_o = \sqrt{\frac{\pi^2 EI_y}{L_e^2}}\left[\sqrt{GJ + \left(\frac{\pi^2 EI_w}{L_e^2}\right)} + \left(\frac{\beta_x^2}{4}\frac{\pi^2 EI_y}{L_e^2}\right) + \left(\frac{\beta_x}{2}\sqrt{\frac{\pi^2 EI_y}{L_e^2}}\right)\right]$$

The correct equation is

PART 6 : STEEL AND COMPOSITE CONSTRUCTION

$$M_o = \sqrt{\frac{\pi^2 EI_y}{L_e^2}\left[\sqrt{\left[GJ + \left(\frac{\pi^2 EI_w}{L_e^2}\right) + \left(\frac{\beta_x}{4}\frac{\pi^2 EI_y}{L_e^2}\right)\right]} + \left(\frac{\beta_x}{2}\sqrt{\frac{\pi^2 EI_y}{L_e^2}}\right)\right]}$$

(Error: length of square root sign)

Equation 5.6.2

The version in the standard is:

$$\alpha_s = \left[\sqrt{\left[\left(\frac{M_s}{M_{ob}}\right)^2 + 3\right]} - \left[\frac{M_s}{M_{ob}}\right]\right]$$

The correct equation is:

$$\alpha_s = 0.6\left[\sqrt{\left[\left(\frac{M_s}{M_{ob}}\right)^2 + 3\right]} - \left[\frac{M_s}{M_{ob}}\right]\right]$$

(Error: 0.6 missing)

Table 5.6.5(A)

The relationship for factor, k_t, for case PP, shall be:

$$1 + \frac{\left[2\left(\frac{d_1}{L}\right)\left(\frac{t_f}{2t_w}\right)^3\right]}{n_w}$$

(Error: '2' missing from in front of (d_1/L))

Table 5.6.5(B)

Version in the standard is:

Longitudinal position of the load	Restraint arrangement	Load height position	
		Shear centre	Top flange
Within segment	FF, FP, FL, PP, PL, LL, FU, PU	1.0 1.0	1.4 2.0
At segment end	FF, FP, FL, PP, PL, LL, FU, PU	1.0 1.0	1.0 2.0

Correct version is:

Longitudinal position of the load	Restraint arrangement	Load height position	
		Shear centre	Top flange
Within segment	FF, FP, FL, PP, PL, LL,	1.0	1.4
	FU, PU	1.0	2.0
At segment end	FF, FP, FL, PP, PL, LL,	1.0	1.0
	FU, PU	1.0	2.0

Error: FU and PU values incorrect.)

PART 6 : STEEL AND COMPOSITE CONSTRUCTION	
	Equation 6.4.2.2(5) The version in the code is: $\lambda_d = 0.018\left(\frac{L_b}{r_y}\right)^{\frac{1}{2}}\left(\frac{d_w}{t_w}\right)^{\frac{1}{3}}$ Correct version is: $\lambda_d = 0.018\left(\frac{L_b}{r_y}\right)^{\frac{1}{2}}\left(\frac{d_w}{t_w}\right)^{\frac{1}{3}} - 0.4$
	Equation 6.6.4.4(2) Delete existing equation and replace by: (b) $f_{ks} = 0.31 d_{bs}^{2}\sqrt{f'_{cy} E_c}$
	Equation 10.6.2.2(1) The version in the code is: $N_{us} = \phi A_s \eta_2 f_y + \phi A_r f_{ry} + \phi_c A_c f_c'\left(\frac{1+\eta_1 t f_y}{d_0 f_c'}\right)$ Correct version is: $N_{us} = \phi A_s \eta_2 f_y + \phi A_r f_{ry} + \phi_c A_c f_c'\left(1+\frac{\eta_1 t f_y}{d_0 f_c'}\right)$
	Equation 10.6.2.2(2) The version in the code is: $\eta_{10} = 4.9 - 18.5\lambda_r + 17(\lambda_r)^2$ (*but* ≥ 1) Correct version is: $\eta_{10} = 4.9 - 18.5\lambda_r + 17(\lambda_r)^2$ (*but* ≥ 0)
	Equation 10.6.2.2(3) The version in the code is: $\eta_{20} = 0.25(3 + 2\lambda_r)$ (*but* ≤ 0) Correct version is: $\eta_{20} = 0.25(3 + 2\lambda_r)$ (*but* ≤ 1)
	Equation 10.6.2.2(4) The version in the code is: $\eta_1 = \eta_{10}\left(\frac{1-10e}{d_o}\right)$ Correct version is: $\eta_1 = \eta_{10}\left(1-\frac{10e}{d_o}\right)$

PART 6 : STEEL AND COMPOSITE CONSTRUCTION	
	Equation 10.6.2.2(5) The version in the code is: $\eta_2 = \eta_{20}(1-\eta_{20})\dfrac{10e}{d_o}$ Correct version is: $\eta_2 = \eta_{20} + (1-\eta_{20})\dfrac{10e}{d_o}$
	Appendix A, Equation A4 (3) The version in the code is: $K = \dfrac{\sqrt{\pi^2 EI_w}}{GJL^2}$ Correct version is: $K = \dfrac{\pi}{L}\sqrt{\dfrac{EI_w}{GJ}}$ (Error: square root)
	Appendix E, Equation E (5) The version in the code is: $M_p = f_y\left[Ad_g - b_f\left(d_h + d_s\right)d_h\right]$ Correct version is: $M_p = f_y\left[Ad_g - b_f\left(d_h - d_s\right)d_h\right]$ (Error + in bracket)

PART 7 : RATING OF EXISTING STRUCTURES	
	Amendment 1 of AS 5100.7:2010. This amendment shall be adopted.
	Appendix A, Figures A11, A12, A13 The last three figures are incorrectly located and shall be amended as follows: The diagram of Figure A11 shall be shifted to Figure A13; The diagram of Figure A12 shall be shifted to Figure A11; The diagram of Figure A13 shall be shifted to Figure A12; All three Figures shall have two notes: 'Dimensions in meters' and Axle loads in kN' The title of Figure A12 shall be 'Figure A12 300-A-12 Railway Traffic Loadings Axle Group Spacing'
	Appendix A, Clause A 3.2, first sentence Line 2, 'Figure A12' shall be 'Figure A11' Line 3, 'Figure A13' shall be 'Figure A12'
	Other Information Specialist literature may be consulted for unusual situations. Any errors or anomalies in AS 5100 shall be discussed with the Deputy Chief Engineer (Structures) for clarification or for amendment to this document and the code.

7 Matters for resolution to AS 5100

Matters for resolution before design commences.

The matters for resolution listed below shall be confirmed as accepted by Transport and Main Roads before commencing the design process:

No.	Issue	Applicable to Project
	AS 5100.1 Scope and general principles	
1	a) Application of the provisions of this Standard to the design of modifications to existing bridges (see Clause 2)	Bridges over 100 m span will have additional special criteria.
2	Design life of ancillary elements (see Clause 6.2)	Refer Clause 3.7.1 of this document.
3	Use of non-linear analysis methods (see Clause 6.4)	Non-linear analysis is not permitted as primary design method. Computer program must be tested and certified.
4	Other effects, including load effects, to be considered regarding specific additional conditions and requirements (see Clause 6.8)	Some special cases may be required. Discuss with Transport and Main Roads.
5	Bridge waterway requirements (see Clause 7.1)	Job specific. Refer hydraulic brief. In general, velocities must be kept close to natural velocities.
6	Determination of environmental requirements including requirements of the waterway authority (see Clause 8)	Drainage from deck on case by case. In general, water to discharge through scuppers unless over road or railway.
7	Geometric requirements for all bridges (see Clauses 9.1, 9.2 and 9.3)	Safe design speed ® minimum radius as required by rail or waterway authority and Transport and Main Roads. Geometry shall conform to the *Road Planning Design Manual* and *Austroads Road Design Guide*.
8	Geometric arrangement of railway bridges (see Clause 9.2)	As required by rail authority
9	Road bridge carriageway widths (see Clause 9.4)	In accordance with AS 5100
10	Edge clearances from the edge of the traffic lane to the face of the safety barrier (see Clause 9.5)	In accordance with AS 5100
11	Horizontal clearances to substructure components of bridges over roadways (see Clause 9.6)	Job specific.
12	The minimum vertical clearance of structures over roadways (see Clause 9.7)	Refer Clause 3.1.2.4 of this document. Job specific requirements may override Table 9.7.
13	Vertical and horizontal clearances for bridges over railways (see Clause 9.8)	As required by rail authority.
14	The superelevation and widening of the deck surface of a bridge on a horizontal curve (see Clause 9.9)	As per Transport and Main Roads *Road Planning and Design Manual*.

No.	Issue	Applicable to Project
15	Geometric requirements for walkway and pedestrian bridges (see Clauses 9.10 and 9.11)	Minimum clearance on stand-alone footbridge 6.5 m but 300 mm higher than adjacent bridges.
16	Dimensional requirements for pedestrian subways (see Clause 9.12)	1:33 for disabled access – varies with length.
17	Determination of barrier performance level and barrier type requirements (see Clause 10.2)	“Regular” level as minimum for new road bridges (not over rail). New bridges over railways to conform to railway requirements (QR/MR documents MCE-SR-007) but the minimum level shall not be less than “regular”.
18	Acceptance criteria for bridge traffic barriers (see Clause 10.4)	Strength of the bridge barriers shall be evaluated using structural analysis in accordance with traffic barrier design loads given in AS 5100.2. Crash test results shall not be solely used as an acceptance criterion. Structural analysis and crash testing are both required for evaluation.
19	Specification of performance levels for traffic barriers including bridge rehabilitation (see Clause 10.5.1)	New bridges over railways to conform to railway requirements (QR/MR documents MCE-SR-007). Retrofit barrier shall conform to both Transport and Main Roads and the rail authority criteria. For all other bridges: For new bridges, a minimum criterion is "regular" to AS 5100.2. The actual level shall conform to AS 5100. However, Safety in Design considerations may require higher levels (for example, work taking place adjacent to barrier, hence vehicle incursion must not occur to protect the workers). For design speed equal to or in excess of 80 km/h and a radius less than 400 m, bridges shall have 1500 mm minimum height bridge barriers on the outside of the curve. For design speed less than 80 km/h and a radius less than 400 m, consideration shall be given to a bridge barrier higher than 1100 mm for concrete parapets and/or 1000 mm for steel traffic barrier to prevent overturning on the barrier and loss of side friction on the pavement. Special consideration shall be given where the speed environment transitions from high speed to a lower speed (for example, off ramps), In such cases the barrier shall be designed for the higher speed. Design of road approach barriers shall be in accordance with AS 3845 and the *Road Planning and Design Manual* respectively. On widened bridges The barrier on the widened side must conform to current design requirements. The barrier on the un-widened side would have been designed to the design criteria current at the time of design. The following action shall be undertaken:

No.	Issue	Applicable to Project
		Bridges with a repeated crash history of vehicle impacts or vehicles overturning shall be replaced by barriers conforming to AS 5100. Where AS 5100 would currently require a performance level higher than “Regular”, the bridge must be modified to provide a higher level of protection. If impractical or uneconomic, applications for a design relaxation shall be submitted to the Director (Bridge and Marine Engineering) for assessment. Where a “regular” level barrier or less is required by AS 5100 and the deck cannot support the current barrier design loads, a risk analysis for an existing bridge shall be undertaken in accordance with AS 5100.1 Clause 10.5.1. The minimum strength for replacement rails is 50% of “low” performance level for concrete decks. If impractical or uneconomic, application for a design relaxation shall be submitted to the Director (Bridge and Marine Engineering) for assessment. Note: Some existing barriers with little strength (concrete post with water pipe rails and concrete posts with balustrade) have little strength. <u>Replacement of barrier damaged by vehicle impact, flood or due to bridge maintenance.</u> The original barrier on the bridge would have been designed to the design criteria current at the time of design. The following action shall be undertaken: (1) The barrier should be replaced with a barrier conforming to AS 5100 if the existing deck has sufficient structural capacity to support the design load. Where AS 5100 specifies a performance level higher than “Regular”, the deck must be modified to provide a higher level of protection. If impractical or uneconomic, applications for a design relaxation shall be submitted to the Director (Bridge and Marine Engineering) for assessment. Where a “regular” level barrier or less is required by AS 5100 and the deck cannot support the current barrier design loads, a risk analysis for an existing bridge shall be undertaken in accordance with AS 5100.1 Clause 10.5.1. If the bridge conforms to these criteria, a barrier of a lesser performance level may be installed. The minimum strength for replacement rails is 50% of “low” performance level. If impractical or uneconomic, applications for a design relaxation shall be submitted to Director (Bridge and Marine Engineering) for assessment.

No.	Issue	Applicable to Project
		Note: Some existing barriers with little strength (concrete post with water pipe rails and concrete posts with balustrade) have little strength. For timber decks, which do not conform to the above, the matter should be referred to Deputy Chief Engineer (Structures). <u>Upgrading of existing traffic barriers on bridges.</u> There is no requirement to replace barriers automatically just because a new code has been released. The barrier on the original bridge would have been designed to the design criteria current at the time of design. Upgrading of exiting barriers is a rare event. However, based on a risk assessment or adjacent accidents or near misses, it may be decided to upgrade a barrier. The following actions shall be undertaken: 1. The barrier would be replaced with a barrier conforming to AS 5100 if the existing deck has sufficient structural capacity to support the design load. 2. Where AS 5100 would currently require a performance level higher than "Regular", the bridge shall be modified to provide a higher level of protection. If impractical or uneconomic, applications for relaxation shall be submitted to the Director (Bridge and Marine Engineering) for consideration. . 3. Where a "regular" level barrier or less is required by AS 5100 and the deck cannot support the current barrier design loads, a risk analysis for an existing bridge shall be undertaken in accordance with AS 5100.1 Clause 10.5.1. The minimum strength for replacement rails is 50% of "low" performance. If impractical or uneconomical, applications for a design relaxation shall be submitted to Director (Bridge and Marine Engineering) for assessment.
20	The need and provision of special performance level barriers (see Clause 10.5.6)	Minimum height 1.4 m. Risk analysis to be undertaken.
21	The height and profile of parapet type barriers (see Clause 10.6.1)	Minimum 1.1 m
22	Geometric requirements for post and rail type barriers (see Clause 10.6.2)	In accordance with Clause 10.6.2
23	The extent of transition of the road approach barrier system to the bridge barrier (see Clause 10.6.3)	In accordance with Transport and Main Roads Standard Drawings.
24	Performance levels for collision protection (see Clause 11.1)	As per AS 5100
25	Requirements for protection of bridge supports from road traffic collision (see Clause 11.2)	A concrete conforming to the geometry of Figure 7.22 of the *Road Planning and Design Manual*.

No.	Issue	Applicable to Project
26	Requirements for protection of bridge supports from railway traffic collision (see Clauses 11.3.1, 11.3.2, 11.3.3 & 11.3.4)	In accordance with railway authority requirements.
27	Requirements for protection of bridge supports from ship collision (see Clause 11.4)	The Harbour Master or Port Authority shall recommend the type of vessel, weight of vessel and speed for impact on the bridge. This includes the channel and adjacent pier locations. The upper bound loads shall consider all vessels currently operating in the waterway or likely to operate in the waterway for the next 100 years. The minimum velocity of impact shall be the larger of the maximum of flood velocity or the speed of the vessel under power. The proposed design vessel and speed shall be reviewed by the Transport and Main Roads and amended if necessary prior to acceptance by the department. The Equivalent Static Ship Impact Force in the ultimate loads shall be determined in accordance with AASHTO LRFD Bridge Design Specification. The minimum Equivalent Static Ship Impact Force applicable to piers in navigable waterways shall be determined or accepted by Transport and Main Roads. Transport and Main Roads does not permit collapse/removal of a pier provided the superstructure does not collapse as an allowable design case (Paragraph 2 of Clause 11.4 is deleted). Method of design for ship impact shall be based on one of the two following methods. Energy dissipation separate from bridge The preferred option is that the energy dissipation system shall be separate from the bridge structure and spaced so that the dissipation system does not impact the bridge after deformation from ship collision. This may take form of a fender system or an artificial island built around the pier. The fender system shall be designed as an ultimate design load case. The layout of the fender system shall be such that it guides the vessel through the bridge opening and does not have opening such that the vessel can directly contact the pier/abutment by bypassing the fender system. The artificial islands must be resilient to scour and their extent must not reduce the navigation clearance. The choice of artificial island as an energy dissipation device would be subject to the relevant environmental permit and to acceptance by the Harbour Master or Port Authority. Impact on pier (or abutment) Transport and Main Roads may in some cases permit the provision of a combined pier/abutment and fender system. Piers in the stream shall be designed for an Equivalent Static Ship Impact Force in the

No.	Issue	Applicable to Project
		direction of the channel centreline. The piers shall be designed to resist a load of half the Equivalent Static Ship Impact Force applied separately in a direction perpendicular to the channel centreline. These forces hall be applied anywhere between 1.0 m above Mean Low Water Spring(MLWS) and 1.0 above Mean High Water Spring(MHWS). The superstructure shall be designed to resist force equal to 20 percent of the Equivalent Static Ship Impact Force. The bridge shall be proportioned designed to resist the above collision loads elastically. The capacities of members shall then be determined by applying the appropriate material factors to these “elastic” member loads. The elastic capacity shall be determined using linear elastic stress strain curves and assuming that the steel stress is limited to its yield stress (0.0025 strain for 500 MPa steel) and concrete strain is limited to the strain corresponding to 0.85 times F’c (0.0011 strain for S50 concrete). The collision load may be applied simultaneously with permanent serviceability loads and 0.4 times the live load. The following load cases shall be considered: 1.2 DL + 2.0 SDL + 0.4 $(1+\alpha)$ W * 1.8 *SM1600 + 1.8 PL + Ship Impact + PE; or YDL (min) DL + YSDL (min) SDL + Ship Impact Where:- DL = Dead Load SDL = Superimposed Dead Load α = Dynamic Factor W = Multiple lane factor SM1600 = Live load with or without braking PL = Pedestrian Load YDL = Dead Load Factor YSDL = Superimposed Dead Load Factor PE = Permanent Effects as defined in CI 22.1.1 of AS 5100.2 except for Dead Loads and Superimposed Dead Loads NOTE – The load combinations shall include effects to obtain the most severe loading. Serviceability thermal effects may be included if they produce an adverse effect. Rubbing rails and fenders shall be provided to ensure no direct vessel contact on the pier/abutment. The Equivalent Static Ship Impact Force energy dissipation model adopted in design shall be described in detail in the Design Report. Pier positioning, fender systems and/or collision systems shall also be considered and accepted by Transport and Main Roads prior to undertaking the detailed design.

No.	Issue	Applicable to Project
		The type of vertical arrangements of fenders shall be designed for the tidal range and the range of vessels expected during the design life of the bridge. The fender arrangement shall be acceptable to Transport and Main Roads and the Harbour Master or Port Authority. All areas subject to ship impact shall have a layer of sacrificial stainless steel mesh, to protect the structure from damage due to ship impact. Protection of the bridge structure during the construction phase shall also be designed
28	Requirements for protection barriers for bridges over electrified railways (see Clause 12.2)	In accordance with rail authority requirements.
29	Requirements for protection screens to prevent objects falling or being thrown from bridges (see Clause 12.3)	In accordance with rail authority requirements.
30	Requirements for the attachment of and design loads for noise barriers on bridges (see Clause 13)	All attachments and fittings hot dip galvanized or stainless steel.
31	Drainage requirements for bridge approaches (see Clause 14.1)	Refer road design.
32	Attachment of utility services on structures (see Clause 16)	Job specific.
	AS 5100.2 Design Loads	
33	Varying loads on the basis of engineering measurements and calculations (see Clause 1)	Design code: AS 5100: 2004 Significant variation from code SM 1600 HLP 400 position diagram Design speed Fatigue criteria (for Concrete Railway Bridges, Steel Bridges) Pedestrian load Collision load Wind speed Flood data (velocity, level) Earthquake zone Differential settlement (If Applicable) Barrier performance level Construction method (When Required)
34	Value of γ_g for large segmental cantilever construction for the case when dead load reduces safety (Table 5.2)	Job specific
35	Value of γ_{gs} to be applied to the nominal superimposed dead load (see Clause 5.3)	2.0
36	Specification of heavy load platform design load (see Clauses 6.2 and 6.3)	HLP 400. May be higher on specific heavy load routes.

No.	Issue	Applicable to Project
37	Requirement for design loads and load factors if road bridges are to carry tramway or railway traffic (see Clause 6.4)	Job specific
38	Number of lanes to be included for braking force and calculations (see Clause 6.8.2)	As per code. Taking into account future redevelopment.
39	Number of stress cycles for fatigue load calculation (see Clause 6.9)	As per AS 5100
40	Design vehicle load for walkway (Clause 7.1)	20 kN
41	Requirement for design for crowd loading (see Clause 7.1)	Job specific. May be higher than AS 5100 value where crowd loading expected. Minimum of 5 kPa over the whole span for crowd loading for special events/festivals.
42	Design loads for railway bridges and bridges carrying light rail and the like (see Clause 8.1)	As specified by relevant authority.
43	Dynamic load allowance for specific structures, track standard and train speeds (see Clause 8.4.7)	As determined by rail authority.
44	Need for protection beams to protect superstructures of low clearance bridges (see Clause 10.3)	For existing bridges Protection beam shall be provided as per AS 5100.2 Clause 10.3 For new bridges If the bridge height clearance could not be provided as specified in Clause 3.1.2.4 of this document, bridge superstructure shall be designed for additional loads as per the AS 5100.2 Table 10.3.
45	Risk analysis and redundancy levels for determination of alternative load path (see Clause 10.4.2)	As determined by rail authority.
46	Need for and determination of collision loads on support elements (see Clause 10.4.3)	As determined by rail authority.
47	Other design requirements for collision loads from railway traffic (see Clause 10.4.6)	As determined by rail authority.
48	Determination of traffic barrier design loads (see Clause 11.2.2)	Minimum level “regular”. Higher level if determined by risk study.
49	Determination of effective heights of traffic barriers (see Clause 11.2.3)	In accordance with AS 5100.
50	Barrier anchorage requirements (see Clause 11.2.4)	As per Clause 11.2.4
51	Requirement for pedestrian barrier design for crowd loading (see Clause 11.5)	Panic load in high profile locations.
52	Criteria for dynamic analysis (see Clause 12.2.3)	Determined on job specific basis.

No.	Issue	Applicable to Project
53	Need for assessment of vibration behaviour for railway bridges (see Clause 12.3)	As required by rail authority.
54	Classification of bridges and associated structures that are essential to post-earthquake recovery (see Clause 14.3.2)	Type III includes major stream crossing including Gateway bridge, Captain Cook bridge, Burnett River, Fitzroy river, Burdekin river and any major road where there will be a major deviation. Type II is overpasses as per Clause 14.3.2.
55	Identification of an requirements for earthquake design for bridges identified as particularly important (see Clause 14.4.1)	Bridge specific requirements.
56	Any changes to the importance level for noise barriers (see Clause 24.2)	Refer Transport and Main Roads Specification MRTS15.
	AS 5100.3 Foundations and soil-supporting structures	
57	Design requirements for foundations for overhead wiring structures (see Clause 2)	Refer relevant authority design criteria.
58	Detailed method and formulae to be used for the design of geotechnical or structural elements (see Clause 2)	As per AS 5100.
59	Supervision of site investigation (see Clause 6.1)	Geotechnical engineer unless specified otherwise.
60	Extent and coverage of preliminary and design investigation (see Clause 6.1)	Unless job specific requirement.
61	Minimum number of bore holes (see Clause 6.2)	One per pier/abutment
62	Selection of the geotechnical strength reduction factors (see Clause 7.3.4)	As per AS 5100
63	Requirements for consideration of future development (see Clause 7.8)	Job specific when specified.
64	Other durability criteria (see Clause 9.1)	Job specific
65	Use of treated and untreated timber (see Clause 9.2)	Not permitted for bridges.
66	Requirements for prevention of corrosion of reinforcement (see Clause 9.3)	Consult rail authority for electrified lines, other areas seek expert advice.
67	Acceptance of rates of corrosion for steel surface (see Clause 9.4)	Adopt AS 5100 unless better site data provided.
68	Requirements to minimise corrosion effects of stray currents (see Clause 9.3)	Consult rail authority for electrified lines, other areas seek expert advice.
69	Acceptance of slip factor coatings (see Clause 9.5)	Refer MRTS67
70	Durability requirements of other materials (see Clause 9.6)	Subject to written acceptance by Transport and Main Roads.
71	Design requirements for durability of materials used in shallow foundations (see Clause 10.3.6)	As per AS 5100

No.	Issue	Applicable to Project
72	Requirements for structural design and detailing for shallow footings (see Clause 10.4)	As per AS 5100
73	Requirements for materials and construction for shallow foundations (see Clause 10.5)	As per AS 5100
74	Use of timber piles (see Clause 10.3.1)	Temporary works only
75	Requirements for durability of materials used (see Clause 10.3.4)	As per AS 5100
76	Requirements for structural design and detailing for construction of piles (see Clause 11.4)	As per AS 5100
77	Requirements for materials and construction for pile (see Clause 11.5)	As per AS 5100
78	Requirements for testing of piles (see Clause 11.6)	Dynamic testing in accordance with Standard Specification MRTS68
79	Design requirements for durability of anchorages and anchorage components (see Clause 12.3.6)	As per MRTS03
80	Requirements for materials and construction for anchorages (see Clause 12.4)	As per AS 5100
81	Requirements for method of installation and on-site assessment tests for anchorages (see Clause 12.6.1)	As per MRTS03
82	Proof load test for anchors (see Clause 12.6.2)	As per MRTS03
83	Requirements for anchorage acceptance tests (see Clause 11.6.3)	As per AS 5100
84	Requirements for design of retaining and abutments (see Clause 13.1)	As per AS 5100
85	Acceptance of geotechnical strength reduction factor for retaining walls and abutments (see Clause 13.3.1)	As per AS 5100
86	Design requirements for durability (see Clause 13.3.5)	As per AS 5100
87	Requirements for structural design and detailing for retaining walls (see Clause 13.4)	As per AS 5100
88	Requirements for materials and construction for retaining walls and abutments (see Clause 13.5)	As per AS 5100
89	Acceptance of drainage system (see Clause 13.6)	As per AS 5100
90	Requirements for the design of buried structures (see Clause 14.1)	As per AS 5100

No.	Issue	Applicable to Project
91	Design requirements for the durability of materials (see Clause 14.3.3)	As per AS 5100
92	Requirements for structural design and detailing for buried structures (see Clause 14.4)	As per AS 5100
93	Requirements for materials and construction for buried structures (see Clause 14.5)	As per AS 5100
	AS 5100.4 Bearings and deck joints	
94	No entries	
	AS 5100.5 Concrete	
95	Acceptance of the use of new or alternative materials and methods of design or construction (see Clauses 1.5.1 and 1.5.2)	Subject to written acceptance by Transport and Main Roads.
96	Design requirements of lightweight structural concrete (see Clause 1.5.4)	Not permitted
97	Minimum cover at post-tensioning anchorages (see Clause 4.10.2(e))	No reduction permitted
98	Requirements for control of cracks in columns and tension members (see Clause 10.1.4)	Must comply with Clause 8.6
99	Determination of proof test load (see Clause 17.3)	Case specific, to be accepted by Transport and Main Roads.
	AS 5100.6 Steel and composite construction	
100	Requirement for members and materials for new and unusual bridge types (see Clause 1.1.2)	Only with written Transport and Main Roads acceptance
101	Design requirements for structural elements using non-ferrous metals (see Clause 1.1.2)	Only with written Transport and Main Roads acceptance
102	Requirements for steels for machined parts and for uses in other than structural member elements (see Clause 2.2.4)	Only with written Transport and Main Roads acceptance
	AS 5100.7 Rating of existing bridges	
103	Application of performance load testing results to determine the rated load (see Clause 5.4.4)	Shall conform to AS 5100
104	Conditions for amending the dynamic load allowance (see Clause 5.5.1)	Shall conform to AS 5100
105	Transport and Main Roads acceptance to the use of a reduced live load factor for load capacity rating of a bridge (see Clause 5.5.2)	Shall conform to AS 5100
106	The load factors to be used when rating a bridge (see Clause 6.1)	Shall conform to AS 5100

No.	Issue	Applicable to Project
107	Transport and Main Roads acceptance to modification of load factors for serviceability limit states (see Clause 6.2)	Shall conform to AS 5100
108	Transport and Main Roads acceptance to modification of load factors for ultimate limit state (see Clause 6.3.1)	Shall conform to AS 5100
109	Transport and Main Roads acceptance to the use of a live load factor which is less than the design value (see Clause 6.3.2)	Shall conform to AS 5100
110	Use of modified live load factors based on probability of overloading (see Clause 6.3.3)	Shall conform to AS 5100
111	Conditions for use of load factors for specific loads (see Table 6.3)	Shall conform to AS 5100
112	Transport and Main Roads acceptance to the determination of ratings for fatigue (see Clause 7)	Shall conform to AS 5100
	Design Specified requirements	
S1	Stage construction	Job specific
	minimum lane widths	
	minimum number of traffic lanes	
S2	Special conditions	Job specific
	special clearances	
	abnormal loads	
	existing barriers on bridges to be widened (non widened side)	

8 Tunnel design requirements

8.1 Design and construction of tunnel structures

8.1.1 Scope

The scope of this section includes:

- Immersed tube tunnels
- Bored tunnels
- Cast-insitu in a waterway using coffer dams
- Tunnels for the cartage of dangerous goods. Such goods being transported on designated alternative open road routes
- Bus stations.

Documents to be referenced in Design and Construction of Tunnels

This guide is complementary to the *Austroads Guide to Road Tunnels.* This document takes precedence over the Austroads *Guide to Road Tunnels* where there is a disagreement. The following documents shall be referenced in design and construction:

- Tunnel Code of Practice 2007 (Queensland).
- Australian Standard for Tunnel Fire and Life Safety.
- Austroads *Guide to Road Tunnels - Part 1: Introduction for Road Tunnels*
- Austroads *Guide to Road Tunnels - Part 2: Planning, Design and Commissioning*
- Austroads *Guide to Road Tunnels - Part 3: Operation and Maintenance of Road Tunnels*
- Transport and Main Roads Queensland, *Road Planning and Design Manual*: Chapter 23 Tunnels.
- Queensland Transport, *Busway Planning and Design Manual*
- BS 8081 *Code of Practice for Ground Anchorages*
- AS/NZS ISO 31000:2009 *"Risk Management - Principles and Guidelines".*

8.1.2 Useful references in design and construction of tunnels

The following documents are considered useful references.

- BS 6164 *Code of Practice for Safety in Tunnelling in the Construction Industr*y
- UK Highways Agency, *Design Manual for Roads and Bridges, Design of Road Tunnels*, BD 78/99
- Road and Traffic Authority: *Road Tunnel Design Guidelines Part 1 Concept Design*
- Road and Traffic Authority, *Road Tunnel Design Guidelines Part 2 Development of a Scope of Work and Technical Criteria*
- Road and Traffic Authority, *Road: Design Guidelines Part 3 Design Development*
- International Tunnelling Insurance Group, *A Code of Practice for Risk Management of Tunnel Works, 2006*.

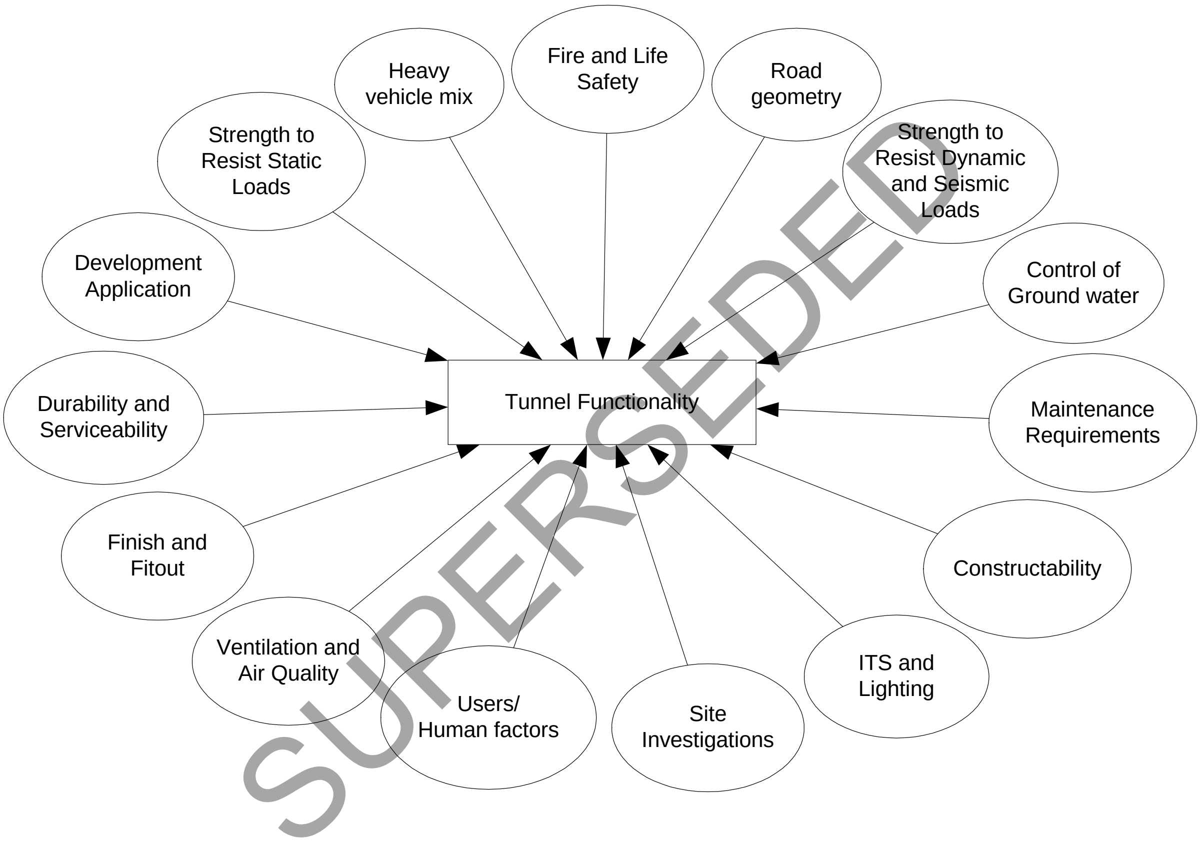
8.1.3 Design objectives

8.1.3.1 General

a) The objectives for design and construction of a tunnel are derived from the functionality requirements of the tunnel and shall be documented in the Design Brief (may be termed the "functional specification" for detailed design).

b) Figure 8.1.3.1 identifies a range of inputs into tunnel functionality that inputs into the tunnel design objectives (some of which are further expanded upon in following sections).

Figure 8.1.3.1 – Tunnel functionality inputs



8.1.3.2 Specific objectives

The specific objectives for design of any tunnel typically include:

a) *Operational* – To provide an internal space and environment appropriate to the functions of the tunnel.

b) *Structural* – To provide support for the surrounding ground for the design life of the tunnel, and to control the movement of ground water.

c) *Safety* – To provide a tunnel structure that can be constructed, operated and maintained safely, such that the risk of failure or damage from all reasonably foreseeable causes is extremely remote during construction and throughout the design and operational life of the tunnel.

d) *Economic* – To provide a tunnel structure that minimises whole of life cost.

e) *Role of the structure* – The tunnel structure and other structures provided undertake a variety of roles:

- to support the transport function throughout the design and operational life, and
- to provide structural adequacy to ensure fire resistance and fire separation in the event of fire.

While the first role ordinarily needs an understanding of geotechnical conditions and imposed loads to ensure a durable tunnel structure, the second role requires consideration of internal conditions to aid in the reduction of the conditions conducive to fire development, to enable detection and verification systems to function, to create appropriate separation between fire/smoke and safe areas, to prevent such safe areas becoming untenable and to prevent situations that may endanger emergency response personnel.

f) *Durability* – The tunnel must consist of components that are manufactured and/or constructed in such a manner that achieves efficiency, safety and economic requirements over the operational life.

g) *Robustness* – A tunnel structure shall not collapse due to the failure of one structural component. Tunnel facilities subject to deterioration through use shall be easily accessible and replaceable (for example, fans). Robustness requires that facilities that cannot be inspected, repaired or replaced (for example, permanent anchors and drainage on the earth face) must be equal or more durable than the rest of the tunnel (i.e. the design life shall be equal or greater than the tunnel structure itself). The structure shall be designed to be suitable for development adjacent to the tunnel.

h) *Functionality* – Achieving the intended purpose at the required level of services is critical to a successful outcome, whether the tunnel be for transport purposes, utilities, power water supply, and so on

8.1.4 Durability

Durability of the tunnel structure and its associated infrastructure will be determined by the design detail of those elements. The following criteria are to be adopted/used in the design:

a) Minimum exposure classification for cover to reinforcement shall be generally B2 to AS 5100 for the permanent components except for components where the design life of 50 years or less is specified in Clause 8.2 shall be designed for minimum exposure classification A2 to AS 3600.

b) Also refer to Clause 3.8.4 for additional requirements of concrete durability.

c) Structural design for control of cracking shall be carried out considering the exposure classification of AS 5100.5 Clause 4.3. However, in saline water, exposure classification C shall be used.

d) Cover to reinforcement in permanent concrete components shall be in accordance to AS 5100.2.

e) The cover to reinforcement in permanent shotcrete components (excluding reinforcement bars) shall be twice the cover for normally compacted, standard formwork concrete (based on AS 5100).

f) Shotcreting of reinforcement bars for permanent structural members is not permitted.

g) Protective treatment of permanent rock anchors shall be in accordance with BS 8081 "*Code of Practice for Ground Anchors"*.

h) Protective treatment of permanent steel structural members shall be by the provision of a coating to achieve the 100 year design life and specified fire rating,

i) Permanent mechanical fasteners/anchors are not permitted for heavy overhead facilities (for example, jet fans), however, mechanical fasteners/anchors may be used for supporting cable trays and lights. Chemical/adhesive anchors must not be used at all as the resin softens at 100°C and also suffers from creep. The ability of overhead fasteners to withstand the weight of the facilities (for example jet fans) under all conditions, including fire, shall be considered. Adhesive anchors shall not be used unless an analysis of embedment has determined that the thermodynamics of fire heat transfer of the adhesive are suitable and can withstand the effects of the design fire. Correctly specified adhesive anchors shall not suffer from creep and shall have an appropriate design life.

j) The minimum reinforcement in all blockwork shall be 12 mm diameter bars at 200 mm maximum centres horizontally and vertically.

k) Continuous flight auger piles are not permitted for tunnels.

8.1.5 Serviceability of tunnels

a) Maximum crack width in permanent concrete and shotcrete shall be 0.2 mm.

b) Following completion of construction, the in-service performance shall be nothing that dislodges and provides a hazard to the operation of the tunnel (for example, concrete particles, fittings and so on).

c) Tunnel portals shall have flood immunity derived from the greater of:

- The probable maximum precipitation event plus a 300 mm freeboard for climate change.
- Mean high water Spring tide, 100 year ARI flood and a 100 year ARI storm surge (where applicable) plus 300 mm freeboard for climate change.
- Highest Astronomical Tide plus 300 mm freeboard for climate change.
- Where the roadway geometry is such that surface water may otherwise run into the tunnel appropriate drainage is to be provided to prevent such ingress. Drainage is also to be provided to collect any rain water carries in by vehicles.

d) Drainage and any pump systems provided in the tunnel shall be designed for the worst of a 100 year ARI storm event, the requirements of any deluge system, wash down requirements or for firefighting incident management.

8.1.6 Fire and life safety

a) The following fire safety objectives shall be considered during design:

- Safeguard people from injury and exposure to toxic fumes/products due to a fire within a tunnel
- Facilitate the activities of operators and emergency services personnel
- Control and limit fire growth
- Control and limit fire spread between vehicles

- Minimise the risk of tunnel collapse resulting from fire
- Minimise the risk of flooding subsequent to a fire event
- Minimise the risk of collapse of adjoining buildings and structures as a result of fire within a tunnel
- Minimise the interruption to the operation of a tunnel resulting from a fire
- Develop a clear, reliable incident response plan to manage fire emergencies
- Safeguard people from the accumulation of harmful substances in a tunnel.

b) Structurally, tunnels shall provide the following in the event of a fire:

- fire rated separation between the fire zone and the nearby areas of comparative safety, such as a cross passage or the adjacent tunnel
- a limit to structural damage in the direct area of the fire to support response emergency services operation and emergency response
- an area away from the fire, where emergency equipment continues to operate and where objects do not fall thereby making conditions safe for people trying to escape or for emergency service response efforts accessing the incident.

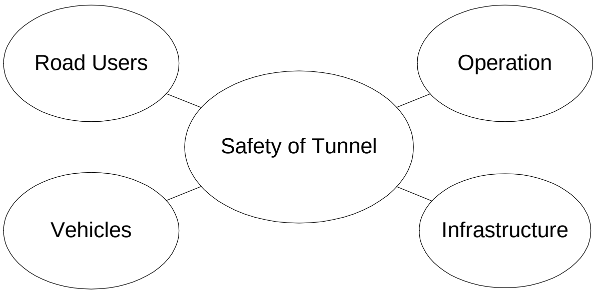
c) Typically, the rock/soil/concrete pillar largely creates the separation between tunnels. However fire doors in the cross passages and the walls built to house the doors will need to be designed to withstand a two hour fire. There are some situations however where more onerous design conditions are warranted, such as where there is the risk of tunnel collapse or inundation. These include:

- where any driven tunnel ramps cross over the main tunnels
- where the driven tunnels and shallow and significant structures above may be affected
- in cut and cover tunnels where significant structures above may be affected
- intermediate floor/roof levels in multilevel cut and cover sections
- in water bearing ground
- where failure of the lining would allow in inrush of water in significant quantities which could not be practically controlled by pumping.

d) In situations such as listed in (c), a secondary lining using a suitable passive fire protection material would be required. Further geological investigations are required to determine the passive resistance provided by rock and soil materials, particularly in areas of poor sub-surface materials.

e) Design for Fire and Life Safety shall be in accordance with AS 4825 Tunnel fire safety.

Figure 8.1.6 – Tunnel safety inputs



The design fire shall be:

- For road tunnels, a fast to ultra fast growth rate to a PHRR of 100 MW fire with a sensitivity case of 120 MW
- Busway tunnel shall be designed to withstand a fast to ultra fast growth rate to a PHRR of 30 MW fire with a sensitivity case of 40 MW
- Light rail tunnels shall be designed for a RABT-ZTV (train) fire curve.

f) The structural integrity of the tunnel shall remain intact after the fire. Structural fire resistance minimum is to be 120 minutes of ISO curve for non-critical locations, and 120 minutes of hydrocarbon fire for critical components. Where ISO fire applies, structural design shall comply with AS 3600 “Concrete Structures” provisions. Where hydrocarbon fire applies, passive protection shall be provided to the supporting structural components in the proximity of the fire to limit the maximum heat rise at concrete surface to 380 degrees for the specified duration.

g) The tunnel shall be designed for an extreme case of “no collapse” in the event that any installed deluge system does not operate.

h) The tunnel shall provide emergency “cross passages” or other emergency exist passages with a spacing not exceeding 120 m with fire safety doors allowing direct emergency exit.

i) The tunnel shall be designed for an extreme case of a “no collapse” case in the event that any installed deluge system does not operate.

j) Plastic reinforcement bar chairs are not permitted as, in the event of a fire, they melt and thus allow heat transfer to prestressing materials and reinforcement.

8.2 Design life – tunnels

- Permanent structural components – 100 years
- Inaccessible drainage components – 100 years
- Accessible drainage that is replaceable – 50 years
- Jet fan/major overhead equipment – 100 years
- Temporary structural components for support – 5 years
- Fans – 25 years
- Tunnel lights, sensors – 4 years

- Luminaries housing and supports – 25 years
- Cabling – 20 years
- ITS hardware – 15 years unless otherwise specified
- ITS software – 5 years
- Other electrics – 15 years
- Pumps – 10 years
- Wall panels, doors and architectural components – 40 years
- Asphalt surfacing (if provided) – 20 years

8.3 Review of drawings and scheme documents

The drawings and scheme documents are to be reviewed and accepted for safety, durability, future performance, constructability and maintenance by Transport and Main Roads officers in accordance with design management (generally reflecting a 15%, 85% and final design stages) and any permission to use (PTU)) requirements of the contract.

Handover Reports for Tunnels

a) The following reports shall be submitted:
   - RPEQ certified "As constructed" drawings signed and dated by the Administrator
   - Design Report
   - Construction Handover Report
   - Fire and Life Safety Report (minimum requirement is a copy of submission to Queensland Fire and Rescue Service (QFRS)
   - Operation, Inspection and Maintenance Manual
   - Incident Management and Recovery Manual
   - Level 2 (and Level 3 if required) Tunnel Inspection Report

b) All reports and manuals shall be submitted and accepted by Transport and Main Roads in accordance with the contract prior to opening the facility to use. All procedures/trials/ simulations/tests/training are to be satisfactorily completed prior to opening the facility to use.

8.3.1 "As constructed" drawings

a) The Contractor or Alliance shall provide "As Constructed" drawings, stamped, certified and dated by an RPEQ engineer experienced in the relevant engineering discipline (geotechnical, structural, civil, electrical and so on). Where tunnel schemes are constructed in accordance with the original drawings and specifications issued for construction, the Contractor/Alliance shall provide the original documents, stamped, certified and dated by the RPEQ engineers as a conformance record:
   - "As constructed" drawings shall certified by an RPEQ
   - An RPEQ shall certify all design changes and include into " As constructed" drawings
   - The Administrator must have documentation to prove "As constructed" details are true and correct, and shall sign the plans accordingly.

b) "As constructed" drawings shall contain, but not be limited to:

- Foundation details
- Variations/modifications during construction
- Works constructed outside tolerance
- Updated geotechnical reports, based on actual profile as determined during excavation
- Location of all rock anchors, including a statement if the anchors are short-term or long-term
- Service/Public Utility Plant (PUP) locations (and relocations).

8.3.2 Design report

a) A Design Report shall be prepared and provide details including, but not limited to:

- Transport and Main Roads publication design criteria/codes used, including date of publications and (any) amendments
- Date of referenced Transport and Main Roads *Design Criteria for Bridges and Other Structures* (Date of this document stated on the first page of this attachment)
- Other referenced documents
- Design criteria adopted, including those from other jurisdictions/regulatory authorities/ stakeholders
- The design methodology, durability, serviceability and ultimate loads, together with a statement of the design life for each structure and each component category (drainage, signs, metalwork, mechanical, ITS, asphalt, architectural components and so on)
- Controls/limits/restrictions/assumptions
- Construction methodology for the design developed
- Durability and Robustness
- "Safety in Design" considerations for construction, inspection, maintenance and operation.
- Achievement of functionality
- Achievement of Level Of Service (LOS)
- Assumptions, departures, Extended Design Domain (EDD).

b) The report shall demonstrate compliance with the Design Brief. Any proposed departures/relaxations/ exemptions from the Design Brief shall be discussed in terms of safety, durability, future performance, constructability, operations, maintenance and whole-of-life cost considerations. Any proposed departures/relaxations/exemptions shall be submitted to Transport and Main Roads Deputy Chief Engineer (Structures) for consideration in accordance with the contract. The Design Report shall be certified by the RPEQ responsible for each component of the design.

c) The final Design Report shall be submitted as part of the final scheme submission for Transport and Main Roads acceptance. For Alliance/Early Contractor Involvement (ECI)/

Design and Construct type projects, the Design Report shall be accepted by the department prior to construction commencing.

8.3.3 Construction handover report

A Construction Handover Report shall include:

- Safety in Design Report updated for construction
- Details of proprietary products
- Commissioning records - fire tests, ventilation validation, electrical supply validation, lighting validation, drainage validation and system integration
- Casting yard records
- Material test records

8.3.4 Fire and life safety report

Minimum requirement is a copy of submission to the QFRS.

Operation, Inspection and Maintenance Manual

a) An Operation, Inspection and Maintenance Manual shall be prepared as a part of the designer's Safety in Design obligations under the relevant act and regulations. The Manual relates to in-service inspection, maintenance and operation of the bridge and/or structure.

b) The Operation, Inspection and Maintenance Manual shall include but not be limited to:

   - Operational information on all structures and equipment (mechanical, electrical, ITS, and so on)
   - Inspection frequency (For typical bridges, this will be in accordance with the Transport and Main Roads *Bridge Inspection Manual*. For special/non-routine design, the frequency needs to be developed.)
   - Operational requirements
   - Inspection frequency (For tunnel structures special/non-routine design, the frequency will need to be developed.)
   - Details of inspection access requirements (including any confined space access requirements)
   - Design life of all components and sub-components. For any component or sub-component that has a design life less than the specified design life of the structure, details for replacement of the (sub-) component shall be provided.
   - Routine maintenance schedule, including cleaning, wash down, failed light replacement, incident response systems testing, and so on
   - Scheduled maintenance program, incorporating procedures for maintenance including replacement schedules. For paint systems, the procedure shall be suitable for repainting by roller or brush without abrasive blasting to bare metal. The recoat system shall be suitable for over-coating the previously applied system.

- Details of how routine and schedules maintenance will be undertaken
- Special maintenance.

8.3.5 Incident management and recovery manual

An Incident Management and Recovery Manual shall be prepared and shall include, but not be limited to:

- Vehicle breakdown
- Damage-only incident
- Debris on road
- Fire
- Injury incident
- Spills
- Load shedding
- Over-height vehicles
- External electrical supply failure
- Water on pavement
- Flooding
- Explosion and release of noxious liquid or gas
- Incident management training (including any in-tunnel incident trials/simulations/tests).

8.3.6 Level 2 (and Level 3) inspection of tunnel

a) A Level 2 (and Level 3 if required) inspection shall be carried out by a qualified inspector prior to opening of the facility to use in accordance with the Transport and Main Roads *Bridge Inspection Manual* and the results provided to the department for entering into Transport and Main Roads Bridge Information System.

b) Structure and Design inventory verification forms shall be completed.

8.3.7 Learnings

The projects shall identify in the documentation any learnings for possible application to future projects.

8.4 Investigations for tunnels

a) Tunnel design differs significantly from design of plant and other structures because of the difficulty of determining accurate geological properties and the potential variability of these properties along the tunnel.

b) It is essential that adequate information is obtained from the site investigations so that the best possible information is obtained for the design (refer to Austroads *Guide to Road Tunnels,* Part 1, Workplace Health and Safety Queensland's *Tunnelling Code of Practice* (2007) and Work Cover NSW's *Tunnels under Construction – Draft Code of Practice* (2006).

c) Site investigation should include but not be limited to:

- Geological modelling
- Geotechnical investigations
- Hydrogeological assessment
- Ground water and soil aggressivity testing.

8.5 Design criteria

8.5.1 General

Tunnels shall conform to the following criteria:

a) When the top surface of the tunnel roof forms part of a road or busway, this section of the tunnel shall be designed for **one** of the following four options:

- the worst combination of tunnel and bridge design criteria (for example, cast-in-place piles for a bridge may be the controlling criterion)
- interconnected reinforced concrete secant pile with a minimum diameter of 900 mm.
- 1200 mm diameter cast-in-place piles installed in accordance with Standard Specification MRTS63 when an inspection shield is required with a maximum spacing of 2.5 diameters. The space between the piles shall be connected with a reinforced concrete arching system that has a drainage layer behind it.
- 900 mm diameter cast-in-place piles installed in accordance with Standard Specification MRTS63 when no inspection shield is required with a maximum spacing of 2.5 diameters. The space between the piles shall be connected with a reinforced concrete arching system that has a drainage layer behind it.

b) A theoretically drained tunnel designed without hydraulic head is not permitted. The minimum head shall be the higher of:

- the water table, or
- not less than 2/3 of the tunnel height, with the full tunnel height being sensitivity test.

c) All tunnels in road reserve or under public space shall have a 100 mm reinforced concrete protection slab constructed above the tunnel.

d) Tunnels shall be designed for asymmetric load transfer and asymmetric hydraulic head of water.

e) If the height of cover over the tunnel crown is in material capable of arching, and is less than the width of the tunnel, a detailed analysis of arching shall be undertaken.

f) Design of concrete shall consider concrete shrinkage and temperature effects.

g) Any concrete ceiling to separate traffic from air ducts shall be supported on concrete corbels.

h) All structural fittings/anchors shall be Grade 316 stainless steel.

i) The outside of the tunnel lining is to be provided with a drainage layer and waterproof membrane.

j) No water shall leak from the tunnel or wall, or drip from the tunnel soffit onto the tunnel road surface.

k) Long-term concrete modulus relevant for deflection calculations shall be used.

l) Any property acquisition and areas required for easements, including those to mobilise the soil block for ground anchors, soil nails, rock bolts, and so on, shall be determined.

m) The designer shall produce resumption and easement plans to identify the tunnel in regards to permissible future development above the tunnel.

n) Geometric design, pavement design, visual amenity, drainage design, ventilation design, lighting design, electrical supply, monitoring and control, services and plant rooms shall be in accordance with Austroads Guide to Tunnels – Part 2: Design of Road Tunnels, draft.

8.5.2 Road and bus tunnels – additional requirements

a) For road and bus tunnels, traffic barriers in tunnels shall be a minimum of 1100 mm high, single slope concrete barriers.

b) The geometric constraints of tunnels mean that the designer shall ensure that the geometric shape of the tunnel and (decorative) wall panels is such that errant vehicles do not contact the tunnel or wall panels after they have impacted the barrier (refer Chapter 7 of the *Road Planning and Design Manual*).

c) The confined space of the tunnel must be adequately considered when designing for crash cushions.

d) The geometric shape of a tunnel poses additional risks that are required to be protected by barriers. These include:

- Protecting the tunnel and other infrastructure from being impacted by vehicles
- Reduced sight distances on curved sections
- Reduced lateral clearances.

e) Special consideration needs to be made to the use of work cushions at entrances/approaches/merges and diverges.

8.5.3 Design criteria – driven tunnel

Driven tunnels shall conform as follows:

a) Design of concrete shall consider shrinkage of concrete, and temperature (ordinal and differential) effects.

b) Symmetric and asymmetric loads are to be considered for design of initial and permanent support.

c) Unreinforced concrete and/or fibre reinforced concrete tunnel secondary linings are not permitted in the tunnel roof as permanent support.

d) Sprayed waterproof membranes are not permitted.

e) Contiguous piles shall have a minimum diameter of 600 mm

f) A drainage layer shall be provided behind the walls.

8.5.4 Design criteria – cut and cover tunnel

Cut and cover tunnels shall conform as follows:

a) The cut and cover tunnel shall be designed as undrained.

b) The tunnel roof and connection to the walls shall be coated with a sheet membrane.

c) Cover to concrete shall be in accordance with AS 5100.

d) The minimum exposure classification for cover of concrete members shall be B2. Structural design for control of cracking shall be undertaken, taking the exposure classification of AS 5100.5 Clause 4.3 into account.

e) The exterior walls and deck shall be integral. Bearings are not required under deck units if they are used in the roof.

8.5.5 Parametric study

A parametric study shall be undertaken on the sensitivity of the tunnel design to the adopted design loads and assumptions.

8.6 Design loads

8.6.1 Live loading

Live loading above Tunnels, in surface Tunnel Portal Transition Zones, and within Easement Areas shall be in accordance with Clause 8.6.1.1 to 8.6.1.3 as appropriate.

8.6.1.1 Vehicle live loads – to be applied anywhere in the road corridor

a) Live Loading shall be limited to SM1600, HLP 400, W80 and A160 in accordance with the requirements of Australian Standard AS 5100-2004 and the vehicles in Figure 8.6.1.3.

b) Crane loading:

- It is desirable that crane outrigger loads must not exceed other additional loads listed in Clause 8.6.1.2.
- However crane loads are project specific and shall be nominated by the design engineer.
- The maximum outrigger load, outrigger spacing and minimum rigid bearing area shall be specified by the designer.

8.6.1.2 Other additional loads

"Other additional loads" comprise:

- Resulting uniformly distributed working loads of up to 50 kPa acting at ground level,
- Natural surface level build-up of up to 1 m with fill equivalent to a uniformly distributed load of 20 kPa, and
- Any loads from permitted developments above (such as residential, commercial or industrial, etc).

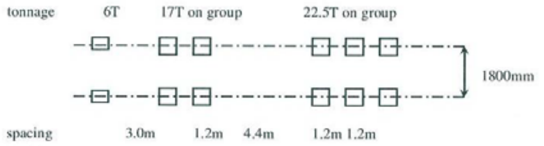
8.6.1.3 Tunnel structure retaining wall design loads

a) Fill maximum surcharge of 25 kPa (1.2 m Depth).

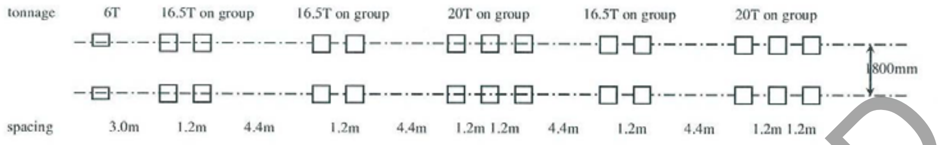
b) Live load surcharge load behind retaining walls to be applied as 25 kPa uniform surcharge in accordance with AS 5100.

Figure 8.6.1.3 – Design vehicles live loads above tunnels

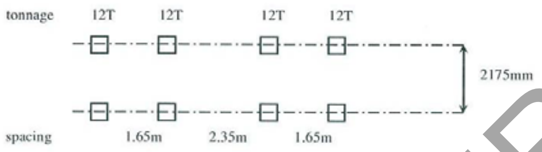
1. A 45.5T Semi Trailer:
   - Overall width and tyre patch as per T44 loading from Austroads Bridge Design Code 1992.
   - All axles except 6T axle are tandem axles.



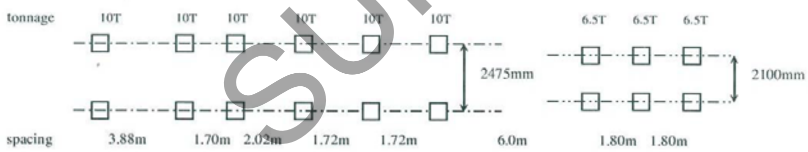
2. A Road Train configuration:
   - Overall width and tyre patch as per T44 loading from Austroads Bridge Design Code 1992.
   - All axles except 6T axle are tandem axles.

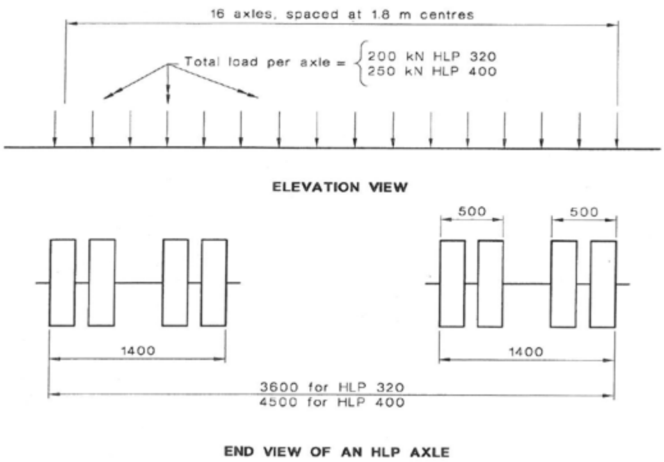


3. A 48T crane configuration (V3)
   - Overall width (outside if tyres): 2700mm
   - All axles with single tyres of width: 525mm



4. A 79.5T crane configuration (V4)
   - Overall width (outside if tyres): 3000mm (front) & 2600 (mm)
   - All 10T axles with single tyres of width: 525mm
   - All 6.5T axles with dual tyres of width: 500mm





8.7 Mechanical and electrical services and ITS

The tunnel design shall accommodate the provisions of AS 61508 *"Functional safety of electrical/electronic/programmable electronic safety-related systems"* and ITS.

8.8 Construction

8.8.1 Construction specifications

a) Supplementary specifications for tunnel concrete and shotcrete shall be in accordance with Transport and Main Roads requirements.

b) Concrete shall conform to the requirements of Transport and Main Roads Standard Specification MRTS70 for alkali silicate reactivity assessment.

c) Tunnel construction shall conform to Transport and Main Roads Specifications MRTS03, MRTS04, MRTS06, MRTS71, MRTS72, MRTS73, MRTS74, MRTS75, MRTS78, MRTS78A, MRTS79, MRTS91, MRTS93, MRTS94, MRTS95 and the relevant Transport and Main Roads ITS specifications.

d) The contractor's working method and system shall be designed to control ground water. Removal of ground water by the contractor shall not be undertaken in such a manner as to cause damage to any existing development or structure and the tunnel.

e) Significant lowering of the natural ground water table shall be avoided.

f) The contractor shall install piezometric devices to monitor seasonal fluctuations in ground water between the tunnel and any existing development or structure.

8.8.2 Instrumentation

The contractor shall install thermocouples in concrete linings to monitor the response of the concrete. Shrinkage testing of the actual concrete shall be undertaken to confirm the actual performance of the concrete

8.8.3 Design validity check during construction

a) The design assumptions must be validated during construction.

b) Testing or other physical assessment is required to ensure that any drainage liner has not been crushed or otherwise damaged during construction.

8.8.4 Validation of permanent anchors

a) 1% of all permanent anchors shall be cored out to demonstrate rock/mortar and mortar/anchor interfaces are adequately constructed.

b) 10% of all rock anchors shall be proof tested to the serviceability load.

c) The design and construction shall allow for extra 1% of all rock anchors in excess of the design number for long-term durability monitoring/testing.

8.8.5 Level 2 inspection of tunnel

A Level 2 inspection shall be carried out by a qualified inspector prior to opening of the facility to use in accordance with the Transport and Main Roads *Bridge Inspection Manual* and the results provided to the department for entering into Transport and Main Roads Bridge Information System.

9 Development application in the proximity to tunnels

9.1 General

The tunnels that service the network are either cut and cover tunnel or driven (mined) tunnel.

The following tunnels, a combination of cut and cover as well as driven tunnels are already built, being built or in the planning stage:

- Nundah Bypass Tunnel
- Tugun Bypass Tunnel
- Buranda Tunnel
- Water Street Tunnel
- Vulture Street Tunnel
- Inner Northern Busway Tunnel (Roma Street to RBH)
- Boggo Road Tunnel
- Eastern Busway Tunnel – Stage II
- Northern Busway Tunnel
- Future Northern Busway
- Cross River Rail Tunnel
- Airport Link Tunnel.

It is possible that some of the above mentioned tunnels have been constructed prior to the current Design Criteria being developed.

Design of new tunnels shall follow this criteria and any new development application is vetted against this criteria as well as the condition imposed by the designer on the tunnel, on a case by case basis.

The tunnel Design Loads are given in Section 8.6.The tunnel design loads differs from one tunnel to the other. The easement arrangements are in place for some tunnels, being negotiated for the other. Some tunnels have no easement arrangement, but volumetric resumption are in place.

Hence it is mandatory for the developer who proposes to build adjacent to existing tunnels to consult the department regarding the permissible loading on the tunnel, adjacent to the tunnel as well as permissible excavation on the tunnel and near the tunnel.

9.2 Development scenarios

Any new development application falls into the following two situations:

- The proposed new development precede the tunnel construction
- The proposed new development comes after the tunnel construction.

a) The proposed new development precedes before the tunnel construction:

The development application shall be reviewed by Transport and Main Roads using the available information of the proposed tunnel design, current at the time of the application.

The tunnel design engineer to make provisions for future development stream lined along the tunnel corridor or in anticipation of future development allowance should be made in the design. However, Transport and Main Roads shall impose conditions that the proposed development shall not interfere with the future tunnel construction and the developer deemed to take adequate measures not to hinder the tunnel construction once the development had been completed.

b) The proposed new development comes after the tunnel construction

There are two scenarios in this category. The future development is adjacent to the tunnel or on top of the tunnel.

This criterion is directed to the developments adjacent and or on top of the already built tunnel that it is either a new one or an earlier generation tunnel.

Any new developments adjacent to the tunnel may consist of some or all of the following: demolition, excavation and construction. Transport and Main Roads is vested with responsibility to safeguard the vital tunnel infrastructure and to ensure that the proposed new development has no adverse impact on the integrity of the tunnel. The **safety of the travelling public is paramount** and the tunnel safety cannot be compromised at any time due to any construction activity large or small adjacent to the tunnel.

9.3 Additional requirements for tunnels

a) Excavation, installation of services or other construction works under the tunnel is not permitted without the written acceptance of Transport and Main Roads prior to commencement of works. The department will advise of the design checks required to be accepted, prior to commencing work, on a case-by-case basis.

b) Easement plans on some tunnels detail the maximum depth of excavation and maximum increase of vertical loading. If the Development conforms to these instructions, no further design checks are required.

c) When the excavation does not conform to these limits, the department will detail the scope of the design check and the need for an independent proof engineering on a case-by-case basis.

d) Installation of permanent anchors within the tunnel easement area for structures on adjacent properties is not permitted. Temporary anchors shall be de-stressed prior to the completion of construction. RPEQ certification of the de-stressing shall be submitted to Transport and Main Roads within 28 days of their de-stressing.

e) Acceptance to install rock anchors that protrude in to the tunnel easement area or within 2 m of Transport and Main Roads tunnel infrastructure shall be obtained prior to undertaking the works.

f) Transport and Main Roads may permit temporary anchors to be installed in departmental property, subject to the anchors being sufficiently clear of exiting tunnel infrastructure so as not to damage it. The developer shall de-stress the anchors prior to completion of the development.

g) Any work adjacent to any tunnel infrastructure shall cause no deleterious effect on Transport and Main Roads infrastructure.

9.4 Zone of influence for tunnels

9.4.1 Bored tunnels

a) For development involving proposed construction adjacent to a Transport and Main Roads bored tunnel, the lateral distance from the extreme perimeter of tunnel structure which does not trigger the need for Transport and Main Roads review shall be the greater of:

- 25 m
- $W/2 + D_t$
- $W/2 + D_c$
- $2D_t$
- $2D_c$

where,

W = Tunnel width

D_t = Tunnel depth

D_c = Depth of construction.

b) For multiple bored tunnels, this clearance distance is:

- as above
- where clearance envelopes for two tunnels or more overlap, all proposals shall be referred to Transport and Main Roads for acceptance.

9.4.2 Cut and cover tunnel

For the cut and cover tunnels, a lateral distance greater than 10 m from the extreme perimeter of the tunnel structure does not trigger the need for Transport and Main Roads review.

9.5 Permissible excavation within the easement area

9.5.1 Bored tunnel

No excavation above the tunnel roof shall be deeper than 2 m or a quarter of the tunnel width for driven tunnels whichever greater and the excavation must not extend into the minimum top cover (above the tunnel roof) which was defined by the tunnel designer.

Additional criteria are subject to agreement with Transport and Main Roads Deputy Chief Engineer (Structures).

9.5.2 Cut and cover tunnel

a) Above the Tunnel

From the natural surface level, no closer than 0.5 metres to the top of the tunnel roof for cut and cover tunnels,

b) Beside the Tunnel and in the Transition Zone from the Surface to the Tunnel Portal

- no excavation to approach closer than 0.5 metres to side of the tunnel structure.
- from the natural surface level to a depth of no greater than 3.5 metres. Where tie back anchorages are present Transport and Main Roads review is required.

9.6 Potholing criteria for tunnels

a) Potholing, demolition, excavation, installation of services or other construction works above the tunnel and for a width equivalent to the tunnel width each side of the tunnel, are not permitted without the written acceptance of Transport and Main Roads prior to commencing the works.

b) Tunnels rely on the support of the surrounding soil as part of the soil-structure interaction. The Developer is required to submit a design report certified by an RPEQ tunnel engineer for any proposed works.

All details and associated conditions of the development shall be shown on the plans.

9.7 Development scenarios

9.7.1 The new development is adjacent to the tunnel

a) The Proposed new development is without basement, no excavation and no shoring – called without basement

b) The proposed development is with basement, excavation and shoring – called with basement

Based on the development scenarios the following tunnel monitoring scheme to be followed:

Table 9.7.1 - Tunnel survey and monitoring requirements

Type of Monitoring	Cut and Cover Tunnel		Driven Tunnel	
	Without Basement	With Basement	Without Basement	With Basement
Dilapidation Survey (DS)	Yes	Yes	Yes	Yes
Vibration Monitoring	Yes if piling involved	Yes	Yes if piling involved	Yes
Crack Monitoring	Based on DS	Based on DS	Based on DS	Based on DS
Tilt Meter	N/A	N/A	N/A	Yes
Ground Movement				
Inclinometers	N/A	Yes	N/A	Yes
Rod Extensometers	N/A	N/A	N/A	Yes
Ground Water Monitoring	N/A	Yes	N/A	Yes

9.7.2 The new development is on top of the tunnel volume

Among the tunnels listed in Section 9, some tunnels will have volumetric resumption negotiated with the property owner. Hence there will be a buffer around the tunnel governed by the volumetric extent negotiated. Nevertheless, future development might occur on top of the tunnel. There will arise scenarios where the new development- basement construction may encroach the buffer negotiated.

Hence the following cases can be anticipated:

- Development on top of the tunnel - basement not encroaching the easement buffer
- Development on top of the tunnel - basement ends at the easement boundary, however footing encroach into the easement buffer
- Development on top of the tunnel – basement and footing encroach the easement buffer.

The conditions related to the above cases are to be addressed on a case-by-case basis.

9.8 Tunnel survey

9.8.1 Dilapidation survey: prior to during and post construction

a) The tunnel dilapidation survey shall be carried out by the Developer prior to demolition, excavation and construction work. The survey shall assess the tunnel's current structural condition and shall record all existing cracks and other defects. Photographs shall support the dilapidation survey. An RPEQ engineer shall carry out the dilapidation survey, which is carried out with the consent and in the presence of the Transport and Main Roads Representative. A copy of the dilapidation survey shall be given to the Transport and Main Roads Representative not less than five (5) working days before any works that cause vibration or alter local stresses in foundation materials. The dilapidation survey shall be undertaken no more than six months prior to commencement of work.

b) Dilapidation survey – Survey duration for Driven tunnels:

Transport and Main Roads required inspection of the tunnel lining (the secondary layer) on a monthly basis during excavation stage of the basement bulk excavation and thereafter at the following stages: (i) End of bulk earth work basement excavation, (ii) completion of basement work – "close off" of basement ground level slab, (iii) End of the development. Early termination of dilapidation survey is at the discretion of the Deputy Chief Engineer, Structures in the event of no change in the tunnel behaviour.

c) Dilapidation survey – Cut and Cover Tunnels:

For cut and cover tunnels, Transport and Main Roads will rule on the survey duration based on the initial dilapidation survey report. However, a minimum of two dilapidation surveys (prior to the development and the other at the end of the development) are mandatory.

d) Prior to commencing work, the Developer shall have a prestart meeting with Transport and Main Roads to discuss the construction method and program, monitoring of trigger and alarm levels, and any matters requiring reporting of changed conditions or the need to stop work until a safety assessment is completed. Site meetings to discuss progress and issues shall be held not less frequently than monthly. No demolition, excavation or construction shall commence prior to the department's acceptance of the dilapidation study.

e) The Developer shall, at his own cost, make good any damage to the adjacent infrastructure adversely affected by his construction work.

9.8.2 Survey of instability due to excavation – capping beam survey

Any basement construction adjacent to the tunnel always consists of retaining walls. The depth of soil retention depends on the number of basements proposed. The instability of the excavation wall, that is, the retaining walls needs to be captured during and after construction. Transport and Main Roads requires survey monitoring points to be identified on the retaining wall capping beams and monitored. Transport and Main Roads required survey monitoring to occur twice daily during excavation and daily when no excavation work is occurring on site. Report will be produced daily, reviewed by the developer's consultant and copied to Transport and Main Roads.

9.9 Monitoring for tunnels

Monitoring devices are placed inside the tunnel to capture any trends early on that might compromise the integrity of the tunnel due to developments on and adjacent to the tunnel.

a) Prior to any demolition, excavation or construction work, monitoring devices as detailed in Clauses 9.8.1, 9.8.2, 9.9.1, 9.9.2, 9.9.3, 9.9.4 and 9.9.5 are to be placed in and around the tunnel.

b) Monitoring is to be conducted for **2 months prior** to commencement of work to establish base level conditions, during the construction, and for a **minimum of three (3) months** after completion of work. Monitoring can be terminated only with the acceptance of the department's representative, once monitoring establishes the situation.

9.9.1 Ground water monitoring

a) The Contractor's working method and system shall be designed to control ground water. Removal of ground water shall not cause damage to the existing tunnel structure.

b) Significant lowering of natural ground water table shall be avoided.

c) The Contractor shall install minimum two piezometric devices to determine the seasonal fluctuations in ground water between the tunnel and the new development.

d) The developer's specialist tunnel engineer require collection and review of all inclinometer and ground water monitoring data on a daily basis during the excavation stage of the basement earthworks, and thereafter weekly until 3 months after completion on the basement construction, unless more or less frequent monitoring is deemed acceptable by the department's representative.

e) Unusual fluctuations are to be reported immediately to the department's representative.

9.9.2 Tunnel rotation monitoring (driven tunnel only)

The developer to install suitable and reliable rotation sensors (Tilt meters) with the required accuracy, to capture tunnel liner rotation. Tunnel rotations are to be recorded as a macro measure of tunnel performance. The number of sensors and the sensor locations are dependent on the type of projects and the outcome of the tunnel impact studies due to the adjacent development. It is prudent to install rotation sensors based on the analysis where tunnel rotation will be maximum should movement occur during excavation. Alternatively the sensor locations can be identified from deformed shape outputs from Finite Element Studies.

Trigger levels for tunnel rotation are to be identified prior to the development work.

9.9.3 Vibration monitoring

9.9.3.1 General

a) The developer is required to install vibration monitoring equipments utilising triaxial geophones (4.5 Hz) to capture vibration in the tunnel roof prior to commencement of any demolition, excavation or construction work. The devices should be calibrated against a traceable event.

The devices should be installed as per manufacturer’s installation guideline. The output result should also include waveforms of extreme events.

b) A suitable measurement frequency to be specified by the instrumentation designer, such that all events are captured, to avoid the two scenarios - low and high measurement frequencies. The first will lead to data overflow and the second will miss the critical event.

c) Background monitoring and baseline reading should determine and correct external influences on monitoring results (for example, temperature, traffic, atmospheric pressure) which can lead to errors in reported data. Hence a two month baseline reading regime is imposed (see Section 9.8b).

d) System reliability is important as a lack of monitoring results may result in limitations on works or even suspension of construction operations. Where the consequences of monitoring system failure are unacceptable to a project, there should be sufficient redundancy built into the system so that losses of discrete elements do not cause loss of the entire monitoring system.

e) Monitoring systems require routine checks and maintenance. Most monitoring systems require some access for maintenance. The monitoring designer must consider how this can be achieved. A log of maintenance undertaken on the system is recommended. This log should record the date, nature of the work and who undertook it. This is useful for error tracing and a change in control procedures.

f) The location and number will be accepted on a project basis.

9.9.3.2 Trigger and alarm limits

a) A PCPV (Peak Component Particle Velocity) threshold of 1.5 mm/sec is to be set in the logger

b) A warning trigger level between 1.5 mm/s to 5 mm/sec is to be set in the logger.

c) The alarm to close the tunnel to buses and immediately cease all excavation is to be set at a PCPV exceeding 5 mm/s.

d) Responses to trigger levels of tunnel lining vibration monitoring shall comply with those listed in Table 9.9.3.2

Table 9.9.3.2 - Monitoring alarm limits and responses, vibration

Trigger Levels	**Tunnel Lining Vibration Monitoring**	**Responses**
Green	PCPV < 1.5 mm/s	Proceed
Orange	1.5 mm/s < PCPV < 5 mm/s	Notify Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures
Red	PCPV > 5 mm/s	Stop all buses from using tunnel. Place hold on excavation. Notify Supervising Engineer and Transport and Main Roads. Release for works to be provided by Transport and Main Roads

Any changes to the above trigger based on the background information or at any time during the adjacent development is to be approved by Transport and Main Roads, namely Deputy Chief Engineer (Structures).

9.9.3.3 Alert and response plan due to vibration

a) The developer has to provide an alert and response plan. The alert and response plan provides the alarm and reporting procedure in the event of unprecedented settlements, ground movements, tunnel liner rotation or vibrations of the tunnel during demolition and excavation for the basement.

b) The alert and response plan shall spell out the contact chain in case of alarm. The first people to inform are TransLink and Transport and Main Roads.

9.9.4 Crack monitoring device (driven tunnels only)

9.9.4.1 General

The developer is required to install crack monitoring devices in the tunnel crown before the start of any demolition, excavation or construction. Suitable crack meters with accuracy and reliability are to record the crack growth inside the tunnel. The location and the number of devices to be installed for crack monitoring are to be identified after the dilapidation survey.

9.9.4.2 Trigger and alarm limits for crack

Responses to trigger levels of tunnel lining crack monitoring shall comply with those listed in Table 9.9.4.2.

Table 9.9.4.2 - Monitoring alarm limits and responses, tunnel lining cracks

Trigger Levels	Tunnel Lining Cracks (Crack Monitoring)	Responses
Green	Existing cracks open < 0.5 mm. New cracks open < 0.2 mm	Proceed
Orange	Existing cracks open between 0.5 mm and 1.0 mm. New cracks open > 0.2 mm and < 0.5 mm	Notify Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures.
Red	Existing cracks open > 1.0 mm. New cracks open > 0.5 mm.	Stop all buses from using tunnel. Place hold on excavation. Notify Supervising Engineer and Transport and Main Roads. Release for works to be provided by Transport and Main Roads.

9.9.4.3 Alert and response plan due to cracking

The alert and response plan shall spell out the contact chain in case of alarm. The first people to inform are TransLink and Transport and Main Roads.

9.9.5 Ground movement adjacent to the tunnel

The developer shall undertake the following monitoring of ground adjacent to the tunnel.

9.9.5.1 Inclinometer

a) Install three inclinometers at 10 m intervals at depth equal to the mid-height of the adjacent tunnel between the existing tunnel and the proposed basement. The decision to increase/decrease the number of extensometers based on the proximity of the excavation adjacent to the tunnel and the length of excavation is at the discretion of the department's representatives.

b) The inclinometer must be monitored daily during basement excavation and weekly until three months after completion of basement construction. The developer's consultant requires collection and review of all inclinometer data during the excavation stage as well as the basement construction stage. Reports are to be compiled to Transport and Main Roads.

c) Trigger and alarm limits for inclinometer movements are to be agreed prior to commencement of any demolition, excavation or construction work.

d) Alert and Response Plan to inclinometer movement shall spell out the contact chain in case of alarm. The first people to inform are TransLink and Transport and Main Roads.

9.9.5.2 Rod extensometer monitoring (for secondary lining on driven tunnels)

a) The contractor must install rod extensometers in the tunnel to determine movement of the ground adjacent to the tunnel primary layer resulting from excavation associated with the new development.

b) Responses to Trigger levels for rod extensometers shall comply with those listed in Table 9.9.5.2.

Table 9.9.5.2 - Monitoring alarm limits and responses, ground displacement adjacent tunnel

Trigger Levels	Ground Deformation Adjacent Tunnel (Extensometers)	Responses
Green	Ground displacement < 1 mm.	Proceed
Orange	Ground displacement between 1 mm and 2 mm.	Notify Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures
Red	Ground displacement > 2 mm.	Stop all buses from using tunnel. Place hold on excavation. Notify Supervising Engineer and Transport and Main Roads. Release for works to be provided by Transport and Main Roads

c) The trigger levels for rod extensometer movement are to be agreed prior to commencement of excavation.

d) The Alert and Response Plan to rod extensometer movement shall spell out the contact chain in case of alarm. The first people to inform are TransLink and Transport and Main Roads.

e) In addition to submitting all alarm trigger reports, the developer is required to submit to Transport and Main Roads, at monthly intervals, the monitoring reports for evaluation and assessment.

9.10 Application for dilapidation survey

9.10.1 General

a) Prior to commencing any demolition, excavation and construction, the Developer shall submit to Transport and Main Roads:

- Demolition method statement (if an adjacent structure is to be demolished)
- Excavation and construction phase method statement, including details of the ground support conditions adjacent to the tunnel
- Dilapidation survey of the infrastructure
- Risk assessment reports on the demolition phase, the excavation phase, and construction phase, as detailed below.

b) No works associated with the development shall commence until the proposed works have been accepted in writing by Transport and Main Roads.

c) The submission shall address the **demolition phase**, the **excavation phase** and the **construction phase**, as appropriate.

9.10.2 Demolition phase

Explosives shall not be used adjacent to the Transport and Main Roads tunnel structures during demolition.

Prior to commencement of any activity, the contractor shall undertake a risk assessment of the potential for damage to nearby premises, buildings, structures and tunnels.

Demolition of buildings or other structures adjacent to the department's assets such as bridges or tunnels must provide for temporary props.

The department's assets in close proximity to the structures subject to demolition must be monitored for displacements, cracks and any effects resulting from demolition.

9.10.3 Excavation/construction phases

During excavation, explosives shall not be used adjacent to the Transport and Main Roads tunnel structures.

No rock blasting shall be permitted during excavation unless the applicant can demonstrate that there is no alternative and approval obtain from Transport and Main Roads, Director (Bridge and Marine Engineering). A separate submission shall be required for proposed rock blasting with consideration for mitigating adverse effects on adjacent structures and utilities. This submission shall be submitted for the department for review and approved.

During the excavation/construction phases, the following issues are to be addressed by the developer:

- Dilapidation, vibration, crack growth and soil movement
- Instability of the excavation wall adjacent to the tunnel
- Ground water fluctuations behind the tunnel
- Change in vertical stress at levels equal to the top and bottom of the adjacent tunnel
- Effect of change in vertical stress on the horizontal stiffness of the rock adjacent to the tunnel and any significant risk implication for the long -term stability and structural safety of the tunnel structure.

9.10.4 Drawings, reports and method statements

The developer and his team shall submit relevant items from the following in the form of drawing or report for Transport and Main Roads review:

- Types of development
- Imposed load on the tunnel roof, tunnel wall due to the activities in the easement area
- Tunnel impact studies due to the new development
- Drawings showing the proximity of the development to the tunnel: Clear distance between tunnel external wall and the closest structural element of the new development
- Excavation details – Method statement of stages of excavation, exclusion zones, machinery used and vibration issues
- Shoring design details, including pile or anchor arrangements
- Soil details and design report
- The types of footing, footing load, including piling, pile load, and depth of penetration
- Vibration internal and external to the tunnel
- GA and other basement arrangement drawings
- Proposed building drawings, details of building with dimensional cross sections
- RPEQ certified drawings when available.

10 Gantries and support structures

10.1 Applicability

This design criterion applies to all structures as given below:-

- Above road gantries and structures
- Cantilever gantries and structures
- Tolling structures on carriageway and side of the road
- Traffic light poles in excess of the parameters given in Transport and Main Roads Standard Specification MRTS94
- Sign supports on the side of the road for signs greater than 7.5 m wide or 8 m high or 40 m²
- Refer to Section 11 for Roadside advertising signs.

Note that supports for traffic signs and tolling systems on the side of the road up to 7.5 m wide or 8 m high up to a maximum area of 40 m² may be designed in accordance with the Transport and Main Roads Manual *Design Guide for Roadside Signs.*

10.2 Provision of ITS devices and support structures

The requirements for selection of appropriate ITS devices and the support structures required to position them are given in different Transport and Main Roads manuals and specifications. The design, details and requirements for ITS devices are given in general and specific ITS specifications as shown in Table 10.2.

Table 10.2 – ITS specifications

General Specifications	
MRTS01 *Introduction to Technical Specifications* MRTS02 *Provision for Traffic* MRS02 *Specification* MRTS50 *Specific Quality System Requirements*	MRS50 *Specification (Measurement)* MRTS96 *Management and Removal of Asbestos* AS3000 *Australian Wiring Rules* ACIF/AS009 *Customer Cabling Rules*
ITS Specifications	
MRTS61 *Mounting Structures for ITS Devices* MRTS91 *Conduits and Pits* MRS91 *Conduits and Pits (Measurement)* MRTS95 *Switchboards and Cables* MRS95 *Switchboards and Cables (Measurement)* MRTS201 *General Equipment Requirements* MRTS202 *Provision of Variable Message Signs* MRTS206 *Provision of Variable Speed Limit and Lane Control Signs*	MRTS210 *Provision of Mains Power* MRTS225 *Imaging Equipment* MRTS226 *Telecommunication Field Cabinets* MRTS228 *Provision of Electrical Switchboards* MRTS232 *Provision of Field Processors* MRTS234 *Provision of Telecommunications Cables* MRTS245 *Principal's Telecommunications Network*

In order to aid the selection process, refer to Technical Note 123 and the attached flow charts. These flow charts do not take precedence over the requirements in the documents.

10.3 Clearance

The minimum vertical clearance of the structure or sign face (whichever is lower) above the pavement shall be 6600 mm (6500 mm plus 100 mm for future overlays) after allowing for vertical deflection from permanent loads. When the structure is not over the road or road shoulder or parking or areas accessible by vehicles, minimum of 2400 mm vertical clearance above the ground level to the underside of the sign face or any structure component shall be maintained to prevent collision with pedestrians.

This design criteria overrides and take the precedence over other documents.

10.4 Additional design requirements

10.4.1 Design life

The design life shall be:

- "Above carriageway" structures or structures that could fall onto the road-
  all steelworks hot-dip galvanized - 50 years
- All connections in "above carriageway" structures - 100 years
- Foundations for "above carriageway" structures - 100 years
- Other support structures on the side of the road - 50 years

10.4.2 Live load

Sign structures that have a maintenance platform shall be designed for live loading of 5 kN concentrated moving load over 1 m² simultaneously with 2.5 kPa distributed load elsewhere. The platform shall also be designed for concentrated load of 1 kN over 300 mm square patch located anywhere on the platform floor.

10.4.3 Aesthetics

Support structures shall be aesthetically compatible with other similar structures in the road network.

10.4.4 Corrosion protection and durability

The minimum protection of all steel shall be hot-dip galvanising to AS 4680 including all internal surfaces of tubular members.

If the steelwork is hot dipped galvanized then:

- Connections shall be sealed on all faces to stop the ingress of water and galvanising acids which causes corrosion at interfaces. Where access for welding is available to one side of a joint only, a full penetration butt weld shall be used.
- Where backing bars/backing rings are used inside members, the backing bars/backing rings shall be removed prior to galvanising. If they are not removed, acid is trapped between the backing bars/rings and the member resulting in crevice corrosion.
- The size of the components shall be checked to ensure that they can be hot-dipped galvanised after fabrication. Double dipping shall be allowed.

10.4.5 Concrete durability

The minimum exposure classification for the purpose of determining cover to reinforcement and the concrete mix for structures of design life 100 years shall be B2 to AS 5100. The exposure classification for structures of design life 50 years or less shall be minimum A2 to AS 3600.

Also refer to Clause 3.8.4 for additional requirements of concrete durability.

10.4.6 Serviceability deflection

The self-weight, live loads and serviceability wind loads shall be taken into account for deflection calculations. The deflection criteria for structures with electrical and electronic equipment shall be specified separately. For example structures that support cameras or Free Flow Tolling devices shall be designed for deflection limits stipulated by the camera or device designer. The deflection calculations for all structures shall include the long term creep deflection resulting from the foundation movement. Deflection criteria for portal and cantilever structures are provided in Table 10.4.6.1 and 10.4.6.2.

Table 10.4.6.1 – Deflection criteria for portal structures

Load case	Deflection	
	Vertical	Horizontal
Selfweight (Permanent loads)	No downwards deviation from the horizontal	-
Live Load	Span/250	-
Serviceability Wind	-	Span/300
Serviceability Wind-camera	Refer to Figure 10.4.6	

Figure 10.4.6 – Camera Deflection Criteria (deflection criteria is subject to specific camera requirements)

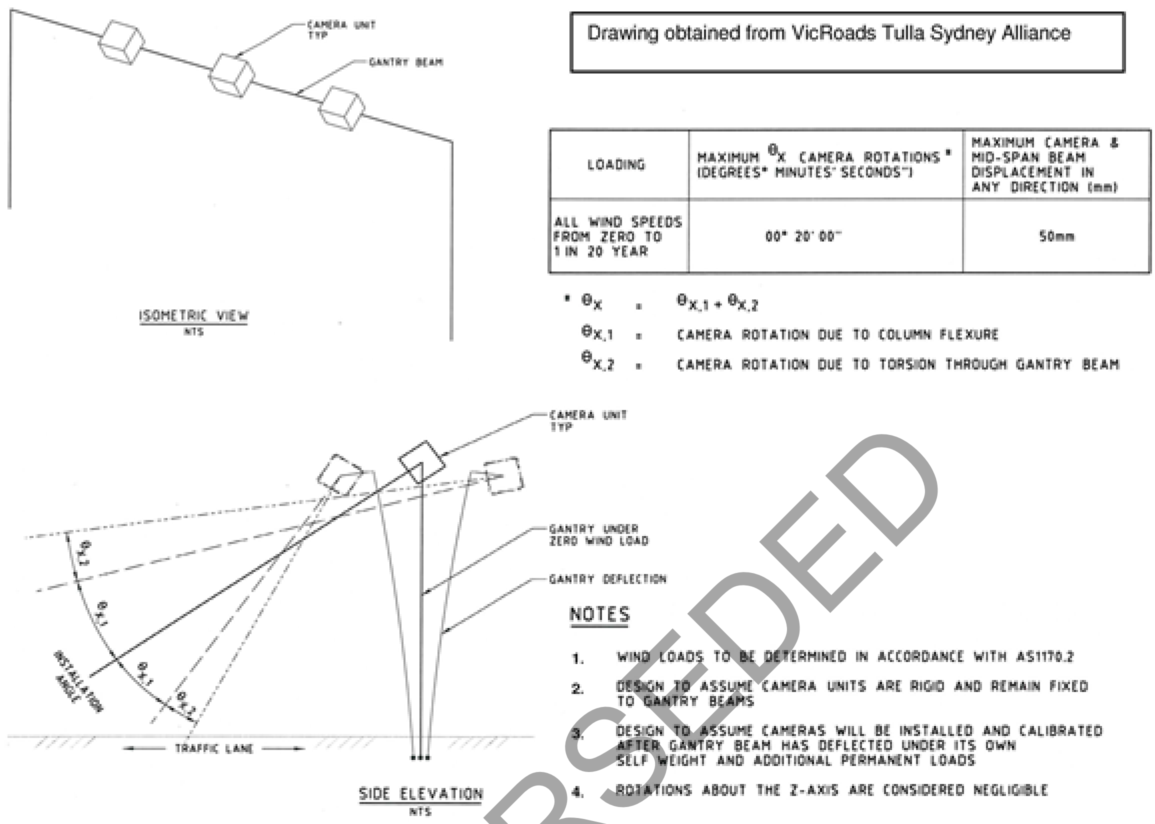


Table 10.4.6.2 – Deflection criteria for cantilever structures

Load case	**Deflection ***	
	Vertical	**Horizontal**
Selfweight (Permanent loads)	No downwards deviation from the horizontal	-
Live Load	Arm Span/125	-
Serviceability Wind	Combined horizontal deflection - 200mm max. at free end of arm (including post and arm horizontal deflection and post torsional deflection)	

* Maximum span for cantilevered gantries shall be less than or equal to 9.5 m, from centreline of the column to the end of the horizontal arm.

10.4.7 Vibration

Vibration limits shall be in accordance with AS 5100 and the manufacturer's requirements for each particular ITS device.

10.4.8 Foundations design

Geotechnical requirements in foundation design including design methodology, geotechnical investigations, design documentations and so on, shall be in accordance with Transport and Main

Roads *Geotechnical Design Standards-Minimum Requirements*. In addition to that, requirements stated in this document shall also be met.

Foundation design for structures shall be based on specific foundation investigation at the sign location to a minimum depth of one full height of the structure unless otherwise directed by RPEQ (Geotechnical) Engineer. RPEQ Geotechnical Engineer who is TMR pre-qualified, shall certify the geotechnical report which shall also include advice to ensure that long term foundation rotation does not result in column deflection in excess of the serviceability deflection limits stated in Clause 10.5.6.

The geotechnical investigation shall identify potential Acid Sulphate Soils. The designer shall use MRTS51 *Environmental Management* and MRTS04 *General Earthworks* to specify the treatment of acid sulphate soils if this is present on the site.

Foundation structures such as pile caps, footings and so on, shall be located below the ground with the top of the pile cap, footing and so on, at the same level as the surrounding ground surface level.

Below foundation types acceptable to Transport and Main Roads:

a) Cast-In-Place piles to MRTS63 or MRTS63A as applicable

   MRTS63A is applicable for piles for high moment low axial load applications such as single Cast-in-place piles. Piles in a pile group where axial load is dominant due to the moment couple shall be in accordance with MRTS63.

b) Prestressed concrete driven piles to MRTS65

c) Spread footings.

Any other foundation types shall be agreed with Transport and Main Roads (Structures) prior to start of design.

Below foundation types not permitted by Transport and Main Roads:

a) Screw piles

b) Continuous Flight Auger (CFA) piles

c) Precast reinforced concrete piles

d) Steel piles

e) Precast concrete piles manufactured by spinning or rolling

f) Pile constructed with bentonite or polymer slurry.

The foundations shall be designed so that the base plate is installed as close to ground level as possible while providing for drainage and other requirements. The design length of the support columns shall take into consideration the variations in the reduced levels of the foundations.

10.5 Structural design

10.5.1 Wind loading

a) Ultimate strength

   Ultimate strength structural design shall be to AS 5100.

   ARI for ultimate limit state wind speed shall be 2 000 years.

b) Serviceability

ARI for serviceability limit state wind speed shall be 20 years.

10.5.2 Structural design criteria - wind and fatigue

Design criteria for wind and fatigue applicable to structures are provided in Table 10.4.2.

Table 10.5.2 – Wind loading and fatigue design criteria

Wind loading	Fatigue
AS 1170.2 with wind perpendicular and at 45 degrees. CD in accordance with AS 1170.2.	Design for fatigue in accordance with Section 11 "Fatigue" of AASHTO *Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, 5th Edition (2009) with Interim revision (2011).

10.5.3 Load combinations

Load factors and load combinations shall be to AS 5100.

10.5.4 Signs attached to bridges – additional design criteria

The following criteria apply to the structural design and fabrication of sign structures mounted on Transport and Main Roads bridges. Other regulatory requirements and Standards that must be complied with are outside the scope of these design criteria.

Type 1 - Signs attached to reinforced concrete traffic barriers on bridges.

The sign structure shall be designed to remain intact when the barrier is impacted by traffic to prevent the structure from falling onto pedestrians and traffic below. The structure shall be attached to the outside face of the reinforced concrete barrier.

Type 2 - Signs attached to bridges with steel traffic barriers.

The sign structure shall be supported independent of the steel traffic barrier, and positioned beyond the deflection limits of the traffic barrier. The sign structure shall not be impacted when the traffic barrier is impacted by a vehicle. For guidance a regular level double steel traffic barrier detailed in Standard Drawing 1508 will deflect 100 mm when impacted.

Common to both Types 1 and 2

The structure supporting the sign shall be positioned outside the "working width" so that if the barrier is impacted by a vehicle, the vehicle will not impact the sign structure.

The "working width" is defined in TMR, RPDM Edition 2 Volume 3.

For large signs requiring a level 2 structural inspection the sign structure shall have a horizontal clearance of 50 mm minimum from the near face of the bridge traffic barrier. The horizontal gap between the face of the traffic barrier and the rear of the sign shall be sealed with a galvanised perforated steel sheet (maximum 10 mm diameter holes) along the full length of the sign structure. This is to prevent vandals, hidden behind the sign, from dropping objects onto the motorway below. This is a "Safety in design" requirement.

The design shall prevent access by vandals to the sign structure and tamper proof fastenings and connections shall be used.

The sign structure shall not restrict access for maintenance and repairs to the traffic barrier. Drilling or coring into PSC is NOT permitted. Signs shall be attached with stainless steel or hot dip galvanized bolts.

When a sign structure is attached to a bridge over road, the design live load for assessing the bridge structure shall be the original design loads used in the design of the bridge.

The impact load on the barrier shall be assessed using the Road Barrier Performance Level Selection Method in AS 5100. The result from this shall be used to determine whether it is justified to use the barrier impact load that the structure was originally designed for. Also refer to Clause 7 *Matters for Resolution*. Item 19 for the procedure and requirements to determine the barrier performance level.

For comparison, the barrier impact load in the Bridge Design codes is as follows:

NAASRA 1976	- 45 kN (working load)	
Austroads 1992	- 90 kN (ultimate load) for $h < 850$ mm	
AS 5100.2	- Low performance	125 kN (ultimate)
	- Regular performance	250 kN (ultimate)

For bridges designed in accordance with the NAASRA or Austroads Codes, the minimum barrier impact load to be used for assessing the bridge structure in combination with the load effects of the advertising sign attached to the bridge, shall be 60% of low performance, that is 62 kN minimum impact load.

For bridges designed in accordance with AS 5100, the full impact load stipulated by AS 5100 for appropriate barrier performance level shall be used for assessing the bridge structure in combination with the load effects of the sign structure attached to the bridge. Designer shall determine the appropriate barrier performance level in accordance with the AS 5100.1 Appendix B.

Bridges designed prior to 1976 are considered as special cases and the appropriate barrier impact load shall be discussed with Transport and Main Roads Director (Bridge and Marine Engineering).

The sign structure designer shall check the structural adequacy of the bridge structure. The following additional load combinations for ultimate design shall be considered.

Combination 1: Ultimate 2000 years ARI wind on sign plus ultimate dead load (Bridge and Sign structure), No traffic load on the bridge, No vehicle impact on the barrier

Combination 2: 10 years ARI serviceability wind on the sign plus ultimate dead load (Bridge and Sign structure) plus ultimate vehicle impact load on the barrier, No traffic load on the bridge.

Combination 3: 20 years ARI serviceability wind on sign plus ultimate dead loads (Bridge and Sign structure), plus ultimate traffic loads on the bridge, plus serviceability live load on the sign structure working platform, No Vehicle impact on barrier.

10.6 Design of elements for structures

10.6.1 Maintenance platform

Unless specifically nominated otherwise by Transport and Main Roads, all gantries and other structures supporting electrical and electronic equipment shall be provided with an access platform to allow maintenance of these equipment and structural components without disrupting traffic.

Where a maintenance platform is required, the maintenance platform shall comply with AS 1657: *“Fixed platforms, walkways, stairways and ladders- Design, construction and installation”* and additional criteria stated in this document. It shall be provided for the full length of the overhead structure. The platform design shall ensure that rear access doors to ITS devices are not obstructed by the platform.

The minimum width of the maintenance platform shall be 800 mm. However, the width shall be greater if required to conform to functional requirements (for example open doors, swing/sliding signs, and so on). Where cameras are mounted in the walkway, 800 mm walkway must be provided on one side of the camera and 500 mm maintenance access on the other side of the camera.

The platform shall be designed for live load stated in Clause 10.3.2. The serviceability deflection under any live load shall not exceed the limits stated in Clause 10.4.6.

All walkways and platforms shall have permanent plates secured and displayed in a prominent position stating the maximum design loads for the walkways and platforms and any constraints to loading intensity. These plates shall be detailed on the drawings conforming to the appropriate Australian Standards.

Floor of the maintenance platform shall be a grated floor to comply with AS 1657 Clause 3.2.3.4 *“Grating and Expanded Metal” and 4.3 “Platform Surfaces”*. The floor shall have a non-slip finish and be self-draining. The “**Weldlok**” A40-205 floor grating is acceptable to Transport and Main Roads. A protection mesh shall be fitted on to the top of the grated floor to protect objects, maintenance tools and equipment from falling onto the area below. Gaps larger than 10 mm at the ends of the floor which permit items to fall on to the area below shall be fitted with the mesh. The protection mesh shall be an expanded metal with the minor axis not exceeding 10 mm and minimum thickness of 1.6 mm. “**Mastermesh Industries**” LD1616 mesh is acceptable to Transport and Main Roads.

Guardrailing shall be provided on the maintenance platform. Guardrailing shall comply with AS 1657 Clause 5.4 *Guardrailing* and have:

- top of the top rail at 1100 mm height from the floor.
- One or more middle rails having a maximum clear distance of 450 mm between the rails and a maximum clear distance of 450 mm between the lowest rail and the top of the toe board.
- a toe-board which shall not be less than 100 mm above the top of the floor. Toe-board shall be provided all around the floor of the platform except at the platform entrance. Toe-board shall be made using structural steel angle of minimum 3 mm thick.
- a protection mesh made from expanded metal mesh with the minor axis not exceeding 10 mm and minimum thickness of 1.6 mm to infill between all the rails and top of the toe-board to ensure that objects, maintenance tools or equipment cannot fall on to the area below. “***Mastermesh* Industries**” LD1616 mesh is acceptable to Transport and Main Roads. The mesh panelling shall be designed to ensure that it will not interfere with ITS equipment operation.
- no gaps greater than 50 mm (with or without a mesh) between ends of the guardrailing and the structure.

Any vertical gaps between the floor of the maintenance platform and the rear of the ITS device shall also be fitted with mesh similar to the mesh fitted with the guardrails to prevent objects, maintenance tools and equipment from falling to the roadway.

Unless otherwise specified, access to the maintenance platform shall be by fixed ladder systems from ground level designed and installed to:

- AS 1657. *Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
- AS/NZS 1891: *Industrial Fall-arrest systems and devices*
- *“Guidance on The Principles of Safe Design for Work” (May 2006) by Australian Safety and Compensation Council*
- “Safe Work Australia Code of Practice”
- WHS legislations, and
- Additional criteria stated in this document.

10.6.2 Access ladder and landings

The ladder system and the landing shall be designed and installed in accordance with AS 1657. The access structure shall be considered as a workplace, and the access provisions must conform to the appropriate act and regulations. The access shall be secure and ensure unauthorised persons cannot enter the structure.

The requirement of intermediate landing, ladder cage and safety harness based fall arrest system shall be in accordance with AS 1657 and Table 10.6.2.

Table 10.6.2.1 - Details of the fall protections

Structure type	Fall distance	Fall protection provisions	AS 1657 reference clauses
Ladder is within four post gantry column	Up to 6.0 m	Ladder cage and harness based fall-arrest system	Table H1 and Clause 7.4.7: Note 2
	> 6.0 m	Intermediate landing at maximum of 4.5 m height, ladder cage and harness based fall-arrest system.	Table H1, Clause 7.4.7 and 7.3.6
		Vertical height between landings in multiple flight ladders should be equal.	Clause 7.3.6: Note 2
Ladder is fixed other than four post gantry columns. e.g. single post VMS structure	Up to 6.0 m	Ladder cage and harness based fall-arrest system	Table H1, Clause 7.4.7: Note 2
	> 6.0 m	Intermediate landing at maximum of 4.5 m height, ladder cage and harness based fall-arrest system.	Table H1, Clause 7.4.7 and 7.3.6
		Vertical height between landings in multiple flight ladders should be equal.	Clause 7.3.6: Note 2
		Omit intermediate landing where installation of intermediate landing is “not reasonably practicable” (Example: A single post VMS structure where an intermediate landing will fall within the working width or over the carriageway)	Clause 7.3.6: Note 3

When intermediate landing with multiple ladders are used, the ladder arrangement shall be in accordance with AS 1657.

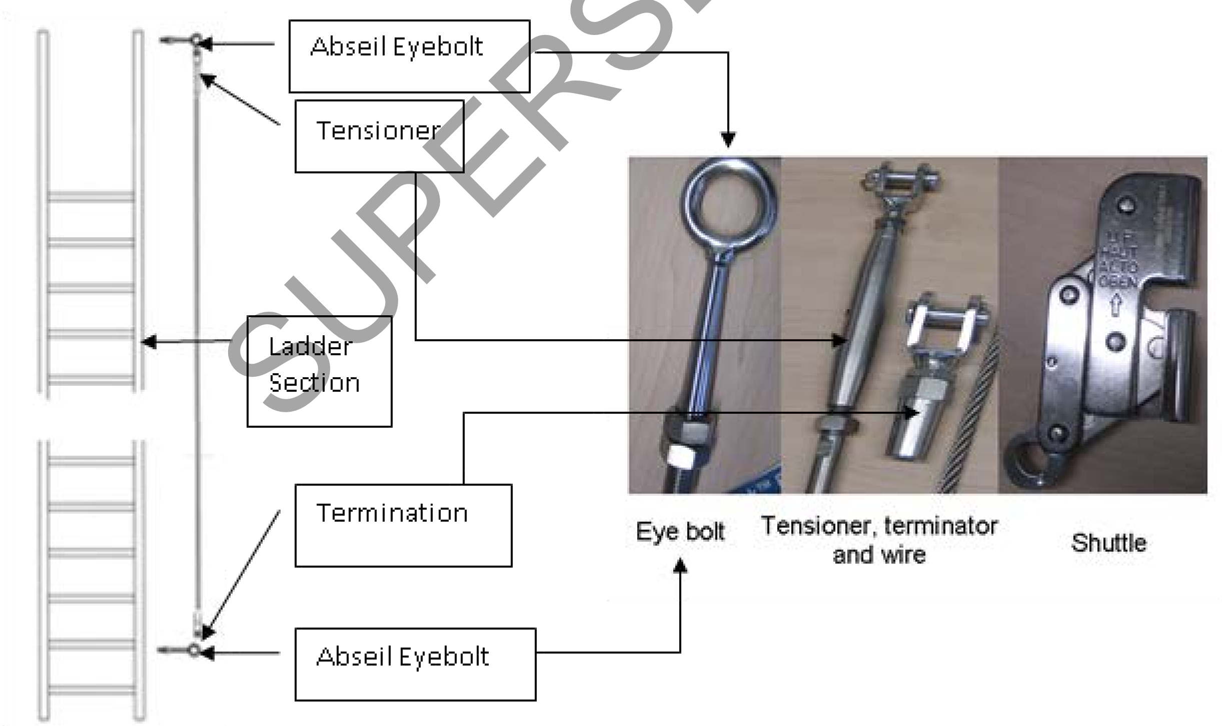
Fall arrester harness systems shall comply with AS/NZS 1891. The harness system shall be capable of arresting falls within a short drop of not greater than 600 mm. The designer shall be responsible for nominating the type of harness and providing attachment points in the structure. The approved fall arrester system shall have Certification and Approval to AS/NZS 1891 (Series): *Industrial fall – arrest systems and devices.*

Table 10.6.2.2 and Figure 10.6.2 show the details of the fall arrester system manufactured by SafetyLink Pty Ltd which is acceptable to Transport and Main Roads.

Table 10.6.2.2 - Details of the fall arrester system

Part Nos.	Product list
Ladder001:10	Vertical Static Line Shuttle with Karabiner (not required for each site, required for those climbing the gantry)
Eyebolt002	Abseil eyebolt (2 Nos.)
Stat.Tensr002	Swage less Tensioner (1 No)
Stat.Term002	Swage less Termination (1 No)
Stat.Cable001	Stainless Steel Cable (typically 9 m length to suite specific gantry)

Figure 10.6.2 - Parts of the fall arrester system



Following additional requirements shall also be met.

1. At the bottom of the ladder, the following sign and the wording shall be attached.

"This ladder shall be used only by suitably trained personnel using approved protection devices"

THIS LADDER SHALL BE USED ONLY BY SUITABLY TRAINED PERSONNEL USING AN APPROVED PROTECTION DEVICE.

2. The base of the ladder shall be kept above the base slab for improved durability. The height to the first rung from base slab shall be not greater than the standard rise. All rises shall be equal except that the first rise may be less than the standard height.
3. Screens shall be provided around the outside of the ladder to prevent children accessing the ladder from the gap between the column and the back of the ladder.
4. All other requirements of AS 1657 shall be strictly adhered to, and are not open to interpretation.
5. VMS gantries have adjustment rods on the signs. These rods protrude horizontally and shall be capped with a suitable cap to prevent injury.
6. Following erection a competent person (as defined in the Work Place Health and Safety Act 2011) shall be engaged by the gantry supplier to carry out an inspection and comprehensive safety audit of the gantry for compliance with AS 1657 and WHS legislations prior to handover to Transport and Main Roads.
7. The Designer shall provide a RPEQ Certified Compliance Certificate stating that the structure complies with AS 1657, AS 1891, "Guidance on The Principles of Safe Design for Work" (May 2006) by Australian Safety and Compensation Council, "Safe Work Australia Code of Practice" and WHS legislations and obtain a Registered Design number with WHS Qld.
8. The gantry supplier shall provide a metal Compliance Plate with the Registration Number embossed on it and securely attach the Compliance Plate to the structure with vandal proof fastenings

10.6.3 Access to the structure site

The design must incorporate a path from where maintenance staff can park a vehicle and gain access to the structure. Access to the structure site shall be designed to ensure that maintenance personnel can access the structure safely. Routine operation and maintenance access to the structure shall not require traffic control measures, and/or lane closures.

Provision shall be made for impact protection of maintenance personnel from errant vehicles.

10.6.4 Protection of structures from vehicle impact

Structures within the clear zone as per Transport and Main Roads, RPDM Edition 2 Volume 3 shall be protected from vehicle impact. Transport and Main Roads Guideline: *Overhead Gantries that project across trafficked lanes: Protection from Vehicle Impact* shall be used to design the barriers.

10.6.5 Wiring enclosures

All wiring enclosures for installation of power cables must comply with AS/NZS 3000 and the relevant Transport and Main Roads technical specifications.

All wiring enclosures for telecommunications cables must comply with AS/ACIF S009 and the relevant Transport and Main Roads technical specifications.

Conduits must comply with Transport and Main Roads Standard Specification MRTS91.

10.6.6 Bolts, nuts and washers

Steel bolts, nuts and washers shall be in accordance with MRTS78.

Self tapping screws are not permitted to use in structural connections and to connect sign face to the structure. Bolted connections with two nuts in predrilled hot dipped galvanised holes shall be used to connect structural members.

Self tapping screws are permitted to fasten cladding only

10.6.7 Anchor bolt/rod details

On the basis of NCHRP reports and learnings from interstate sign failures, the following must be observed:

a) Connections using grade 4.6 grade bolts are less likely to be controlled by fatigue requirements than are those which use grade 8.8, however either grade may be used provided that the design satisfies both ultimate strength and fatigue life requirements. Grade 8.8 bolts shall conform to Transport and Main Roads Technical Specification MRTS78.

b) Pre tensioned bolts are not warranted.

c) Nut tightening and the use of lock nuts are important to prevent nut loosening, which in turn will cause undesirable larger stress fluctuations, thus increasing the risk of fatigue failure.

d) Snug tightening is adequate for fatigue performance provided it is done properly and provided lock nuts are:

   - purpose made half height nuts,
   - made from softer steel than the ordinary nut, and
   - are located between the ordinary nut and the base plate.

e) For grade 8.8 bolts ONLY, to more reliably prevent loosening, tightening in the range 1/2 turn to 1/3 turn beyond snug tight, depending on bolt grade and diameter, is now preferred (in conjunction with lock nuts).

f) The maximum unsupported length of the anchor from top of footing to the bottom of the base plate to be not more than one anchor diameter.

10.6.8 Base plate thickness

The base plate shall be at least as thick as the anchor diameter.

10.6.9 Structural steel

Structural steel material shall meet the requirements of Section 4.20.

10.6.10 Provision for drawing cables and wiring

The design of the structure shall provide adequate radii for redirecting cables and wiring around bends, appropriate for the diameter and type of cable in accordance with the relevant Australian Standards.

The drawings shall note that all access holes for cables and wires shall be fabricated without sharp edges to prevent damage to insulation when the cables are drawn.

The Drawings shall note that no additional holes are permitted to be drilled that are not shown on the RPEQ Certified drawings without approval from the structural designer and the Administrator.

10.7 Drawings and design report

The design submission shall include the design report and the drawings for construction. Drawings shall comply with the Transport and Main Roads *Drafting and Design Presentation Volume 3 - Structures Drafting Manual.* All Engineering Drawings shall be certified by an RPEQ Engineer. The RPEQ Engineer shall also certify on the drawings that the design complies with the relevant Australian Standards relating to Workplace Health and Safety.

The design report shall provide an installation procedure for the structure.

Drawings are to incorporate the following:

a) All design loads for the structure are to be shown on the structure specific drawings and walkways and platforms shall have permanent plates secured and displayed in a prominent position stating the design loads for the walkways and platforms. These plates shall be detailed on the drawings.

b) The erection sequence shall include all requirements for tightening of hold-down bolts prior to grouting and prior to attachment of outreach arms.

c) Construction drawings should include a diagram showing column offset and outreach pre-camber. Designers should calculate column offset based on provision of a 1 in 40 slope after allowance for long-term progressive foundation movement.

d) Use of upper and lower templates for hold down bolts is recommended to ensure a good fit with holes in the base plate. Bending of hold down bolts and use of enlarged boltholes is not permitted without written permission of the designer.

e) Impact protection from errant vehicles.

f) Drainage water should be directed away from the footings of cantilever sign structures to prevent softening of the surrounds and corrosion of base plate and holding down bolts. Concrete paving with or without drainage channels may be appropriate in some areas.

g) All welds are to be detailed on the drawings and weld symbols shall be in accordance with AS 1101.3.

Notes for the construction of structures shall be shown on the set of drawings for the structure. Notes shall be consistent with the standard Transport and Main Roads notes in the *Structures Drafting Manual* and shall address the following additional issues:

a) Prior to concreting, excavated foundations shall be inspected by the Geotechnical Assessor.

b) Only those welds shown on the drawings are permitted. No weld is to be omitted or added without the specific approval of the Administrator.

10.8 Transport and Main Roads review of drawings and design report

Designs shall be submitted at preliminary design (15%), 50% substantial completion (unchecked drawings), 85% complete (checked drawings) and 100% complete for final acceptance prior to fabrication. The submission shall include drawings, geotechnical report and design report. The design report shall include discussion of safety, durability, future performance, constructability and maintenance and shall include a summary of deflections. The preliminary design submission shall involve a meeting between Transport and Main Roads (Structures) and the designer to discuss the drawings. The design shall not proceed until all issues are resolved.

For each submission, Transport and Main Roads will provide comments that the designer must consider and these shall be included in the design. If the comment is not acceptable to the designer, reasons shall be discussed with the department. A final position acceptable to Director (Bridge and Marine Engineering) or Deputy Chief Engineer (Structures) shall be reached. This solution shall be adopted.

Fabrication shall not begin until final drawings have been submitted to the department and accepted by the department. Fabrication shall not begin until all hold points and witness points in MRTS 78 are released by Transport and Main Roads.

10.9 Fabrication of structural steelworks and aluminium components

Fabrication of the structural steelwork shall be to MRTS78 "*Fabrication of Structural Steelwork*". Fabrication of aluminium components shall be to MRTS 79 "*Fabrication of Aluminium components*".

All structural steelwork and all aluminium work shall be inspected by an RPEQ Engineer or their approved delegate who is experienced in the fabrication of structural steelwork who shall ensure all the requirements of the specification are met.

The inspections shall be carried out during the fabrication process. The following documentation shall be supplied to Transport and Main Roads with the sign structure.

- Inspection Report outlining the welding procedures provided used the welds specified on the approved RPEQ Engineering drawings
- Inspection Report outlining the review of the material test certificates to show compliance with the appropriate Australian Standards specified on the RPEQ certified Engineering drawings. The report shall state the member size and grade used in the structure. The report shall also outline the heat number and material test certificate number for the material supplied
- Inspection Report outlining which butt weld preparations were inspected. This report shall include photos of each type of butt weld inspected with a bevel gauge showing the joint matches the approved welding procedure sheet

- Inspection Report outlining the completed welds which have been inspected. The report shall show the welds inspected with the appropriate weld fillet gauge to show the conforming welds and the report shall show any welding defects identified in the inspection
- Inspection Report outlining the non destructive testing carried out in accordance with the specification.

10.10 Installation of structure

Installation shall be in accordance with Transport and Main Roads specifications and technical standards.

Transport and Main Roads does not permit the use of levelling nuts to support the structure. The structure shall be supported by proprietary non-shrink mortar with uniform distribution of the load over the whole plan area of the base plate. An acceptable procedure is as follows:

a) Stand the column section and level the column by placing a minimum of four steel wedges under each base plate

b) Mix the non-shrink mortar to a trowellable consistency

c) Pack the mortar and ensure that the mortar extends over the full area of the base plate

d) Wait for the mortar to set sufficiently to support the weight of the structure

e) Remove the steel wedges

f) Tension the bolts

g) Repair the mortar where the wedges were located.

All materials and bolts shall conform to the requirements of Transport and Main Roads Standard Specification MRTS78.

10.11 Inspection

Large Traffic Management Signs (LTMS) that could fall onto the traffic lanes in the event of a structural failure such as gantries with signs over traffic lanes, cantilevers and butterflies (cruciform) as well as tall light masts and large signs with truss supports in close proximity to the traffic lanes are to be recorded in the inventory of the Bridge Information System (BIS) and will be subject to the inspection regime defined in BAM Support Advice Note No. 112:Large Traffic Management Signs-Inventory Creation & Inspection. The inspection category and inspection frequency to be as specified in LTMS Advice Note.

10.12 Traffic barriers

Portal frame and cantilever style overhead gantries shall be protected by a traffic barrier from vehicle impact. The traffic barrier shall also be designed to suit road environment, traffic volume and mix, and road design speed.

10.12.1 Barrier deflection restrictions

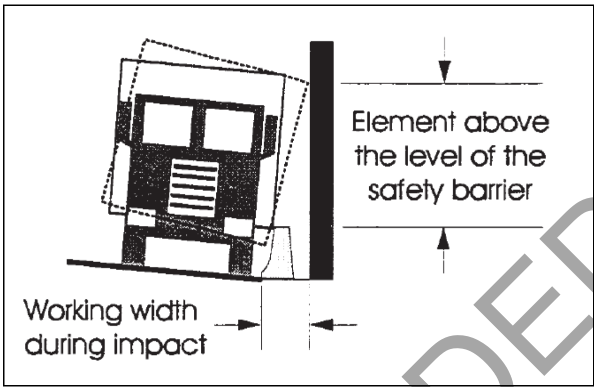
The minimum nearside and offside distance to the edge of the lane and the barrier shall comply with AS 3845 and Transport and Main Roads *Road Planning and Design Manual 2nd Edition Volume 3*. The barrier shall have sufficient clearance to the gantry to allow for barrier deflection and provide access for maintenance. It should be noted that all road safety barriers have a range of deflection values.

10.12.2 Working width restrictions

The sign support structure shall be located outside of the deflection zone of any road safety barrier and at a distance greater than the working width requirements behind the road safety barrier.

The working width takes into account the extent of body roll of a high vehicle striking the barrier. Refer to Figure 10.12.2 below, also the Transport and Main Roads *Road Planning and Design Manual 2nd Edition Volume 3*. This ensures that the gantry is not subjected to vehicle impact loads that cause its collapse.

Figure 10.12.2 - Working Width



10.12.3 Special design requirements

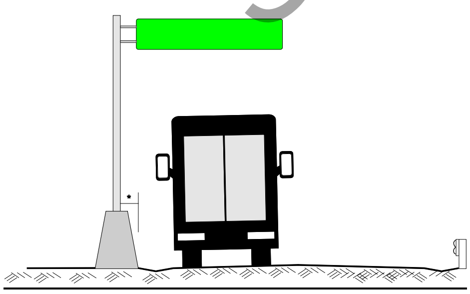
Special design requirements apply where the gantry support is incorporated:

a) Within the road safety barrier itself, and

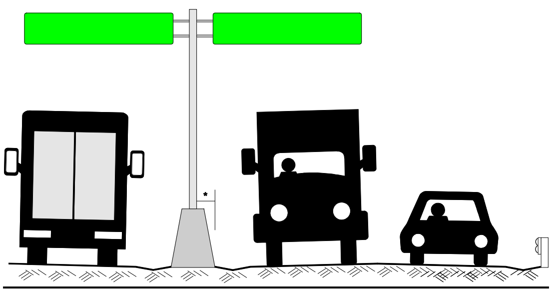
b) Within the working width as described above.

For example, "butterfly" cantilever gantry designs that are installed within median barriers. Refer to the Figure 10.12.3 and the design methodology contained within this document.

Figure 10.12.3 - Gantry supports designs incorporated within road safety barriers" and within the working width



Gantry located on the verge



Gantry located within the median

Notwithstanding the road safety barrier requirements below, it should be noted that “truss-design” supports, which are inherently more vulnerable, must not be incorporated within a road safety barrier design and instead must be protected behind a road safety barrier.

10.12.4 Traffic barrier design criteria

There are two design criteria. Namely:

1. **Normal** road safety barrier where the gantry support is **outside** the working width
2. **Special** road safety barrier where the gantry support is **inside** the working width.

1. Normal road safety barrier requirements where the gantry is outside the working width

The following conditions apply when the sign support structure is not incorporated within a road safety barrier.

Where cantilever or gantry mounted signs are to be installed that project across traffic lanes, the following is required to protect/shield the sign support structure:

- Where the posted speed of the road is 80 km/h or greater, a concrete road safety barrier is required. (The test level requirement will be dependent on the type of vehicle that is to be contained.)
- Where the gantry support is located in the area where two roads merge/diverge, that is the “gore” area, a crash cushion may be an acceptable solution used either on its own or in combination with a barrier as is required for the road environment.
- Where the posted speed of the road is less than 80 km/h, the minimum standard of barrier may be reduced to a steel or wire-rope road safety barrier.
- In an urban environment, where the posted speed of the road is less than 80 km/h, and the sign is located within the clear-zone, a road safety barrier may be required. Transport and Main Roads *Road Planning and Design Manual 2nd Edition Volume 3* for guidance on analysis and risk assessment of road safety barriers.
- In an urban environment, where the posted speed of the road is less than 80 km/h, and the gantry is located outside the clear-zone,
  - where a kerb is present, a road safety barrier is not mandated
  - where there is no kerb, a road safety barrier should be considered based on a risk assessment as set out in the Transport and Main Roads *Road Planning and Design Manual 2nd Edition Volume 3.*

Where the posted speed is greater than 80 km/h, in addition to the above requirements, the structural integrity of the gantry support structure can be used to reduce the road safety barrier requirements. Where the impact resistance of the structure can sustain an impact by a typical heavy vehicle using the road, a lesser standard of barrier may be acceptable. Refer to AS 5100.2 Clauses 10.2 and 10.3 “impact loads on bridge piers” for guidance on the design of the gantry support structure.

Road safety barrier design

Once the type of barrier required is determined, the barrier design including the "length of need" of the barrier is to be designed in accordance with the Transport and Main Roads *Road Planning and Design Manual 2nd Edition Volume 3*. It is noted that there may be a section of road safety barrier where a higher performance is required; both on the approach and at the site of the gantry and this will need to be transitioned into any existing barrier.

On divided roads in urban environments where there are property accesses that prevent the installation of road safety barrier, the placement of the gantry support may be preferable within the median.

2. Special road safety barrier where the gantry support is in the working width

Where a “special” road safety barrier design is required, the design is considered to be outside the scope of standard Transport and Main Roads road safety barrier designs and Chapter 8 of the *Road Planning and Design Manual*. In such instances, the road safety barriers shall be designed in accordance with the "Special Performance" criteria outlined in AS 5100.1 – Table 10.4 and Clause 10.5.6 where the design speed of the road is 80 km/h or greater.
The road safety barrier shall be a rigid reinforced concrete barrier designed to resist the impact load and prevent barrier deflection, for example, by being supported on piles. The minimum effective height for the road safety barrier is 1600 mm above the pavement surface. (Refer to AS 5100.2 – Table A3). The minimum width of the road safety barrier shall be sufficient to protect the column during an impact, taking into account the working width.

With reference to AS 5100.2 – Table A2, “Special performance level barriers”, the ultimate transverse outward load is 750 kN (for a straight horizontal alignment, design speed 110 km/h), and 1000 kN (for a curved horizontal alignment, design speed 110 km/h). Thus, the minimum additional load on the steel column is 25% of 750 kN for a straight alignment, and 25% of 1000 kN for a curved alignment, applied one metre above the top of the road safety barrier. (This is a departmental requirement for robustness).

The minimum length of the section of “Special design” barrier is six metres each side of the gantry support structure. The minimum total length of the road safety barrier shall conform to the requirements set out in Transport and Main Roads, *Road Planning and Design Manual 2nd Edition Volume 3.*

Timing for construction of the barriers
The road safety barriers shall be constructed concurrently with the gantry support structures so that once they are erected, the permanent road safety barriers are in place to protect the gantry support structure from vehicle impact.

11 Roadside advertising signs

11.1 Applicability

These design criteria apply to the structural matters of design and construction of Roadside Advertising Sign structures. Other considerations such as “device distraction” and so on, shall be as referred to in other Transport and Main Roads regulations and standards. The relevant Transport and Main Roads specifications and technical standards are available from the department’s website.

“Structural members” are members whose primary function is to provide a load path within the structure to support vertical, horizontal and torsional loads. These members collectively constitute the structure.

Following items are out of scope of this design criterion:

- “Non-structural members” are members that do not contribute to the structural integrity of the structure. Typically, these are members that support the electronic devices and components, flashings for the “sign box” cladding and water proofing and so on
- Advertising sign face.

Prior to the start of structural design, the Sign Licensee and Transport and Main Roads (Structures) shall agree on which members are to be designed as “Structural members” and “Non-structural members”.

This design criterion applies to all roadside advertising sign structures for two categories:-

a) “On-carriageway” advertising signs

Any sign structure that can fall and land on traffic lanes or on shoulders shall be considered as “On-carriageway” advertising signs. Following structure locations are classified as “On-carriageway”. Refer to Clause 11.4 for design criteria for On-carriageway advertising sign structures.

i) The sign post is within the width of the carriageway plus shoulders, or

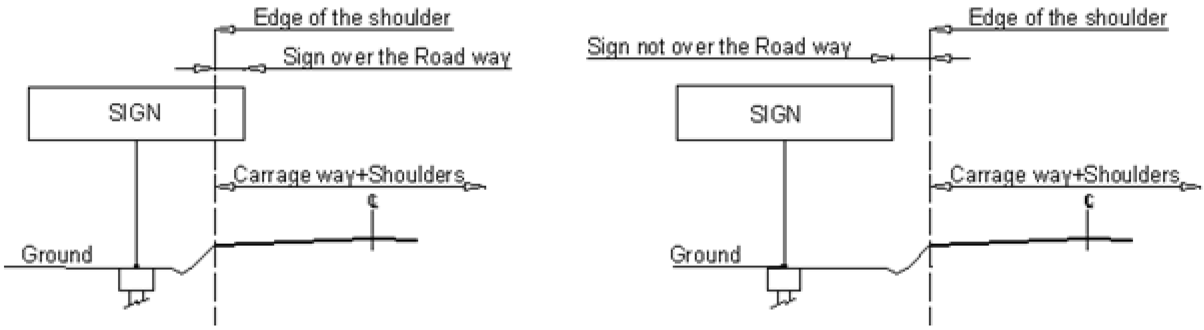
ii) The sign post is located outside the area stated in (i) but the sign face is over the carriageway or shoulders as shown in the Figure 11.1 (a)

iii) The sign is attached to an overpass bridge.

b) “Off-carriageway” advertising signs

All structure locations that are not listed in any of the locations in (a) above to be considered as “Off-Carriageway” advertising signs. A typical “Off- carriageway” sign is shown in the Figure 11.1(b). Refer to Clause 11.5 for design criteria for “Off-carriageway” advertising sign structures.

Figure 11.1 - Advertising sign structure locations



(a) Signs “On-carriageway” (b) Signs “Off-carriageway”

11.2 Sign licensee

Sign Licensee is a company who is the owner of the sign structure including the sign face, Sign Licensee company shall maintain a quality management system audited by a third party organisation and continually improve its effectiveness in accordance with AS/NZS ISO 9001 or ISO 3834.

11.3 Administrator

The Sign Licensee shall nominate the Administrator. Administrator shall be a registered Professional Engineer Queensland (RPEQ). All cost for this Administrator’s services shall be borne by the Sign Licensee.

The role of the Administrator is to:

- Ensure that all the appropriate permits have been obtained.
- Release HOLD POINTS and WITNESS POINTS in the relevant Transport and Main Roads Specifications and this document by RPEQ certification.

11.4 Design criteria for on-carriageway advertising signs

This criterion shall be applied for advertising sign locations stated in Clause 11.1(a). Refer Clause 11.5 for design criteria for off-carriageway advertising sign structures.

11.4.1 Vertical clearance

The minimum vertical clearance of the structure or sign face (whichever is lower) above the road way (carriageway plus shoulders) shall be 6600 mm (6500 mm plus 100 mm for future overlays) after allowing for vertical deflection due to permanent loads. When the sign face is not over the road way or road shoulder or parking or areas accessible by vehicles, minimum of 2400 mm vertical clearance above the ground level to the underside of the sign face or any structure component shall be maintained to prevent collision with pedestrians.

When the sign structure is attached to an existing overpass bridge, vertical clearance to any component of the sign structure shall not be less than the vertical clearance of the existing bridge plus 50 mm.

11.4.2 Advertising signs attached to bridges

11.4.2.1 Geometric layout

The following criteria applies to the structural design and fabrication of advertising signs mounted on Transport and Main Roads bridges. Other regulatory requirements and Standards that must be complied with are outside the scope of these design criteria.

<u>Type 1 – Advertising signs attached to reinforced concrete traffic barriers on bridges.</u>

The sign structure shall be designed to remain intact when the barrier is impacted by traffic to prevent the structure from falling onto pedestrians and traffic below. The structure shall be attached to the outside face of the reinforced concrete barrier.

<u>Type 2 – Advertising signs attached to bridges with steel traffic barriers.</u>

The sign structure shall be supported independent of the steel traffic barrier and positioned beyond the deflection limits of the traffic barrier. The sign structure shall not be impacted when the traffic barrier is impacted by a vehicle. For guidance a regular performance level double steel traffic barrier detailed in Standard Drawing 1508 will deflect 100 mm approximately when impacted.

<u>Common to both Types 1 and 2</u>

The structure supporting the advertising sign shall be positioned outside the “working width” so that if the barrier is impacted by a vehicle, the vehicle will not impact the sign structure. The “working width” is defined in Chapter 7 of the Transport and Main Roads *Road Planning and Design Manual*. These signs require Transport and Main Roads level 2 structural inspections.

The sign structure shall have a horizontal clearance of 50 mm minimum from the near face of the bridge traffic barrier. The horizontal gap between the face of the traffic barrier and the rear of the sign box shall be sealed with a galvanised perforated steel sheet (maximum 10 mm diameter holes) along the full length of the sign structure. This is to prevent vandals, hidden behind the sign, from dropping objects onto the motorway below. This is a “Safety in design” requirement.

The design shall prevent access by vandals to the sign structure and tamper proof fastenings and connections shall be used.

A Structure with vertical balustrades or other suitable which cannot be climbed shall be provided to prevent unauthorised access to the top of the sign structure. Minimum height of this structure shall be 2.4 m from the road surface or highest point of footfall where a person can stand to climb this structure such on top of the bridge kerb or parapet. This structure shall be designed for loading as stated in Clause 11.5 of AS 5100.2.

The sign structure shall not restrict access for maintenance and repairs to the traffic barrier. Drilling or coring into prestressed concrete members is NOT permitted. Signs shall be attached with stainless steel or hot dip galvanized bolts.

11.4.2.2 Working with Asbestos in existing bridges

Designer shall investigate whether any permanent asbestos items have been used in the bridge prior to the preparing the concept design proposal for attaching the sign structure to bridge. Refer Clause 1.3.6.1 of Design Criteria for Bridges and Other Structures for procedure to be followed for identification and working with asbestos.

If the presence of asbestos is identified in the existing bridge, it may be too costly to attach the sign structure to the bridge. This is due to the high cost of working safely with asbestos. However, if the attachment method does not require working with asbestos, it may be possible to attach the sign structure to the bridge. However, approval from Director (Bridge and Marine Engineering) shall be obtained prior to commencing the concept design.

11.4.3 Aesthetics

Sign support structures shall be aesthetically compatible with other similar structures in the road network.

11.4.4 Materials

Concrete shall be to MRTS70 and Steel reinforcement to MRTS71. Structural steel shall be to standards specified in Clause 11.3.4.1.

Other materials, not contained in this specification, shall not be used without the prior approval of Transport and Main Roads. If permitted, the approval letter will contain details of the appropriate standards or codes.

11.4.4.1 Structural steel

Structural steel material shall meet the following requirements:

- All cold formed structural steel hollow sections to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel.
- Steel members fabricated from rolled plates with seam welds need to be designed taking into account the tolerance of rolling in the design. The tolerances are outlined in MRTS63. Rolled plates shall be manufactured in accordance with MRTS63 using Grade XXXL15 material to AS/NZS 3678 where XXX is the grade of the steel. All of these welds shall be 100% ultrasonically tested.
- All hot rolled steel plates shall be to AS/NZS 3678.
- All structural steel hot rolled sections shall be to AS/NZS 3679.1.
- Structural steel welded sections shall be to AS/NZS 3679.2.
- Minimum steel thickness for structural steel members shall be 2.5 mm except for external steel members exposed to weather where the minimum steel thickness shall be 3 mm.
- Structural steel water pipe manufactured to AS 1579 is not permitted unless it is tested along the longitudinal axis to AS/NZS 1163 and is Grade xxx L0 where XXX is the grade of the steel.
- Spirally wound fabricated circular hollow sections are not permitted.

11.4.4.2 Bolts, nuts and washers and safety cables

Steel bolts, nuts and washers shall be in accordance with MRTS78.

Self tapping screws are not permitted to use in structural connections and to connect sign screen components to the structure. Bolted connections with two nuts in predrilled hot dipped galvanised holes shall be used to connect structural members. In addition to bolted connections, safety cables shall be provided to secure every advertising sign screen cabinet to structural members. The minimum factor of safety for the cable system shall be 5.0 to resist self weight of the sign in case of bolt failure. The minimum design life of the safety cable system shall be 40 years.

Self tapping screws are permitted to fasten cladding only.

11.4.5 Structural design

Design life

The design life for advertising sign structures shall be 40 years. However, if advertising signs are attached to a bridge, all fasteners attached to the bridge shall be 100 year design life

11.4.5.1 Live load

Sign structures that have a maintenance platform shall be designed for live loading of 5 kN concentrated moving load over 1 m² simultaneously with 2.5 kPa distributed load elsewhere. The platform shall also be designed for concentrated load of 1 kN over 300 mm square patch located anywhere on the platform floor.

11.4.5.2 Ultimate strength

Ultimate strength structural design shall be to AS 5100.

ARI for ultimate limit state wind speed shall be 2000 years.

11.4.5.3 Structural design criteria - wind and fatigue

Design criteria for wind and fatigue applicable to structures are provided in Table 11.4.5.3.

Table 11.4.5.3 - Wind loading and fatigue design criteria

Wind loading	Fatigue
AS/NZS 1170.2 with wind perpendicular and at 45 degrees. C_D in accordance with AS/NZS 1170.2.	Design for fatigue in accordance with Section 11 “Fatigue” of AASHTO *Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, 5th Edition (2009) with Interim revision (2011).

11.4.5.4 Load combinations

Load factors and load combinations for structural design shall be to AS 5100.

When an advertising sign structure is attached to a bridge over road, the design live load for assessing the bridge structure shall be the original design loads used in the design of the bridge.

The impact load on the barrier shall be assessed using the Road Barrier Performance Level Selection Method in AS 5100. The result from this shall be used to determine whether it is justified to use the barrier impact load that the structure was originally designed for. Also refer to Clause 7 *“Matters for Resolution”* Item 19 for the procedure and requirements to determine the barrier performance level.

For comparison, the barrier impact load in the Bridge Design codes is as follows:

NAASRA 1976	- 45 kN (working load)	
Austroads 1992	- 90 kN (ultimate load) for $h < 850$ mm	
AS 5100.2	- Low performance	125 kN (ultimate)
	- Regular performance	250 kN (ultimate)

For bridges designed in accordance with the NAASRA or Austroads Codes, the minimum barrier impact load to be used for assessing the bridge structure in combination with the load effects of the advertising sign attached to the bridge, shall be 60% of Low performance, that is 62 kN minimum impact load.

For bridges designed in accordance with AS 5100, the full impact load stipulated by AS 5100 for appropriate barrier performance level shall be used for assessing the bridge structure in combination with the load effects of the advertising sign attached to the bridge. Designer shall determine the appropriate barrier performance level in accordance with the AS 5100.1 Appendix B.

For bridges designed prior to 1976, these are considered as special cases and the appropriate barrier impact load shall be discussed with Transport and Main Roads Director (Bridge and Marine Engineering).

The sign structure designer shall check the structural adequacy of the bridge structure. Following additional load combinations for ultimate design shall be considered.

Combination 1: Ultimate 2000 years ARI wind on sign plus ultimate dead load (Bridge and Sign structure), No traffic load on the bridge, No vehicle impact on the barrier.

Combination 2: 10 years ARI serviceability wind on the sign plus ultimate dead load (Bridge and Sign structure) plus ultimate vehicle impact load on the barrier, No traffic load on the bridge.

Combination 3: 20 years ARI serviceability wind on sign plus ultimate dead loads (Bridge and Sign structure), plus ultimate traffic loads on the bridge, plus serviceability live load on the sign structure working platform, No vehicle impact on barrier.

11.4.5.5 Serviceability deflection

The self weight and live loads shall be taken into account for deflection calculations.

a) The serviceability limit state horizontal deflection of structures shall be checked and limited to Structure Height/150.

b) The serviceability limit state vertical deflection under any live load shall not exceed Span/250 for cantilever structures and for other span types span/500.

Structures shall be pre-cambered such that there is zero deflection under permanent loads.

11.4.5.6 Vibration

Vibration limits shall be in accordance with AS 5100 and the Sign Licensee’s requirements for each particular device and screen.

11.4.5.7 Foundation design

Foundation design for sign structures shall be based on specific foundation investigation at the sign location to a minimum depth of one full height of the structure unless otherwise directed by RPEQ

(Geotechnical) Engineer. The RPEQ (Geotechnical)'s report shall include advice to ensure that long term foundation rotation does not result in column deflection in excess of the serviceability deflection limits specified in Clause 11.4.5.5.

The geotechnical investigation shall identify potential Acid Sulphate Soils. The designer shall use MRTS51 *Environmental Management* and MRTS04 *General Earthworks* to specify the treatment of Acid Sulphate Soils if this is present on the site.

Foundation structures such as pile caps, footings and so on, shall be located below the ground with the top of the pile cap, footing and so on, at the same level as the surrounding ground surface level.

Suitability of the type of foundation shall be assessed by the structural designer in consultation with the Geotechnical Engineer.

Below foundation types acceptable to Transport and Main Roads:

a) Cast-In-Place piles to MRTS63 or MRTS63A as applicable;

   MRTS63A is applicable for piles for high moment low axial load applications such as single Cast-in-place piles. Piles in pile group where axial load is dominant due to the moment couple shall be in accordance with MRTS63.

b) Prestressed concrete driven piles to MRTS65;

c) Spread footings

Any other foundation types shall be agreed with Transport and Main Roads (Structures) prior to start of design.

Below foundation types not permitted by Transport and Main Roads:

a) Screw piles

b) Continuous Flight Auger (CFA) piles

c) Precast reinforced concrete piles

d) Steel piles.

e) Precast concrete piles manufactured by spinning or rolling

f) Pile constructed with bentonite or polymer slurry.

The foundations shall be designed so that the base plate is installed as close to ground level as possible while providing for drainage and other requirements. The design length of the support columns shall take into consideration the variations in the reduced levels of the foundations.

11.4.5.8 Anchor bolt details

On the basis of NCHRP reports and learning from interstate sign structure failures, the following shall be observed:

a) Connections using class 4.6 bolts are less likely to be controlled by fatigue requirements than are those which use class 8.8 bolts; however either class may be used provided that the design satisfies both ultimate strength and fatigue life requirements. Class 4.6 and 8.8 bolts shall conform to Transport and Main Roads Standard Specification MRTS78.

b) Pre tensioned bolts are not warranted.

c) Nut tightening and the use of lock nuts are important to prevent nut loosening, which in turn will cause undesirable larger stress fluctuations, thus increasing the risk of fatigue failure.

d) Snug tightening is adequate for fatigue performance provided it is done properly and provided lock nuts are:

- purpose made half height nuts
- made from softer steel than the ordinary nut, and
- located between the ordinary nut and the base plate.

e) The maximum unsupported length of the anchor from top of footing to the bottom of the base plate shall be not more than one anchor diameter.

11.4.5.9 Base plate thickness

The base plate shall be at least as thick as the anchor bolt diameter.

11.4.6 Corrosion protection and durability

The minimum protection of all steelwork shall be either painted or hot-dip galvanised to AS 4680 including all internal surfaces of tubular members.

If the steelwork is hot dipped galvanized then:

- Connections shall be sealed on all faces to stop the ingress of water and galvanising acids which causes corrosion at interfaces. Where access for welding is available to one side of a joint only, a full penetration butt weld shall be used.
- Where backing bars/backing rings are used inside members, the backing bars/backing rings shall be removed prior to galvanising. If they are not removed, acid is trapped between the backing bars/rings and the member resulting in crevice corrosion.
- The size of the components shall be checked to ensure that they can be hot-dip galvanised after fabrication. Double dipping shall be allowed.

11.4.7 Concrete durability

The exposure classification for the purpose of determining cover to reinforcement shall be to AS 3600. Minimum exposure classification shall be A2.

Also refer to Clause 3.8.4 for additional requirements of concrete durability.

11.4.8 Maintenance platform

Unless specifically nominated otherwise by Transport and Main Roads, all structures supporting advertising signs shall be provided with an access platform to allow maintenance of the equipment and structural components without disrupting traffic.

The maintenance platform shall comply with AS 1657: "*Fixed platforms, walkways, stairways and ladders- Design, construction and installation"* and additional criteria stated in this document. Maintenance Platform shall be provided for the full length of the overhead structure. The minimum width of the maintenance platform shall be as specified by the sign owner provided that the minimum width requirement stated in AS 1657 is satisfied.

All walkways and platforms shall have permanent plates secured and displayed in a prominent position stating the maximum design loads for the walkways and platforms and any constraints to loading intensity. These plates shall be detailed on the drawings conforming to the appropriate Australian Standards.

Floor of the maintenance platform shall be a grated floor to comply with AS 1657 Clause 3.3.1 *"Floors".* The floor shall have a non-slip finish and be self-draining. The "***Weldlok***" A40-205 floor grating is acceptable to Transport and Main Roads. A protection mesh shall be fitted on to the top of the grated floor to protect objects, maintenance tools and equipment from falling onto the area below. Gaps larger than 10 mm at the ends of the floor which permit items to fall on to the area below shall be fitted with the mesh. The protection mesh shall be an expanded metal with the minor axis not exceeding 10 mm and minimum thickness of 1.6 mm. "***Mastermesh* Industries**" LD1616 mesh is acceptable to Transport and Main Roads.

Guardrailing shall be provided on the maintenance platform. Guardrailing shall comply with AS 1657 Clause 3.4 *Guardrailing* and have:

- top of the top rail at 1100 mm height from the floor
- one or more middle rails having a maximum clear distance of 450 mm between the rails and a maximum clear distance of 450 mm between the lowest rail and the top of the toe board
- a toe-board which shall not be less than 100 mm above the top of the floor. Toe-board shall be provided all around the floor of the platform except at the platform entrance. Toe-board shall be made using structural steel angle of minimum 3 mm thick
- a protection mesh made from expanded metal mesh with the minor axis not exceeding 10 mm and minimum thickness of 1.6 mm to infill between all the rails and top of the toe-board to ensure that objects, maintenance tools or equipment cannot fall on to the area below. "***Mastermesh* Industries**" LD1616 mesh is acceptable to Transport and Main Roads
- no gaps greater than 100 mm (with or without a mesh) between ends of the guardrailing and the structure.

Any vertical gaps between the floor of the maintenance platform and the rear of the sign face shall also be fitted with a mesh similar to the mesh fitted with the guardrails to prevent objects, maintenance tools and equipment from falling to the area below.

Unless otherwise specified, access to the maintenance platform shall be by fixed ladder systems from ground level designed and installed to:

- AS 1657: *Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
- AS/NZS 1891: *Industrial Fall-arrest systems and devices*
- *Guidance on The Principles of Safe Design for Work* (May 2006) by Australian Safety and Compensation Council
- *Safe Work Australia Code of Practice* and
- WHS legislations, and
- additional criteria stated in this document.

11.4.9 Access ladder and landings

The ladder system and the landing shall be designed and installed in accordance with AS 1657. The access structure must be considered as a workplace, and the access provisions must conform to the appropriate Act and Regulations. The access must be secure and ensure unauthorised persons cannot obtain entry to the structure.

The requirement of intermediate landing, ladder cage and safety harness based fall arrest system shall be in accordance with AS 1657 and Table 11.4.8.

Table 11.4.8 - Details of the fall protections

Structure type	Fall distance	Fall protection provisions	AS 1657 reference clauses
Ladder is within four post gantry column	Up to 6.0 m	Ladder cage and harness based fall-arrest system	Table H1 and Clause 7.4.7: Note 2
	> 6.0 m	Intermediate landing at maximum of 4.5 m height, ladder cage and harness based fall-arrest system. Vertical height between landings in multiple flight ladders should be equal.	Table H1 Clause 7.4.7 and 7.3.6 Clause 7.3.6: Note 2
Ladder is fixed other than four post gantry columns. *e.g. Single post VMS structure*	Up to 6.0 m	Ladder cage and harness based fall-arrest system	Table H1, Clause 7.4.7:Note2
	> 6.0 m	Intermediate landing at maximum of 4.5 m height, ladder cage and harness based fall-arrest system. Vertical height between landings in multiple flight ladders should be equal. Omit intermediate landing where installation of intermediate landing is “not reasonably practicable” (*Example: A single post VMS structure where an intermediate landing will fall within the working width or over the carriageway*)	Table H1, Clause 7.4.7 and 7.3.6 Clause 7.3.6: Note 2 Clause 7.3.6: Note 3 :

When intermediate landing with multiple ladders are used, the ladder arrangement shall be in accordance with AS 1657.

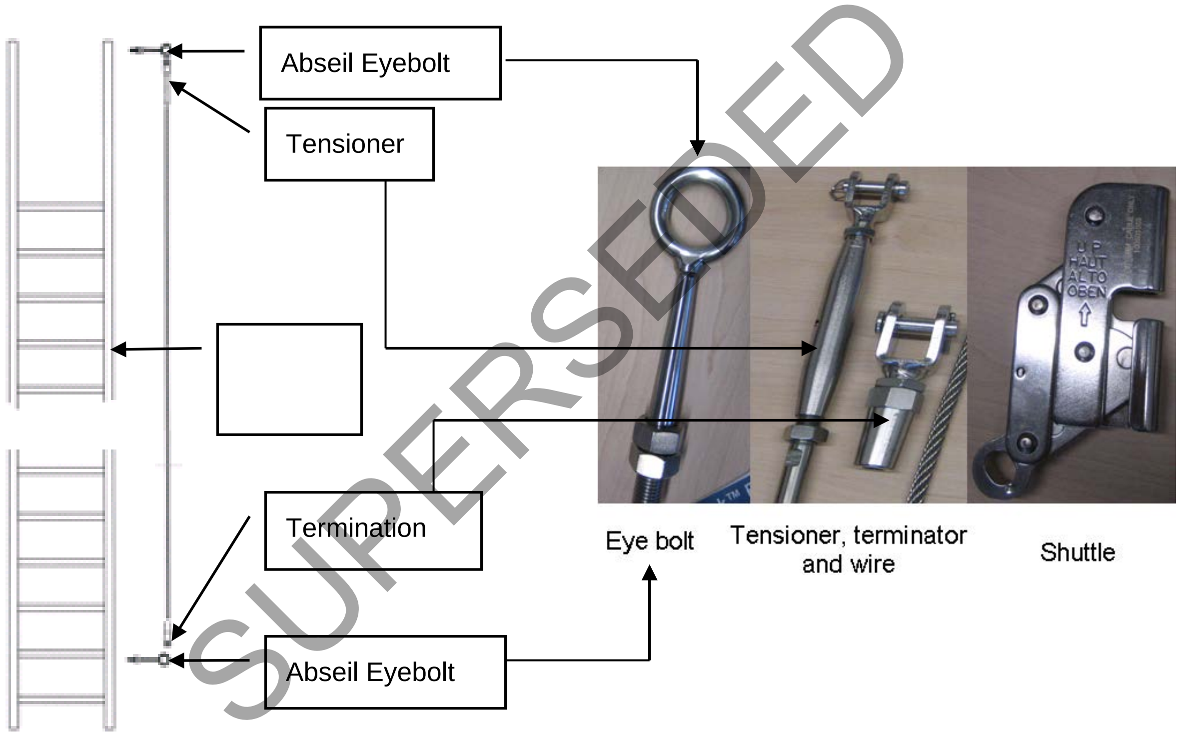
Fall arrester harness systems shall comply with AS/NZS 1891. The harness system shall be capable of arresting falls within a short drop of not greater than 600 mm. The designer shall be responsible for nominating the type of harness and providing attachment points in the structure. The approved fall arrester system shall have Certification and Approval to AS/NZS 1891 (Series): *Industrial fall – arrest systems and devices.*

Table 11.4.9 and Figure 11.4.8 show the details of the fall arrester system manufactured by SafetyLink Pty Ltd which is acceptable to Transport and Main Roads.

Table 11.4.9 - Details of the fall arrester system

Part Nos.	Product list
Ladder001:10	Vertical Static Line Shuttle with Karabiner (not required for each site, required for those climbing the gantry)
Eyebolt002	Abseil eyebolt (2 Nos.)
Stat.Tensr002	Swage less Tensioner (1 No)
Stat.Term002	Swage less Termination (1 No)
Stat.Cable001	Stainless Steel Cable (typically 9 m length to suite specific gantry)

Figure 11.4.8 - Parts of the fall arrester system



Following additional requirements shall also be met.

1. At the bottom of the ladder, the following sign and the wording shall be attached.

“**This ladder shall be used only by suitably trained personnel using approved protection devices**”

2. The base of the ladder shall be kept above the base slab for improved durability. The height to the first rung from base slab shall be not greater than the standard rise. All rises shall be equal except that the first rise may be less than the standard height.
3. Screens shall be provided around the outside of the ladder to prevent children and unauthorised persons accessing the ladder from the gap between the column and the back of the ladder.
4. All other requirements of AS 1657 shall be strictly adhered to, and are not open to interpretation under Clause 1.4.13 “Reasonably practicable”.
5. Following erection a competent person (as defined in the Work Place Health and Safety Act 2011) shall be engaged by the gantry supplier to carry out an inspection and comprehensive safety audit of the gantry for compliance with AS 1657 and WHS legislations prior to handover to Transport and Main Roads.
6. The Designer shall provide a RPEQ Certified Compliance Certificate stating that the structure complies with AS 1657, AS/NZS 1891, “Guidance on The Principles of Safe Design for Work” (May 2006) by Australian Safety and Compensation Council, “Safe Work Australia Code of Practice” and WHS legislations.
7. The sign supplier shall provide a metal Plate with the Sign Identification number embossed on it and securely attach it to the structure with vandal proof fastenings.

11.4.10 Wiring and wiring enclosures

All wiring and wiring enclosures for installation of power cables must comply with AS/NZS 3000 and the relevant Transport and Main Roads technical specifications.

All wiring enclosures for telecommunications cables must comply with AS/ACIF S009 and the relevant Transport and Main Roads technical specifications.

Conduits must comply with Transport and Main Roads Standard Specification MRTS91.

11.4.11 Access to the structure site

The design must incorporate a path from where maintenance personnel can park a vehicle and gain access to the structure. Access to the structure site shall be designed to ensure that maintenance personnel can access the structure safely. Routine operation and maintenance access to the structure shall not require traffic control measures, and/or lane closures.

Provision shall be made for impact protection of maintenance personnel from errant vehicles.

11.4.12 Protection of structures from vehicle impact

Structures within the clear zone as per Chapter 8 of Transport and Main Roads *Road Planning and Design Manual* shall be protected from vehicle impact. Transport and Main Roads Guideline: *Overhead Gantries that project across trafficked lanes: Protection from Vehicle Impact* shall be used to design the barriers.

11.4.13 Transport and Main Roads review of drawings and scheme documents

This clause illustrates the approval process for on-carriageway advertising devices.

The drawings, specifications, design report, safety in design report and geotechnical report shall be submitted to Transport and Main Roads by the Sign Licensee. These documents are to be reviewed by Transport and Main Roads for safety, durability, future performance, constructability and maintenance. Drawings other documents shall be submitted for Transport and Main Roads review at 15% preliminary design, 50% substantial completion (unchecked drawings), 85% complete, (checked drawings) and RPEQ certified drawings for final approval. Drawings shall comply with the Transport and Main Roads *Drafting and Design Presentation Volume 3-Structures Drafting Manual.*

The preliminary design submission shall involve a meeting between Transport and Main Roads (Structures) and the Sign Licensee's RPEQ engineer to discuss the drawings. The drawings shall include all typical project details. The design shall not proceed until the issues are resolved.

Transport and Main Roads will provide comments that the designer must consider, and these shall be included in the design. If the comment is not acceptable to the designer, reasons shall be discussed with Transport and Main Roads. A final position shall be reached, and the final version adopted shall be accepted by Transport and Main Roads. The final decision acceptable to Director (Bridge and Marine Engineering) shall be reached. This solution shall be adopted.

Fabrication shall not begin until RPEQ certified drawings have been submitted to Transport and Main Roads and approved by the department. Fabrication shall not begin until all hold points and witness points in MRTS78 are released by Transport and Main Roads.

For information regarding the acceptance of advertising signs refer to:

Director (Bridge and Marine Engineering)
Department of Transport and Main Roads
Structures Division
GPO Box 1412
Brisbane Qld 4001

11.4.14 Quality assurance in the documentation

- Structural design shall conform to a high level of technical competence and shall be based on proven methods, materials and technology. All structures shall be designed in accordance with good engineering practice, relevant codes and incorporate safety in design principles. All structures must have an attractive appearance appropriate to their general surroundings and any adjacent structures. The design shall be practical and cost-effective to construct and maintain.
- Designer shall be a RPEQ or supervised by a RPEQ structural engineer.
- Design shall be checked by a structural engineer who is a RPEQ or supervised by a RPEQ structural engineer. The engineer who undertakes the check shall be different to the designer and shall do independent calculations.

The design checker must be nominated not later than at the 50% progress stage and approved by the Director (Bridge and Marine Engineering).

All Engineering Drawings shall be certified by an RPEQ Engineer. The RPEQ Engineer shall also certify on the drawings that the design complies with the relevant Australian Standards relating to Workplace Health and Safety.

The Design Report shall contain the following information. .

a) Maximum horizontal and vertical serviceability deflections of the structure

b) Installation procedure for the structure, including erection procedure of the structure

c) Design considerations for Provisions for Safe Maintenance.

The Sign Licensee shall provide a separate report comprising their Structural Inspection and Maintenance Program, and Reporting Format to Transport and Main Roads Structures for review. These shall include defect classifications and remedial measures for each type of defect. The inspection frequency shall be specified in the document.

Drawings are to incorporate the following details or notes:

a) Sign structure location including the location relative to the road edge and nearest property boundaries shall be clearly marked on the drawings. The closest horizontal clearance from the outermost edge of the trafficable lane shall be shown in the drawings. Where the sign structure is above the traffic lanes, minimum vertical clearance above the carriageway shall be shown in the general arrangement drawings.

b) All design loads for the structure are to be shown on the drawings. Walkways and platforms shall have permanent plates secured and displayed in a prominent position stating the design loads for the walkways and platforms. These plates shall be detailed on the drawings.

c) Material standards, design standards and relevant Transport and Main Roads Technical Standards shall be referred in the drawing notes.

d) The erection sequence shall include all requirements for tightening of hold-down bolts prior to grouting and prior to attachment of outreach arms.

e) Construction drawings should include a diagram showing column offset and outreach pre-camber. Designers should calculate column offset based on provision of a 1 in 40 slope after allowance for long-term progressive foundation movement.

f) Use of upper and lower templates for hold down bolts is recommended to ensure a good fit with holes in the base plate. Bending of hold down bolts is not permitted. Use of enlarged bolt holes is not recommended.

g) Impact protection from errant vehicles.

h) Drainage water shall be directed away from the footings of cantilever sign structures to prevent softening of the surrounds and corrosion of base plate and holding down bolts. Concrete paving with or without drainage channels may be appropriate in some areas.

i) All welds are to be detailed on the drawings and weld symbols shall be in accordance with AS 1101.3.

j) All access holes for cables and wires shall be fabricated without sharp edges to prevent damage to insulation when the cables are drawn.

k) No additional holes are permitted to be drilled that are not shown on the RPEQ Certified drawings without approval from the structural designer.

l) Adequate vent holes for galvanising process shall be detailed in the drawings.

m) Only those welds shown on the drawings are permitted. No weld is to be omitted or added without the specific approval from the designer.

11.4.15 Design certification

a) Design Certification is required for each sign structure

b) A geotechnical design report, certified by an RPEQ Geotechnical Assessor, shall be included in the Final Design Report for each sign structure

c) A structural design report, certified by an RPEQ Structural Engineer, shall be included in the Final Design Report for each sign structure.

11.4.16 Acceptance for fabrication and construction

On completion of the department's final review, an acceptance letter will be issued to the Sign Licensee. Fabrication and construction shall not be commenced until the design is approved by the Transport and Main Roads.

11.4.17 Fabrication of structural steelworks and aluminium components

Fabrication of the structural steelwork shall be to MRTS78 *"Fabrication of Structural Steelwork"*. Fabrication of aluminium components shall be to MRTS79 *"Fabrication of Aluminium components".*

All structural steelwork and all aluminium work shall be inspected by an RPEQ Engineer or their approved delegate who is experienced in the fabrication of structural steelwork and ensure all the requirements of the specification are met.

The inspections shall be carried out during the fabrication process. The following documentation shall be supplied to Transport and Main Roads with the sign structure:

- Inspection Report outlining the welding procedures provided match the welds specified on the approved RPEQ Engineering drawings.
- Inspection Report outlining the review of the material test certificates to show compliance with the appropriate Australian Standards specified on the approved RPEQ Engineering drawings. The report shall state the member size and grade used in the structure. The report shall also outline the heat number and material test certificate number for the material supplied.
- Inspection Report outlining which butt weld preparations were inspected. This report shall include photos of each type of butt weld inspected with a bevel gauge showing the joint matches the approved welding procedure sheet.
- Inspection Report outlining the completed welds which have been inspected. The report shall show the welds inspected with the appropriate weld fillet gauge to show the conforming welds and the report shall show any welding defects identified in the inspection.
- Inspection Report outlining the non destructive testing carried out in accordance with the specification.

11.4.18 Installation of the structure

Sign installation shall be undertaken by a company (Installer) who shall operate and maintain a quality management system audited by a third party organisation in accordance with AS/NZS ISO 9001 or ISO 3834.

Installation shall be in accordance with Transport and Main Roads specifications and technical standards.

Administrator is responsible for RPEQ certification for releasing Witness Points and Hold Points referred to in the relevant Transport and Main Roads technical standards. This certification shall include below:

a) Setting out and Excavation:

- Structure location shall be set out on the Site by an experienced surveyor. This witness point shall be released and certified by the Administrator.
- During the setting out process, the Contractor shall be deemed to have checked the location and details of all structural members in relation to the dimensions of such members.
- If an error in the details shown in the Drawings is detected, the Administrator shall be notified immediately and construction shall not be carried out until written agreement is issued by the Administrator.
- The construction of piles, footings, pile caps, and so on, shall be carried out to the details shown in the drawings and in accordance with the relevant Transport and Main Roads technical standards.
- Prior to concreting, excavated foundations shall be inspected by the Geotechnical Assessor and RPEQ certified.
- Excavation for footings and pile caps shall be in accordance with the requirements of Clause 14 of MRTS04 General Earthworks.
- Acid sulphate soils shall be treated in accordance with MRTS51 and MRTS04.

b) Cast-in place piles

Cast-in place piles shall be in accordance with MRTS63 or MRTS63A as applicable and all hold points in Clause 4.1 of MRTS63A and MRTS63A shall be released and certified by the Administrator.

c) Precast prestressed concrete piles

Precast prestressed concrete piles shall be in accordance with MRTS65. All hold points and witness points in Clause 4.1 of MRTS65 and hold point No 3 in Table 5.1 of MRTS73 shall be released and certified by the Administrator.

d) Dynamic testing of piles

Dynamic testing of piles shall be in accordance with MRTS68. All hold points and witness points in Clause 4.1 of MRTS68 shall be released and certified by the Administrator.

e) Concreting

Concreting shall be in accordance with MRTS70. All hold points and witness points in Clause 5.1 of MRTS70 shall be released and certified by the Administrator.

f) Steel reinforcing

Fabrication and placing of Steel reinforcement shall be in accordance with MRTS71. All hold points and witness points in Clause 4.1 of MRTS71 shall be released and certified by the Administrator.

g) Structural steelwork

Fabrication of structural steelwork shall be in accordance with MRTS78. All hold points and witness points in Clause 4.1 of MRTS78 shall be released and certified by the Administrator.

h) Aluminium works

Fabrication of Aluminium components shall be in accordance with MRTS79. All hold points in Clause 4.1 of MRTS79 shall be released and certified by the Administrator.

Transport and Main Roads does not permit the use of levelling nuts to support the structure. The structure shall be supported by proprietary non-shrink mortar with uniform distribution of the load over the whole plan area of the base plate. An acceptable procedure is as follows:

a) Stand the column section and level the column by placing a minimum of 4 steel wedges under each base plate

b) Mix the non-shrink mortar to a trowellable consistency

c) Pack the mortar and ensure that the mortar extends over the full area of the base plate

d) Wait for the mortar to set sufficiently to support the weight of the structure

e) Remove the steel wedges

f) Tension the bolts

g) Repair the mortar where the wedges were located.

Bolts with TB or TF classification shall be tensioned in accordance with MRTS78.

All materials and bolts shall conform to the requirements of Transport and Main Roads Standard Specification MRTS78.

11.4.19 Inspection of the installed sign structure

Large advertising signs that could fall onto the traffic lanes in the event of a structural failure such as gantries with signs over traffic lanes, cantilevers and butterflies (cruciform) as well as tall light masts and large signs with truss supports in close proximity to the traffic lanes are to be recorded in the inventory of the Bridge Information System (BIS) and will be subject to the inspection regime defined in *BAM Support Advice Note No.112:Large Traffic Management Signs-Inventory Creation & Inspection*.

Sign Licensee shall arrange for the Transport and Main Roads level 2 routine inspection for the sign structure. Inspection report including the condition of the structure and any defects identified shall be provided to Transport and Main Roads annually.

The cost for inspections shall be borne by the Sign Licensee.

11.5 Design criteria for off-carriageway advertising signs

This criterion shall be applied for sign locations stated in Clause 11.1(b).

11.5.1 Vertical clearance

Minimum of 2400 mm vertical clearance above the ground level to the underside of the sign face or any structural component shall be maintained to prevent collision with pedestrians.

11.5.2 Materials

Concrete shall be to AS 3600. Steel reinforcement shall be to AS 4671 and ACRS (Australian Certification Authority for Reinforcing Steel) certified. Structural steel shall be to standards specified in Clause 11.4.2.1.

Other materials, not contained in this specification, shall not be used without the prior approval of Transport and Main Roads. If permitted, the approval letter will contain details of the appropriate standard or code.

11.5.2.1 Structural steel

Structural steel material shall meet the following requirements:

- All cold formed structural steel hollow sections to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel.
- Steel members made from rolled liners with seam welds need to be designed taking into account the tolerance of rolling in the design. Rolled liners shall be manufactured using Grade XXXL15 material to AS/NZS 3678 where XXX is the grade of the steel. Welding shall be carried out in accordance with the provisions of AS/NZS 1554.1. All longitudinal and transverse welds shall be made with full penetration butt welds. Where field joints between lengths are required, they shall employ full penetration butt welds. Longitudinal welds along the liner are staggered. The leading edge of the liners shall be reinforced. All of these welds shall be 100% ultrasonically tested. The out-of-round tolerance shall not exceed 5% of diameter of liner. Steel liners shall not exceed a bow of 1% of the length of the pile in any direction. Liners shall be free of any internal steps or ridges.
- All hot rolled steel plates shall be to AS/NZS 3678.
- All structural steel hot rolled sections shall be to AS/NZS 3679.1.
- Structural steel welded sections shall be to AS/NZS 3679.2.
- Minimum steel thickness for structural steel sections shall be 3.0 mm.
- Structural steel water pipe manufactured to AS 1579 is screw unless it is tested along the longitudinal axis to AS/NZS 1163 and is Grade xxx L0 where XXX is the grade of the steel.
- Spirally wound fabricated circular hollow sections are not permitted.

11.5.2.2 Bolts, nuts and washers

Standard bolts, nuts and washers shall confirm to following standards.

Bolts - Property class 4.6 to AS 1110 or AS 1111 as relevant. Bolt diameter, thread form and pitch shall be to ISO coarse pitch series to AS 1275 to 8g tolerances.

Nuts - Normal hexagonal nuts of property class 5 to AS 1112. Diameter, thread form and pitch shall be to ISO coarse pitch series to AS 1275 to 8g tolerances.

Flat washers - to AS 1237.

High Strength Bolts, Nuts and Washers shall confirm to AS 1252. Bolt diameter, thread form and pitch shall be to ISO coarse pitch series to AS 1275 to 8g tolerances.

Self tapping screws are not permitted to connect structural members. Bolted connections with two nuts in predrilled hot dipped galvanised holes shall be used to connect structural members.

Self tapping screws are permitted to fasten cladding only.

11.5.3 Structural design

11.5.3.1 Design life

The design life shall be 40 years.

11.5.3.2 Live load

The design live loads shall be as for the “On-carriageway” advertising signs stated in Clause 11.3.5.2.

11.5.3.3 Ultimate strength

Ultimate strength for concrete design shall be to AS 3600 and steel designs to AS 4100.

ARI for ultimate limit state wind speed shall be a minimum of 500 years for rural applications and a minimum of 1000 years for other cases.

11.5.3.4 Structural design criteria - wind and fatigue

Design criteria for wind and fatigue applicable to structures are provided in Table 11.5.3.4.

Table 11.5.3.4 - Wind loading and fatigue design criteria

Wind loading	Fatigue
AS/NZS 1170.2 with wind perpendicular and at 45 degrees. C_D in accordance with AS/NZS 1170.2.	Design for fatigue in accordance with Section 11 “Fatigue” of AASHTO *Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, 5th Edition (2009) with Interims revision (2011).

11.5.3.5 Load combinations

Load combinations for structural design shall be to AS/NZS 1170.0.

11.5.3.6 Foundation design

Sign structure shall be designed with a suitable foundation based on specific foundation investigation reported by a RPEQ Geotechnical Engineer. Transport and Main Roads will not restrict the foundation types providing they satisfy following Australian Standards as appropriate.

- AS 5100: Bridge design-Foundation and soil support structures
- AS 2159: Piling –Design and Installation.

The geotechnical investigation shall identify potential Acid Sulphate Soils. The designer shall use MRTS51 *Environmental Management* and MRTS04 *General Earthwork*” to specify the treatment of Acid Sulphate Soils if this is present on the site.

The foundations may be designed so that the base plate is installed as close to ground level as possible while providing for drainage and other requirements. The design length of the support columns may take into consideration the variations in the reduced levels of the foundations.

Foundation structures such as pile caps, footings and so on, shall be located below the ground with the top of the pile cap, footing and so on, at the same level as the surrounding ground surface level.

11.5.3.7 Anchor bolt details

Anchor bolt design and installation shall be RPEQ certified.

11.5.4 Corrosion protection and durability

Suitable paint system to meet the specified durability of the structure or hot-dip galvanized.

11.5.5 Maintenance platform

The requirements of the maintenance platform are as specified by the sign owner and shall comply with following standards and guidelines. Refer Clause 11.4.3.2 for design live loads.

- AS 1657: *Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
- *Guidance on The Principles of Safe Design for Work* (May 2006) by Australian Safety and Compensation Council
- *Safe Work Australia Code of Practice*, and
- WHS legislations.

11.5.6 Wiring and wiring enclosures

All wiring and wiring enclosures for installation of power cables must comply with AS/NZS 3000 and the relevant Transport and Main Roads technical specifications.

11.5.7 Protection of structures from vehicle impact

If the post is within the clear zone, the protection shall be in accordance with Clause 11.3.18 otherwise as guidelines provided in the Transport and Main Roads *Road Planning and Design Manual*.

11.5.8 Construction specifications

The minimum criteria for construction shall be the relevant Australian Standard.

The designer shall prepare construction specifications for the sign structure.

11.5.9 Transport and Main Roads design acceptance

This clause illustrates the approval process for off-carriageway advertising devices.

There are no Transport and Main Roads reviews for different stages of design except Safety in Design Report stated below. It is the Designer's responsibility to ensure that the design conforms to Transport and Main Roads design criteria for Roadside Advertising Signs, Transport and Main Roads Standards, Specifications and Guidelines, and WHS Act and Regulations.

Any proposed departures from the above, the Designer shall declare these during the design stage and request Transport and Main Roads to consider and accept the departures. Transport and Main Roads Director (Bridge and Marine Engineering) will provide a written response to this request. Any departure can only be adopted if approved by Transport and Main Roads.

On completion of the design, the Sign Licensee shall submit 100% completed RPEQ Certified design drawings, Design Report, Geotechnical Report and Specifications to Transport and Main Roads, together with a Conformance Statement from the Designer.

The RPEQ Designer shall provide a Conformance Statement confirming that the design conforms to Transport and Main Roads Design Criteria for Roadside Advertising Signs, Transport and Main Roads

Standards, Specifications and Guidelines and WHS Act and Regulations. The RPEQ designer shall provide the Safety in Design Report to Transport and Main Roads for review on completion of the design.

If the design does not conform to Transport and Main Roads requirements, the department has the right to reject the design.

11.5.10 Design certification

a) Design Certification is required for each sign structure.

b) A geotechnical design report, certified by an RPEQ Geotechnical Assessor, shall be included in the Final Design Report for each sign structure.

c) A structural design report, certified by an RPEQ Structural Engineer, shall be included in the Final Design Report for each sign structure.

11.5.11 Fabrication of structural steelwork

Sign fabrication shall be undertaken by a company (Fabricator) who shall operate and maintain a quality management system audited by a third party organisation in accordance with AS/NZS ISO 9001 or ISO 3834.

Structural steel fabrication shall be in accordance with AS/NZS 1554 and supervised by a Transport and Main Roads approved Inspector as per Clause 4.12 of AS/NZS 1554.1. All cost for this Inspector's services shall be borne by the sign Licensee.

Fabrication shall not start until all material test certificates for structural steel, bolts, nuts and washers to relevant standards are available and signed off by the Inspector.

Fabrication shall not start until the welding procedures are qualified and sign off by the Inspector in accordance with AS/NZS 1554.

11.5.12 Construction supervision

Construction cannot be commenced until the design is RPEQ certified.

Construction and Installation shall be in accordance with the construction specifications and relevant Australian standards.

Sign installation shall be undertaken by a company (Installer) who shall operate and maintain a quality management system audited by a third party organisation in accordance with AS/NZS ISO 9001 or ISO 3834.

Construction shall be supervised and signed off by a RPEQ certification.

Structure location shall be set out on the Site by an experienced surveyor. Administrator shall witness the set out structure location and signed off prior to commence excavation or driving piles.

All concrete used in the work shall be subject to sampling and testing to provisions of AS 1012. Administrator is responsible to certify whether slum for concrete placement and the target concrete is achieved.

No concrete shall be placed in the work until the excavation for foundation to the design levels is witnessed and signed off by the Administrator. Formwork and reinforcement shall be inspected and signed off by the Administrator.

The concerting for cast-in-place piles shall not start until RPEQ geotechnical engineer inspect and certify the socket and pile base.

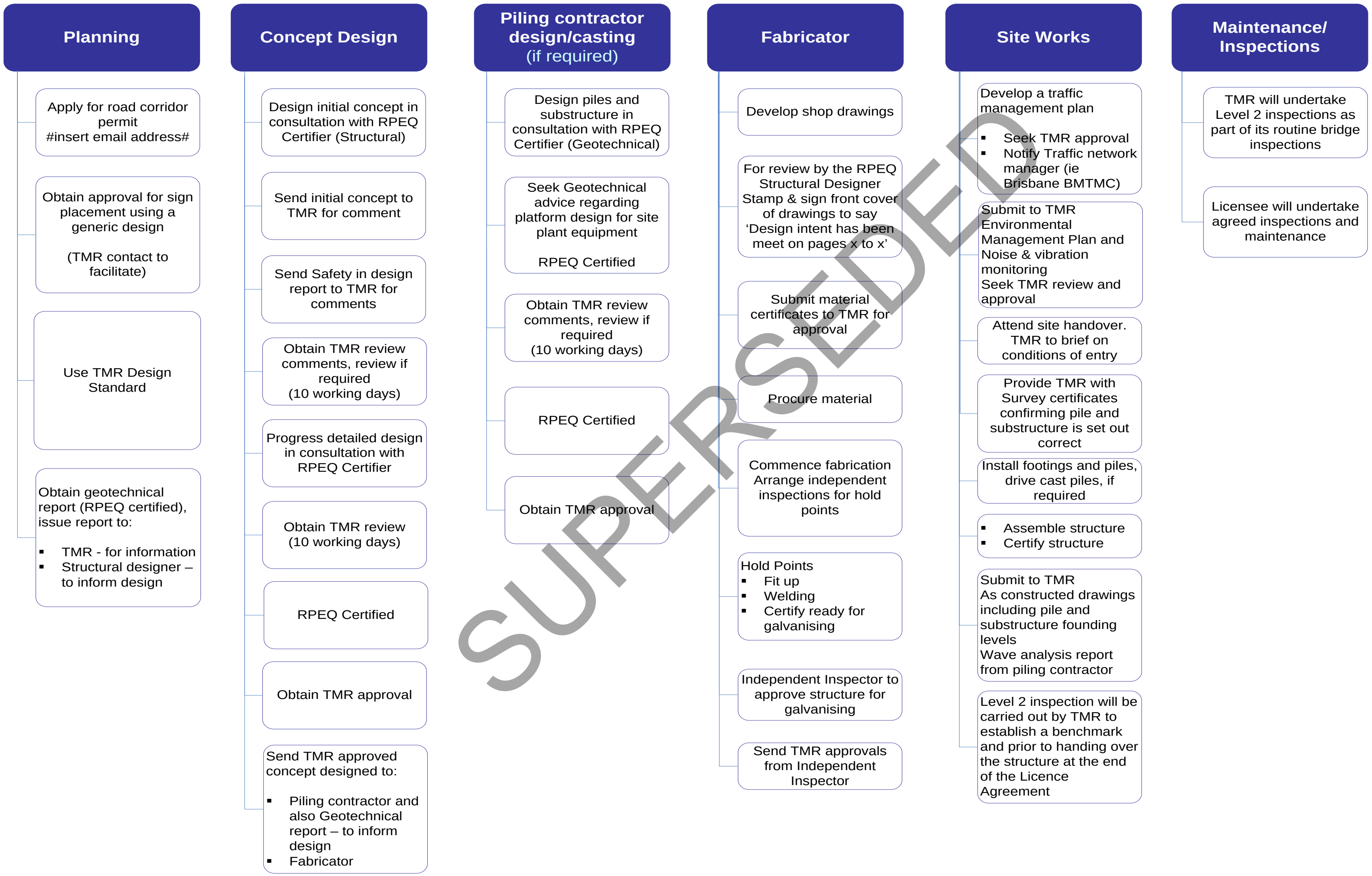
11.5.13 Inspection

Sign owner shall arrange the routine inspection for the sign structure. Inspection report including the condition of the structure and any defects identified shall be provided to Transport and Main Roads annually.

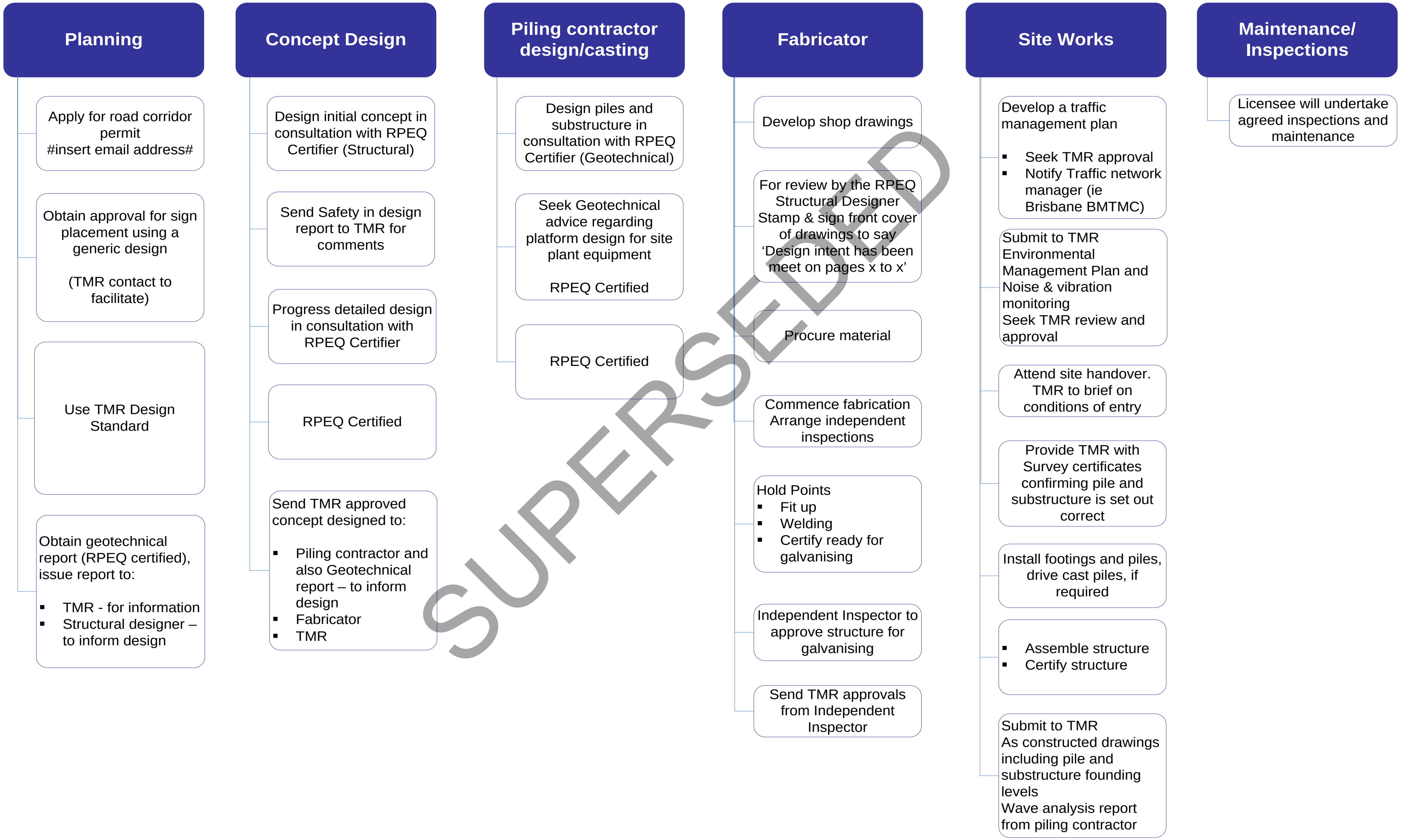
The cost for Inspections shall be borne by the Sign Licensee.

11.6 Approval flow charts

Design requirements for Advertising Devices – on carriageway



Design requirements for Advertising Devices – off carriageway



12 Concrete arch design requirements

12.1 Design life and serviceability

Design life of concrete arches is 100 years with minimum future maintenance. The roof of all arches below ground shall be waterproofed throughout the whole roof, if there is a pedestrian footway and/or bikeway inside the arch.

12.2 Quality assurance in design and documentation

The manufacturer shall submit detailed designs, calculations and fully detailed construction drawings, signed by an RPEQ qualified structural engineer, to Transport and Main Roads Director (Bridge and Marine Engineering) four weeks prior to commencement of construction.

Design acceptance process

a) If a concrete arch culvert or bridge is part of the original design for a roadworks project, the design shall be submitted and accepted as part of the design phase, before tender.

b) If a concrete arch is submitted as an alternative during tender, it is the responsibility of the tenderer to ensure the detailed design and drawings are prepared and submitted for acceptance at the earliest possible date to avoid construction delays. A minimum of four working weeks is required.

c) If all the required design data is not supplied initially, the contractor or manufacturer is responsible for consequent delays.

d) Construction may not commence before the departmental representative has accepted the design, based on input from Director (Bridge and Marine Engineering).

12.3 Design criteria

Geotechnical requirements in arch foundation design including design methodology, geotechnical investigations, design documentations and so on, shall be in accordance with Department's *Geotechnical Design Standards-Minimum Requirements*. In addition to that, requirements stated in this document shall also be met:

a) Geotechnical assessment on site during construction shall be undertaken and certified by a RPEQ Geotechnical Engineer.

b) Geotechnical boreholes shall be taken at maximum spacing of 10 m along the arch foundation, at each of the arch foundations. The scope of the geotechnical investigation shall enable estimation of upper and lower bounds of foundation stiffness for inclusion in the design, and estimates of bearing capacity and long term foundation settlement.

c) The arch foundation designer shall provide the values for predicted vertical differential settlements and horizontal deflections to the arch designer for design of the arch structure.

d) The arch foundation design and the arch structure design shall be RPEQ Certified separately by the respective designers.

e) Structural design shall be in accordance with AS 5100.

f) Design traffic Loads to AS 5100.2.

g) All the load cases and load combinations shall be submitted for acceptance for both the construction and the final fill load cases.

h) The design model of the arch shall incorporate both the vertical and lateral stiffness of the foundation and consolidation effects of the soil above the arch.

i) The design shall make allowance for differential settlement and foundation stiffness. Issues to be considered include:

- A large diameter arch on rigid foundation (rock, and so on) with a high fill will have an increased embankment load effect compared with the effect on a "soft" foundation, as the embankment may settle more than the arch. An estimate of embankment compression is required.
- Stiffness of the foundation. If the arch is designed for rigid foundations but constructed on soft foundation, then the differential movement may generate large shear forces.

j) The design shall model the individual layer, incremental backfilling and compaction.

k) All the design assumptions shall be specified on the drawings, including:

- maximum out-of-balance fill difference
- fill load increments
- compaction methods and any restrictions on the size of compacting machinery
- size of construction vehicles and minimum embankment cover before traffic is allowed on the arch
- design assumption for foundation stiffness and differential settlement, preferably in terms of an acceptable range with maximum and minimum values.
- minimum fill height and properties of the engineered fill material required for the arch.
- the sequence of back filling the arch.
- Refer to Clause 12.5 also.

l) The ground reactions at the base of the arch for both the construction and the final load cases shall be submitted.

m) The design consultant or manufacturer shall provide comprehensive documentation of the method of erection of the arches (including but not limited to backfill material, type of compaction, any propping required and so on).

n) Hydraulic engineering analysis shall be carried out to determine the scour potential of the foundations and all other hydraulic implications. The Hydraulic Report shall be provided to Transport and Main Roads Director (Hydraulics) for review and approval.

o) Piles shall conform to MRTS63, MRTS65 and MRTS68 as applicable.

p) Settlement and deflections of the arch structure at the footings and the crown shall be monitored during construction and at three monthly intervals during the first nine months of traffic loading. Reports for every interval shall be provided to Transport and Main Roads Structures, comparing predicted with actual movements. The reports shall include engineering assessment of the structure if these differ from the predicted values.

q) The joints between all the precast components (such as arch segments, spandrel headwalls, and side walls) shall be sealed with an approved material with sufficient overlap across the joint to prevent loss of fill material and achieve minimal future maintenance. The seal shall comprise bituminous seal and geotextile.

r) In high risk situations as assessed by Transport and Main Roads Director (Bridge and Marine Engineering) the spandrel headwalls and wing walls shall be constructed of in-situ reinforced concrete, not precast components.

s) Sufficient vertical and lateral clearances under the arch shall be provided and approved by Transport and Main Roads Director (Bridge and Marine Engineering).

t) The Designer shall provide Transport and Main Roads with dimensions of all critical underpass vehicles in their loaded configuration, at the concept design stage for Transport and Main Roads review of clearances.

u) “Over height” portal gantries and sensors are required at all approaches. “Maximum height” signage required at approaches and on the arch structure.

v) Traffic barriers shall be designed in accordance with AS 5100, Transport and Main Roads *Road Planning and Design Manual* and Transport and Main Roads Guideline: *Overhead Gantries that Project across trafficked lanes: Protection from Vehicle Impact*. The dimensions and foundation of the barriers shall be designed appropriately for the size of the impact vehicle.

w) The Concept Design for the arch shall be reviewed and approved by Transport and Main Roads Director (Bridge and Marine Engineering) before proceeding to detailed design.

x) The requirements for design review by Transport and Main Roads Structures is the same as for bridges in Transport and Main Roads *Design Criteria for Bridges and Other Structures*. The arch foundation designer and arch designer shall provide their RPEQ Certified Design Reports to Transport and Main Roads Structures for review and acceptance.

12.4 Other requirements

Transport and Main Roads *Structures Drafting Manual* shall be complied with.

12.5 Concrete durability

a) Refer Clause 3.8.4 for concrete durability requirements.

b) Minimum Exposure Classification for cover of Concrete: B2* (Soil face), B2* (Air face) to AS 5100. Higher exposure classifications shall be determined on a project specific basis.

c) Concrete strengths, minimum cover and curing conditions shall be detailed in the drawings.

12.6 Development adjacent to arches

In order to facilitate future development adjacent to an arch, the following shall be specified by the designer on the drawing:

- The allowable future surcharge loading on top of the arch
- The allowable maximum excavation on top of the arch from the natural surface

- The extent of the excavation besides the arch:
  a) the allowable minimum lateral clearance from the arch walls
  b) the allowable maximum permissible depth beside the arch from the natural surface.
- The allowable maximum difference in level from one side of the arch to the other.

12.7 Arch manufacturing criteria

Construction must be in accordance with Transport and Main Roads Standard Specifications:

- MRTS70 *Concrete, with emphasis on curing and durability*.
- MRTS71 *Reinforcing Steel*.
- MRTS72 *Manufacture of Precast Concrete Elements*.

13 Retaining structures

Typical retaining structure types are:

- Reinforced soil structure (RSS) retaining walls
- Embedded retaining walls
- Reinforced concrete cantilever retaining walls
- Soil nail retaining walls
- Gabion retaining walls
- Boulder retaining walls.

13.1 Design requirements for retaining walls

Geotechnical requirements for design including design methodology, geotechnical investigations, design documentations and so on, shall be in accordance with Transport and Main Roads *Geotechnical Design Standards-Minimum Requirements*. In addition to that, requirements stated in this document shall also be met.

13.2 Design life of retaining structures

1. The design life of retaining structures is 100 years.

13.3 Design certification

A Design Certification is required for each retaining structure. Refer Transport and Main Roads *Geotechnical Design Standards-Minimum Requirements* for design certifications for geotechnical designs.

13.3.1 Structural design

a) Structural designs for retaining structures shall be designed and/or supervised by an RPEQ Structural Engineer.

b) All structural designs of retaining structures shall be design-checked by an RPEQ or supervised by an RPEQ. The engineer who undertakes the check shall be different to the designer.

c) Structural design for retaining walls including reinforced concrete retaining walls for bridge abutments subject to traffic live loads shall be designed in accordance with AS 5100.2 and AS 5100.3.

d) Draw-down effects must be catered for.

13.3.2 Design certification – additional requirements

On projects where the Contractor is responsible for the design of retaining wall, the following shall apply.

a) The design documentation shall include a Design Certificate from the Contractor's Designer which confirms that the design of each retaining structure:

   - adequately allows for the site conditions, applied loadings, and relevant material properties for all components of the design, and
   - ensures the structural integrity and serviceability of the wall for the nominated design life.

b) For each retaining wall, the Contractor's Design Documentation shall include the following in addition to the Design Certificate:

- Design calculations
- Contractor's construction drawings
- Contractor's construction specifications, including wall construction sequence
- Any particular requirements for ground and/or foundation improvement, and
- Arrangements for monitoring the performance of the wall over the nominated period.

c) The Contractor's Design Documentation shall be submitted by the Contractor to the departmental Representative and the Verifier prior to commencement of construction of the wall.

d) The Contractor also must submit to the departmental Representative and the Verifier a report certified by the Contractor’s RPEQ Geotechnical Assessor who carried out the design of the retaining structure and supervised its construction, that the retaining structure has been duly constructed as per the design specifications and meets all the design requirements, including the foundation bearing requirements.

13.4 Quality assurance for design and construction

a) Prior to any construction, the Contractor must provide evidence to the Verifier that the material proposed to be placed within the reinforced soil block meets the minimum Deed and any requirements specified by the designer for all material attributes, including the permeability of the material tested at the specified relative dry density.

b) During construction, regular testing must be undertaken in accordance with Transport and Main Roads Standard Specification MRTS06. The designer must inspect the site during construction and on completion of the RSS construction, and must certify that the RSS wall has been constructed to the specified design, including the use of materials that conform to the specified parameters.

13.5 Aesthetics

a) Retaining walls (including wall abutments to bridges) must use simple, straight or large radius curved alignments sympathetic to the road alignment and interfaces with adjoining development, pathways, structures and environmental features. Obvious and incongruous kinks and sharp bends must not be evident in wall alignments. Retaining walls are to be finished in modular concrete panels that conform to a consistent patterned design, with an emphasis on vertical joint lines. Retaining walls are to incorporate integrated design features or separate elements to act as a neat capping feature to the top of the wall and be integrated with other structures and associated urban design treatments used throughout the Project Works. Fixings for retaining structures must be concealed or integrated as a design feature.

b) All structures must be of uniform colour and surface finish, incorporate defects repair and patching that matches the appearance of the remainder of the surface, and present horizontally and vertically aligned and uniformly patterned formed tie holes in the case of concrete components.

13.5.1 Flood loading

All retaining walls subject to flooding must be designed for the appropriate forces for a 2000 ARI event.

13.5.2 Tiered walls

An upper stepped wall shall be permitted only if the toe of the upper wall is outside the 45º wedge drawn through the heel of the lower wall. The interaction effect of the upper wall on the lower wall shall be considered in the design.

13.5.3 Control joint for prevention of cracks in retaining walls

The designer shall nominate the spacings for Control Joints (typically maximum spacing of 4 m) and Construction Joints to prevent cracking of the wall.

13.6 Retaining wall drainage

Drainage shall conform to Technical Standard MRTS03.

13.7 Design calculations

a) Prior to the construction of any retaining structure, the Contractor must supply to the Verifier and the departmental Representative all calculations associated with that retaining structure.

b) In addition to the requirements in Clause 13.8, for RSS Walls the Contractor must supply to the Verifier and the departmental Representative all calculations associated with that retaining structure, together with the duly completed design checklist in MRTS06 Appendix which shall be a Hold Point in the Project Plan.

13.8 Additional requirements for reinforced soil structure (RSS) retaining walls

RSSs comprise of precast concrete panels that retain engineered earth fill using steel straps embedded in the fill.

a) Design of RSS walls must be undertaken in accordance with Transport and Main Roads Standard Specification MRTS06. The designer must inspect the site during and on completion of the RSS construction. The designer must certify that the RSS wall has been constructed to the specified design, including the use of materials that conform to the specified parameters.

b) RSS retaining walls are not permitted where the water level will be at or above RSS foundation level for any flood event below 100 year ARI.

c) Where RSS walls are used as the front face of the bridge abutment, the requirements stated in Clause 4.5.2 shall also be met.

RSS retaining structures are not designed to resist Road/Train traffic impact.

<u>Impact protection from Road traffic</u>

If RSS wall is located within the 10 m clear zone *(measured from the edge of the white marked lanes),* RSS walls shall be protected from impact as follows.

The minimum requirement is a Medium Performance, 1100 mm high single slope concrete barrier to protect the RSS wall from road vehicle impact. The concrete barrier shall be designed with loads in accordance in AS 5100. The concrete barrier shall be separated from the RSS wall to avoid transfer of impact loads to the RSS wall. For this purpose, the minimum clear distance between the barrier and the RSS wall shall be 700 mm based on the 1100 mm working width in accordance with the Transport and Main Roads *Road Planning and Design Manual* and 200 mm allowance for barrier deflection. Foundation of the protection barrier shall be structurally designed to cater for the deflection of the barrier in the event of a crash within this clearance.

Impact protection from rail traffic

The minimum requirement is a concrete crash wall designed in accordance with AS 5100 to protect the RSS wall from train impact. The minimum height of the crash wall shall be 3000 mm from the top of the rail track. The crash wall shall be separated from the RSS wall to avoid transfer of impact loads to the RSS wall. For this purpose and access for maintenance, the gap between the crash wall and the RSS wall shall be minimum of 700 mm unless the RSS wall base is located above the top of the crash wall where the impact load will not transfer to the RSS wall. This gap shall be closed at the top of the wall using a suitable cover to prevent unauthorised access into the gap. Adequate drainage provisions shall be provided for possible collection of water within the gap.

For Queensland Rail (QR) trains the impact force shall be in accordance with the latest version of QR document *MCE-SR-012 - Collision Protection of Supporting Elements Adjacent to railways*.

For freight and mine ore haul trains the impact forces shall be determined as appropriate for the particular train details.

The concrete crash wall shall extend beyond each end of the RSS wall by at least half the length of a train carriage (QR pedestrian train carriages are typically 25 m long, a six car train is 150 m long), and for mine haul trains the extension of the crash wall shall be half the length of the ore wagon beyond each end of the RSS wall.

Mine haul vehicle impact

RSS structures are not designed to resist large vehicle impact of the magnitude associated with mining or similar industries. Bridge abutments (of all types including RSS structures) and piers of bridges shall be protected with a “granular fill” barrier that has been designed to resist vehicle impact through energy absorption without adversely affecting the structural integrity of the abutments and piers. The “granular fill” barrier or “gravel mound” barrier may have vertical faces or battered slopes that form the sides of the barrier.

The impact forces shall be derived using the specific vehicle characteristics. The design forces shall be specified on the bridge design drawings including assumed angle of impact, height of impact, vehicle mass and velocity. The properties of the granular fill shall be specified. The design of the barrier system shall be described in the Bridge Design Report.

The height of the “granular fill” wall shall be at least the height of the vehicle wheels but not less than 4 m high. The width across the top of the “gravel mound” barrier could be of the order of 5 m approximately depending on the size of the mine truck.

Unlike RSS structures that have vertical faces, for abutments that have spillthroughs with battered slopes, the design details of the abutment protection from impact could be of a different form to the “granular fill” barrier for RSS walls. The details of barriers at spillthroughs need to be discussed with Transport and Main Roads Structures at concept stage and at peer review stages.

The design of the barriers shall consider the ease of repair or replacement when damaged after impact.

Clearance height of the over bridge cannot be determined until the proximity of the unloading point relative to the bridge is understood. The truck will ride up onto the sides of the battered gravel mound on impact with the barrier. This increases the required clearance height of the over bridge.

The use of steel gantries over the road at each approach is required to prevent excess height vehicles from reaching the bridge. The gantries need to be located well before the bridge approaches to provide ample warning of excess height loads.

The use of trucks fitted with anti-acceleration devices to prevent gear changes when the tray is in the raised position, is also a factor in appraising the required vertical clearance under the bridge.

The design envelope of the design vehicle and its load under the bridge shall be shown on the drawings.

13.9 Additional requirements for piles

13.9.1 Cast-in place piles for high moment, low axial load applications

Piles for high moment, low axial load applications shall conform to the following:

a) The design intention is that the piles are cast in the dry. Liners shall be used to limit water ingress.

b) The minimum diameter for piles is 600 mm.

c) Temporary liners are not permitted.

d) Bentonite or polymer slurry shall not be used.

e) Piles for high moment, low axial load applications shall be designed to conform to MRTS63A.

13.9.2 Contiguous piled walls

Contiguous piled walls shall conform to the following:

a) The design intention is that the piles are cast in the dry. Liners shall be used to limit water ingress.

b) The minimum diameter for piles is 600 mm and temporary liners are not permitted in situations with high water table and/or collapsible soils. Approval from Transport and Main Roads Director (Geotechnical) shall be obtained prior to use of temporary liners.

c) Bentonite or polymer slurry shall not be used.

d) Foundations for high moment, low axial load applications shall be designed to conform to Transport and Main Roads Standard Specification MRTS63A.

e) Maximum crack width in permanent shotcrete shall be 0.2 mm.

f) Shotcrete infills between piles shall be minimum 150 mm thickness, and shall be reinforced with minimum SL81 mesh.

g) Testing of production shotcrete for compressive strength, density, relative density and permeability, including test frequency shall comply with Appendix B82L of Roads and Maritime Services (RMS) Bridgework Specification B82 Shortcrete Work.

h) Steel Fibre Reinforced Shotcrete shall only be used where approved in advance by the Deputy Chief Engineer (Structures). Its Toughness shall comply with Clause 3.9 of RMS Specification B82, and test frequency shall comply with Appendix B82/L of RMS Specification B82.

14 Busway stations, light rail stations and ancillary structures

14.1 Design life

a) The design life of the structural members shall be:

- 100 years for bridges
- 100 years for all major infrastructure elements that are above the busway, light rail or above a roadway/rail
- 100 years for all elevated parts of the infrastructure not integrally connected to the bus/road bridge (major infrastructure element excludes roofing, glazing)
- 100 years for bus station buildings or similar of more than one storey
- 50 years for bus station buildings or similar of one storey
- 50 years for slab-on-ground building, building not constructed over road, rail or other transport infrastructure
- 50 years for retaining walls, paths, walkways or similar
- 50 years for bus shelters and other elements that are not over road, busway, rail or transport infrastructure
- 50 years for building architectural and fit-out items sub-elements such as windows, glazing, tiles, fascia.

b) 50 years for all other elements. The designer shall specify the design life of any elements with a design life less than 100 years. The *Inspection and Maintenance Manual* shall detail the method of replacement of all sub-elements with a design life less than 100 years.

14.2 Materials

14.2.1 Concrete class

a) Normal class concrete may be used for pedestrian slab on ground, retaining wall not supporting road or bus traffic where the retaining wall is not adjacent to a road or busway.

b) Special class concrete in accordance with Transport and Main Roads Standard Specification MRTS70 shall be used for all structural members.

14.2.2 Structural steel

Structural steel material shall meet the requirements of Clause 4.20.

14.3 Design and construction criteria

Design and construction of Busway Stations, Light Rail Stations and Ancillary Structures shall be in accordance with the draft Specification MRTS99 *Bus Station, Light Rail Station and Associated Buildings*. MRTS99 will be eventually superseded by MRTS300 (series) (In development,).

14.3.1 Column base plate details

The detailing of column footings are required to satisfy durability and safety in design considerations. Steel posts shall not extend below ground level because corrosion will occur. For durability reasons, the steel post/column shall end with a base plate above ground.

Safety in design considerations mean that anchor bolts at ground level may be a tripping hazard. For example, this hazard may be overcome by ornamental screens to stop people tripping or placing on a raised plinth.

Base plates shall be constructed above ground/finished floor level. Base plates shall be left open without embedment into concrete or other material.

14.3.2 Corrosion protection for structural steelworks

14.3.2.1 General

All structural steelworks shall be hot dip galvanised to AS 4680. Galvanising surfaces may be painted to colours shown in the architectural drawings. Such paint systems shall be compatible and adhesive on to the galvanising surface. Paint systems shall be applied in accordance with the Transport and Main Roads standard specification MRTS88.

Refer section 3.8.1 for additional requirements for galvanising on steel with low silicon and low phosphorous contents. Following additional requirements shall be met in galvanising of steel works.

- Connections shall be sealed on all faces to stop the ingress of water and galvanising acids which causes corrosion at interfaces. Where access for welding is available to one side of a joint only, a full penetration butt weld shall be used.
- Where backing bars/backing rings are used inside members, the backing bars/backing rings shall be removed prior to galvanising. If they are not removed, acid is trapped between the backing bars/rings and the member resulting in crevice corrosion.
- The size of the components shall be checked to ensure that they can be hot-dipped galvanised after fabrication. Double dipping shall be allowed.

14.3.2.2 Substitute for hot dip galvanising

Where hot dip galvanising is not possible due to a reason such as limitation of the galvanising bath sizes, zinc metal paint system in accordance with MRTS85A shall be applied subject to prior approvals from Deputy Chief Engineer (Structures). Following additional requirements shall be met.

a) Any paint system specified must include details of how the coating shall be repainted in the future. The recoat system must be compatible with normal operating systems, for example:
   - Abrasive blasting on site is difficult and undesirable
   - The closure of some lanes for repainting is not possible on highly trafficked roads. Similar conditions shall apply to other transport corridors.
   - All coatings shall be able to be applied by airless spray, brush, roller, and air. The first coating system shall be applied in the shop. Recoats would be field applications.

b) Any painted steelwork (for example components in gantry or bridge) over a road, rail or shopping corridor shall be provided with a maintenance gantry attached to the structure. The design of the maintenance gantry shall be such that when the maintenance gantry is in use, it will not intrude into the clearance envelope of all surrounding corridors.

c) All bolt, rivets and edges shall be stripe coated.

14.4 Durability for concrete

The minimum exposure classification for the purpose of determining cover to reinforcement and the concrete mix shall be B2 to AS 5100 except exposure classification for components with design life of 50 years or less as specified in Clause 14.1 shall be to AS 3600. Minimum exposure classification for components of 50 years or less shall be A2 to AS 3600.

Also refer to Clause 3.8.4 for additional requirements of concrete durability.

15 Development application in the proximity to bridges and other structures including transport infrastructures

Refer Section 9 for development application in the proximity to tunnels.

15.1 General

Transport and Main Roads is vested with the responsibility to inspect, maintain and operate state-controlled infrastructure. In order to undertake these duties, Transport and Main Roads must make the following provisions:

a) Provision must be made for duplication and widening of the road/transport infrastructure

b) A corridor of 20 m wide or to the limit of the existing property boundary, whichever is lesser to full length both sides along the infrastructure must be provided as a Transport and Main Roads road reserve.

15.2 Drawings, reports and method statements

The developer shall submit relevant items from the following list in the form of drawing or report for Transport and Main Roads review:

a) Structural drawings and architectural drawings of the new development showing minimum of but not limited to the following. RPEQ certified structural drawings shall be submitted before commencement of the construction.

- Extent of the development relative to the department's assets
- Type of development
- General arrangement drawing and the cross section of the new structure
- Clear distance to the department's structures from closest structural element of the new development
- Foundation details of the proposed structures including the type of foundation, founding levels and the geotechnical design loads such as applied bearing pressure under shallow foundations, pile design loads and so on
- Details of temporary anchors into and adjacent departmental properties including the location, anchor loads and so on
- Construction sequence

b) Imposed loads on the department's structures due to constructions activities.

c) Impact of development on departmental infrastructure

Developer shall submit a report explaining the impact of development on Transport and Main Roads infrastructure, if any. Minimum of following areas shall be described in this report.

- Demonstrate that the adequacy of the proposed retaining system to keep the effects of the excavation (and installation of anchors) within allowable limits.
- The sections of foundation of all the adjacent Transport and Main Roads structures (which are within the influence zone of the excavation work and the anchors) in relation to the retaining system (including the wall and anchors). The influence zone can be as much as two times the excavation depth in soft grounds.

- The predicted movements of the foundation and the surroundings.
- The effect of Negative Skin Friction (NSF) on pile foundation of the Transport and Main Roads structures. NSF due to dewatering and the excavation induced settlement could be expected on piles within the soft clay.

d) Excavation details including method statement, exclusion zones, machinery used and vibration issues.

e) RPEQ certified temporary works designs including shoring details, pile or anchor arrangements

f) Soil investigation reports and geotechnical design report including settlement calculations for proposed development and any possible influence on adjacent Transport and Main Roads structures.

15.3 Potholing criteria

a) Potholing, demolition, excavation, installation of services or other construction works within the 20 m wide road corridor or inside the property boundary are not permitted without the written acceptance of Transport and Main Roads prior to commencement of the works.

b) The Developer is required to submit a RPEQ certified design report including detailed drawings of proposed works for Transport and Main Roads review. All details including the construction sequence of the development shall be shown on the plans. All possible effects on Transport and Main Roads structures, design assumptions and proposed mitigations measures shall be clearly demonstrated in the report.

15.4 Demolition phase

Explosives shall not be used adjacent to the Transport and Main Roads bridge structures during demolition.

Prior to commencement of any construction activity, the contractor shall undertake a risk assessment for the potential damage to nearby Transport and Main Roads structures. Demolition of buildings or other structures adjacent to Transport and Main Roads structures shall be provided with temporary props.

The department’s assets in close proximity to the structures subject to demolition must be monitored for displacements, cracks and any effects resulting from demolition.

15.5 Construction phases

- During the construction phases including excavation, following issues are to be addressed by the developer:
- Dilapidation, vibration, crack growth and soil movement due to the construction activity.
- Instability of the excavation walls adjacent to Transport and Main Roads structures.
- Instrumentation and monitoring

  Adequate instruments, namely inclinometers, piezometers, tiltmeters, anchor load cells, settlement markers and prisms shall be provided. This is to verify design assumptions and to monitor the effects on Transport and Main Roads structures due to the excavation and installation of anchors.

- Ground water fluctuations next to Transport and Main Roads structures.
- Installation of permanent anchors into the department's road reserve for structures on adjacent properties is not permitted.
- Transport and Main Roads may permit temporary anchors to be installed in departmental property subject to the anchors being sufficiently clear of existing Transport and Main Roads infrastructure so as not to damage it and to avoid transferring additional load effect on it. Developer shall obtain written approvals before installing temporary anchors. The Developer shall de-stress the temporary anchors on or before completion of the development. RPEQ certification of the de-stress shall be submitted to Transport and Main Roads within 28 days of their distressing
- Acceptance to install rock anchors that protrude into the Transport and Main Roads road reserve or within 2 m of departmental infrastructure shall be obtained prior to undertaking the works.
- Any work adjacent to any Transport and Main Roads infrastructure shall cause no deleterious effect to departmental infrastructure.

15.6 Additional criteria for development adjacent to bridges

During excavation, explosives shall not be used adjacent to the bridge structures.

No rock blasting shall be permitted during excavation unless the applicant can demonstrate that there is no alternative and approval obtain from Transport and Main Roads Director (Bridge and Marine Engineering). A separate submission shall be required for proposed rock blasting with consideration for mitigating adverse effects on adjacent structures and utilities. This submission shall be submitted to the department for review and approved.

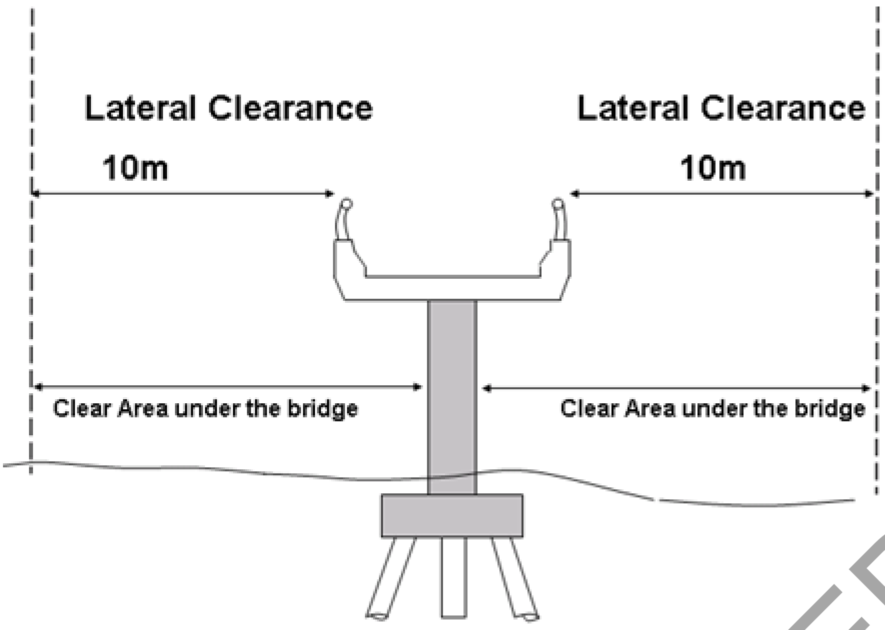
The following additional requirements apply to bridges:

a) No excavation within 10 m of any part of bridge substructure

b) Where the base of the new excavation is below the founding level of the bridge, no excavation shall be within the limit stated in item (a) above. Where battered earth retaining design is adopted, the top of the batter shall not encroach within the 10 m limit referred in (a) above. RPEQ certified earth retaining design report and drawings shall be submitted for Transport and Main Roads review in accordance with Clause 15.2.Where appropriate, the earth retaining design shall take into account the influence of the loading from the bridge. In this case, the retaining structure shall be permanently support the portion of the bridge loads imposed. Any future proposed changes to this retaining structure shall be submitted to Transport and Main Roads for review

c) 10 m minimum lateral clear distance shall be maintained either side of the bridge from permanent widest parts of the bridge structures as shown in the Figure 15.6(a). This lateral clearance shall be maintained from all areas including underneath of the bridge and for the full length of the bridge foot print

Figure 15.6(a) – Lateral clearance to the bridge structures



d) 6.5 m vertical clear height above the highest point of bridge carriageway. Additional provision or buffer in terms of height shall be provided for tunnelling effect, lighting, exhaust fans and signage

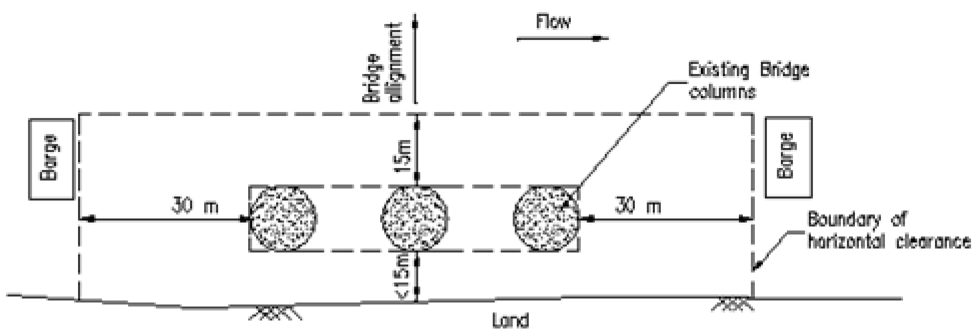
Provision for noise suppression and fire protection shall also be provided for tunnel effect around the structure.

e) Where the bridge columns located in water and no land access, horizontal clearance around the bridge columns shall be maintained as shown in Figure 15.6(b) and Figure 15.6(c) as applicable for:

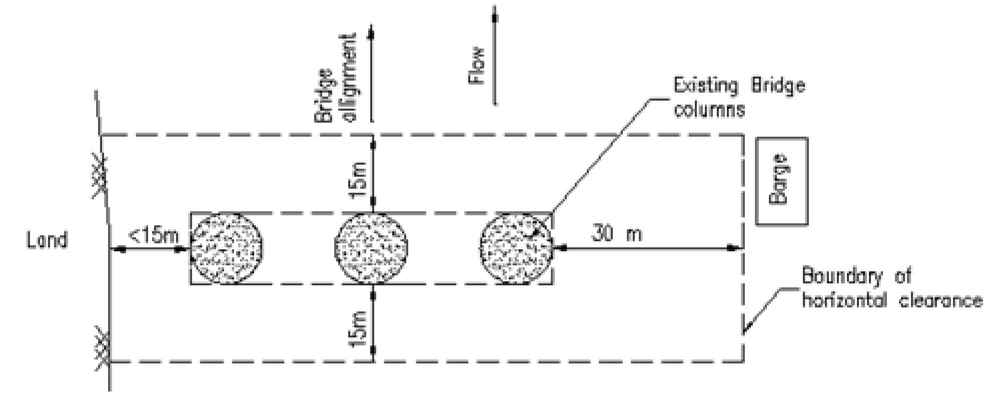
- construction of temporary work platform
- barge access associated with rehabilitation works
- underwater inspection of the piles and pile caps.

Within the above horizontal clearance, vertical clearance shall be maintained for pile driving for temporary work platforms at every column in the river.

Figure 15.6(b) – Lateral clearance to the bridge columns located closure to river bank

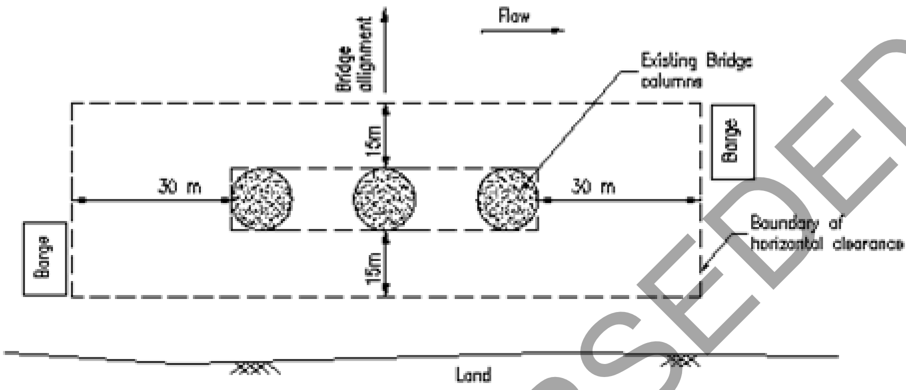


a) Land is perpendicular to the bridge alignment

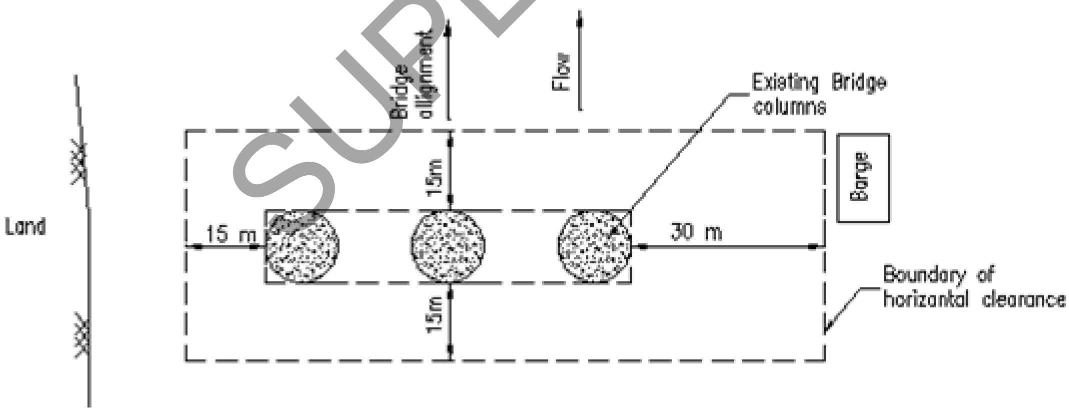


b) Land is parallel to the bridge alignment

Figure 15.6(c) – Lateral clearance to the bridge columns located away from river bank



a) Land is perpendicular to the bridge alignment



b) Land is parallel to the bridge alignment

f) Additional requirements adjacent to Riverside Express Way (REX) structures are as follows;

- The existing Queens Wharf Road (QWR) shall be kept for use for maintenance access for REX. When there is no access via the QWR, then a truck and crane access corridor 6.0 m wide shall be provided between QWR and the Brisbane River Bank for the section of the REX footprint. This corridor shall be continuous straight horizontal alignment without interruptions and kept open for Transport and Main Roads access at all times (24/7).

- Lateral access for Truck and Crane to the REX Bridge shall be provided via QWR or the new truck and crane access corridor. Lateral access shall be kept open for Transport and Main Roads access at all times (24/7).

16 Design of Fibre Reinforced Polymer (FRP) Composite Girders

A content within a highlighted box in this section of the design criteria is to be considered as a commentary.

16.1 Scope and application

This section of the Design Criteria specifies the minimum requirements for the design of FRP Composite Girders for the following two categories of Transport and Main Roads road bridges.

Category A: FRP composite girders to be used as superstructure in a new bridge

Category B: FRP composite girders that replace timber girders in a timber bridge renewal program.

FRP girders for Category a bridges shall be designed in accordance with Clause 16.5 to 16.9 and additional requirements stated in Clause 16.10.

FRP girders for Category B bridges shall be designed in accordance with Clause 16.5 to 16.9 and additional requirement stated in Clause 16.11.

Except where specified, design of FRP girders shall be according to Eurocomp Design Code, refer to Table 16.2.

16.2 Reference document

Table 16.2 lists documents referenced in this section of the Design Criteria.

Table 16.2 - Reference documents

Reference	Title
AS 5100(2004)	*Australian Standard Bridge Design*
AS 1530.4(2005)	*Method for fire tests on building materials, components and structures: Part 4 Fire - resistance test of elements of construction*
ISO 2559	*E-glass chopped strand mat for the reinforcement of polyester resin systems.*
ISO 2797	*Glass fibre rovings for the reinforcement of polyester and epoxy resin systems*
ISO/IEC 17025:2005	*General requirements for the competence of testing and calibration laboratories*
MRTS59	*Manufacture of Fibre Reinforced Polymer (FRP) Composite Girders*
MRTS78	*Fabrication of Structural Steelworks*
Engineering Innovation, March (2014)	*Engineering Innovation within the Department of Transport and Main Roads, March 2014*
Eurocomp Design Code (1996)	*Structural Design of Polymer Composites – Eurocomp Design Code and Handbook (J. Clarke, ed.), E & F Spon, London.*
Timber Bridge Maintenance Manual (2005)	*Timber Bridge Maintenance Manual, Department of Transport and Main Roads, Queensland Government*

16.3 Symbols and notations

The symbols and notations used in this section are listed in Table 16.3.

Table 16.3 - Symbols and notations

Symbol and Notations	Description	Clause Reference
E	Modulus of Elasticity of the Girder (MPa)	16.11
EI	Flexural Stiffness of the Girder	16.11
I	Second Moment of Area (mm^4)	16.11
k	Additional reduction factor	16.10.4
K_{test}	Reduction factor used in the absence of sufficient test samples	16.11
R_u	Ultimate Strength	16.10.4
S*	Design Action Effects (required strength due to factored loads)	16.10.4
α	Dynamic Load Allowance	16.10.2
γ_g	Load factor for dead loads	16.10.2
ε	Uni Axial Strain	16.8.1
σ	Uni Axial Stress	16.8.1
ϕ	Strength Reduction Factor	16.10.4

16.4 Provision for innovation

This section provides for innovation in fibre composite girder design. Adopting innovation allows to capture benefits from rapid changes and evolutions in the fibre composite field.

For this section, the term 'innovation' applies to new:

- fibre materials
- resins
- manufacturing processes of fibre composites
- coatings
- development in the fibre composite field
- a complete girder

Above innovative products shall be assessed against this section and comply with the structural performance matrix in Table 16.4. An evaluation process shall be triggered if an innovative product scores an average of four or more on the structural performance scale. The strategy for assessing product innovation is described in 'Engineering Innovation', referenced in Table 16.2.

Submissions regarding innovation are made to the Director (Bridge and Marine Engineering).

Table 16.4 – Structural performance matrix for evaluation of innovation

Score: 1 = Unsuitable, 3 = Satisfactory, 5 = Excellent			
Structural Performance	**Standards to be complied**	**Score**	**Remark**
1. Structural Adequacy • Bending Capacity • Shear Capacity • Deflection - Short Term - Long Term • Damage Tolerance • Impact Resistance • Fatigue Resistance	Section 16 of Design Criteria for Bridges and other structures		
2. Structural Stability • Lateral Torsional Rigidity • Robustness • Overturning • Uplift/Sliding	Section 16 of Design Criteria for Bridges and other structures		
3. Adaptability of Fibre Composite using established bridge construction techniques • Girder - Holding Down bolt fixing • Deck - Fixing/connections • Bridge Barrier • Bearing Requirement	Existing Timber Bridges: • Transport and Main Roads *Timber Bridge Maintenance Manual* and Timber Bridge Standard Drawing • Standard Drawings 2605 and 2606 • Chapter 16 of Design Criteria for Bridges and Other Structures New Bridges: Chapter 16 of Design Criteria for Bridges and Other Structures		
4. Constructability Fitting into an existing timber bridge with different substructures: • Timber Headstock and Abutments • Concrete Headstock and Abutments • Easy to drill • Easy to cut • Easy to handle.	• Transport and Main Roads *Timber Bridge Maintenance Manual* • Standard Drawings 2605 and 2606 • MRTS60		
5. Durability • Deflection due to creep • Short term and long term deflection • Fibre Tear at bolt connections due to fatigue • Effect of UV degradation • Effect of alkaline or acidic environment	Section 16 of Design Criteria for Bridges and other structures		

Score: 1 = Unsuitable, 3 = Satisfactory, 5 = Excellent			
Structural Performance	**Standards to be complied**	**Score**	**Remark**
• Effect of Moisture • Effect of extreme temperatures and thermal cycles • Fire resistance • Wearing resistance • Insect resistance			
6. Ductility	Section 16 of Design Criteria for Bridges and other structures		
7. Inspection • Easy to inspect critical defects	Manufacturer's guideline		
8. Value for Money • Short Term Cost: (Material/fabrication/construction) • Long Term Cost: (maintenance/demolition/disposal) • Life Cycle Cost: - initial cost - maintenance cost - operating cost - replacement and refurbishment cost - retirement and disposal costs.			

16.5 Maximum operating temperature

The maximum operating temperature for structural members, components and system designed shall not exceed T_g – 22°C. T_g is the glass transition temperature of the composite system. The maximum operating temperature shall be 68°C corresponding to T_g of 90°C.

16.6 Exclusions

Laying of hot asphalt overlay on top of the FRP composite girders are not permitted. This is to prevent post cured FRP girders approaching its glass transition temperature (T_g).

16.7 Material properties

16.7.1 General

Designers shall always seek specialist advice from the polymer, reinforcement and manufacturing supplier, or a technical specialist.

FRP composite girders are manufactured in different ways. Examples are not limited to:

a) assembly of only FRP sections by means of suitable adhesives

b) assembly of FRP sections, FRP panels and steel in a hybrid section

c) assembly of FRP section, steel, concrete, lightweight core into a hybrid

d) by means of a vacuum assisted resin infusion process.

16.7.2 Reinforcement

16.7.2.1 Fibres

Only the following glass fibre types are permitted in FRP composite girders. Minimum properties of fibre before processing shall be as specified in Table 16.7.2.1.

- E-glass
- ECR-glass
- S-glass

E-glass shall not be used in the following applications:

- Members in salt-rich arid areas
- Sea water – tidal or splash zone
- Soft or running water.

Table 16.7.2.1 Minimum properties of fibres before processing

Fibre Properties	E-glass	ECR-glass	S -glass
Specific Gravity	2.54	2.71	2.47
Tensile Strength MPa (22˚C)	3400	3300	4600
Tensile Modulus GPa (22˚C)	72	72	88
Elongation %	4.8	4.8	3.0
Coefficient of Thermal Expansion 10^{-6}/˚C	5.0	5.9	2.9

16.7.2.2 Rovings

Use of rovings shall comply with ISO2797 or equivalent.

16.7.2.3 Mats – continuous filament mats

Use of continuous filament mats shall comply with ISO2559 or equivalent.

Non continuous, chopped strand mat shall not be used for structural purpose. The glass fibre in the chopped strand mats shall not be included in any calculations of structural performance.

16.7.3 Polymer matrices

Selection of polymer matrices shall comply with Clause 3.2 of Eurocomp Design Code.

Knowledge of the operating temperature is vital in selecting an appropriate stable resin system. If the service temperature is closer to the heat distortion temperature, as with all polymers loss of stiffness and significant creep will occur.

The selection and design of polymer resins is a critical aspect of the design of fibre composite girders.

16.7.3.1 Acceptable resin types

The following types of resins are acceptable to be designed according to properties and limits in accordance within the Eurocomp Design Code:

- Polyester resins
- Vinyl Ester resins
- Phenolic resins
- Epoxy resins

The allowable material properties of resins shall be as shown in Table 16.7.3.1.

Table 16.7.3.1 Allowable properties of resin

Property	Units	Polyester Resin	Epoxy Resin	Vinyl Ester Resin	Phenolic Resin
Tensile Strength (min)	MPa	70	70	70	40
Young's Modulus (range)	GPa	2-3	2-4	3-4	1.5-2.5
Flexural Elongation at Failure (min)	%	4	4	4	1.5
Density (range)	g/cm^3	1.2-1.3	1.2-1.3	1.12	1.24
Heat Distortion Temperature (min)	^{o}C	90	90	90	90
Shrinkage (max)	%	5	2.5	5	5

16.7.4 Core materials

A general description of the core material shall be submitted. It shall be demonstrated that the core materials used are suitable for the intended purpose. Core materials shall be compatible with the resin used and the manufacturing system. They shall not impair the curing of the laminating resins.

16.7.5 Gel coats

Gel coats shall be considered non-structural. Gel coat shall be appropriate for the structure and to suit particular environment.

Gel coats are applied to the surface of a composite structure to:

- filter out ultraviolet radiation and improve weathering
- add flame retardency to provide an increased thermal barrier
- improve erosion
- provide an increased barrier to moisture
- provide colour scheme and improve general finish.

16.7.6 Laminates

Laminates to be incorporated into FRP composite girders shall be designed according to Clause 4.10 of Eurocomp Design Code.

> The laminates in bridge beams shall be arranged such that all major loads are carried by fibres.

16.7.7 FRP profiles

FRP profiles shall have a minimum 60% of fibre content by weight.

Minimum properties of FRP composite profiles shall be as shown in Table 16.7.7.

Table 16.7.7 – Minimum properties of FRP profiles

Property	Units	Test Method	Minimum Properties
Tensile Strength - axial	MPa	EN ISO 527-4/ASTM D3039	300
Tensile Strength - transverse	MPa	EN ISO 527-4/ASTM D3039	55
Tensile Modulus - axial	GPa	EN ISO 527-4/ASTM D3039	30
Tensile Modulus - transverse	GPa	EN ISO 527-4/ASTM D3039	7
Flexural Strength - axial	MPa	EN ISO 14125/ASTM D4476	240
Flexural Strength - transverse	MPa	EN ISO 14125/ASTM D4476	100
Shear Strength – in plane	MPa	ASTM D5379	50
Shear modulus – in plane	GPa	ASTM D5379	3
Interlaminar Shear Strength	MPa	ASTM D5379	25

16.8 Design and detailing

16.8.1 Design for ultimate limit state

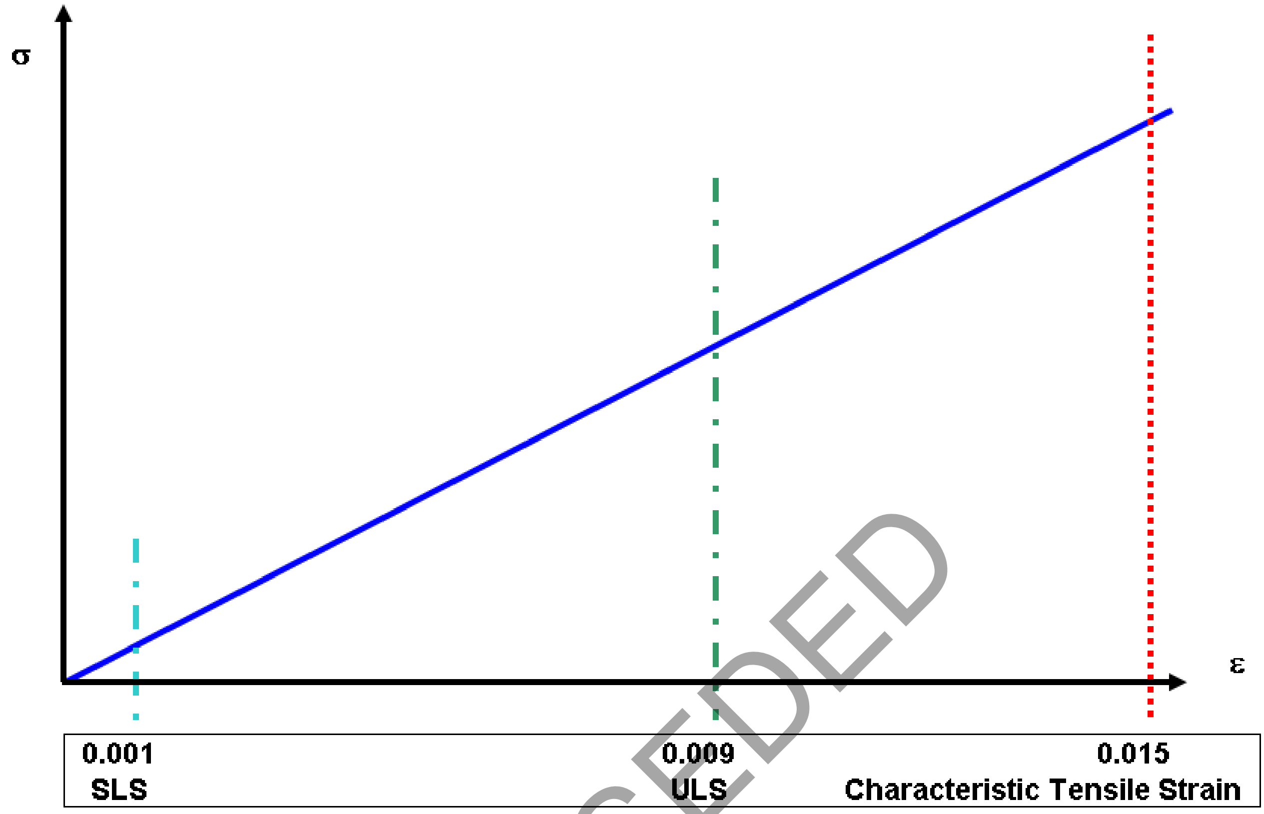
The Ultimate Strength of the girder shall satisfy the following:

Characteristic tensile strain of unidirectional lamina shall be 0.015.

Glass Fibre Reinforced Polymer (GFRP) components shall not exceed their Ultimate Limit State (ULS) capacity at a strain of 0.009 (60% of the characteristic tensile strain of unidirectional lamina = 0.6 x 0.015) as shown in Figure 16.8.1.

FRP composite structures shall be designed for ultimate limit states according to Clauses 2.3.2 and 4.1 of Eurocomp Design Code.

Figure 16.8.1 – ULS and SLS strain limitations



16.8.2 Design for serviceability limit state

At the Serviceability Limit State (SLS), the strain in the GFRP girders shall not exceed 0.001 as shown in Figure 16.8.1.

Fibre composite structures shall be designed for SLS according to Clauses 2.3.4 and 4.2 of Eurocomp Design Code.

16.8.3 Warning of failure

Structures made with FRP composites shall be designed to give reasonable and adequate warning of failure before reaching an ultimate limit state.

The design shall ensure that a serviceability limit state is reached before its ultimate limit state.

The design shall avoid the following limits occurring at serviceability limit state:

- excessive deflection
- buckling or wrinkling
- local failures.

16.8.4 Failure modes

Failure mode due to adhesive separation shall not be permitted.

Resin and adhesive dominated failure modes shall not be permitted.

Delamination is a common failure mode in FRP composite structures and the designer shall provide adequate details in the design to confine the structure against catastrophic delamination.

16.8.5 Design for stability

Fibre composite girders shall be designed for stability according to Clause 4.7 of Eurocomp Design Code.

Girders shall be designed to be:

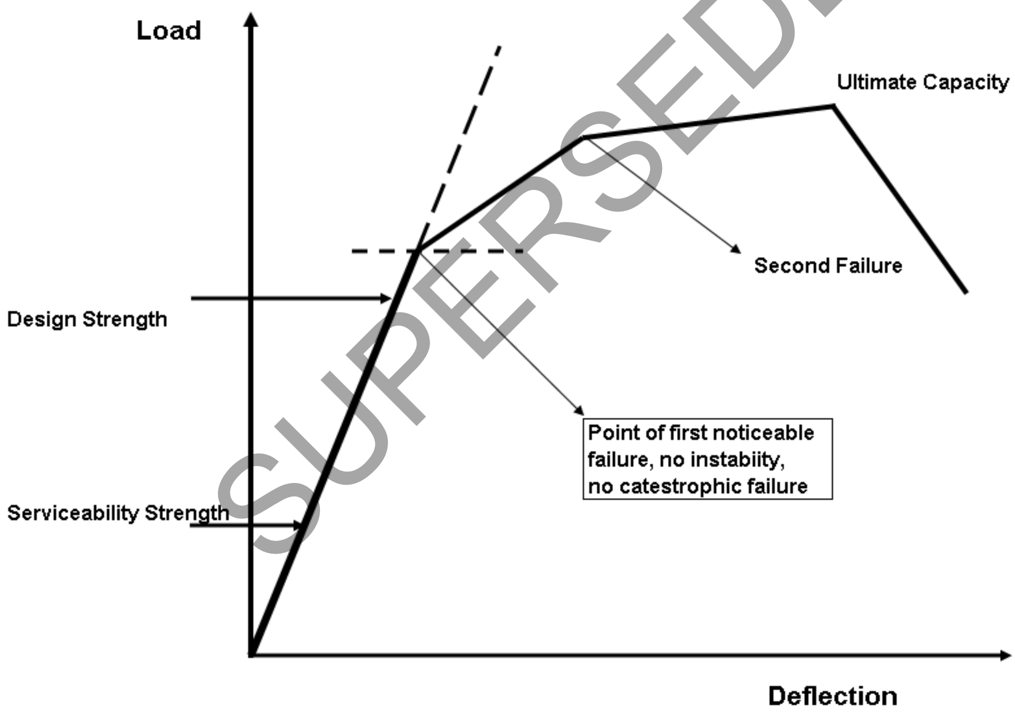
- independent, and not require lateral stiffeners
- torsionally stable in the lateral direction

16.8.6 Ductility of FRP composite girders

FRP composite girders shall demonstrate ductile behaviour before reaching its ultimate capacity as shown in Figure 16.8.6.

FRP composite girders shall not fail in a catastrophic manner at the target capacity.

Figure 16.8.6 – Load deflection behaviour of FRP structure



16.8.7 Durability

FRP composite components shall be designed using a degraded E value estimated for the end of the design life.

FRP composites generally have excellent acid resistance compared with steel. But, FRP composites are prone to deterioration in environments with high concentrations of acid or alkali. Creep rupture and stress corrosion are two consequences of exposure to acidic environments. UV resistance of some resins is low and it is recommended that appropriate measures be taken by the manufacturer to shield the FRP composite girders from deterioration.

The only true test for durability is the in-service highway bridge. FRP composites deteriorate with environmental exposure and repeated application of load. This degradation of modulus of Elasticity, E, has been measured experimentally in accelerated durability tests for various FRPs.

16.8.8 Fire resistance

Fire retardant coating, fire retardant resin or fire retardant resin additives shall be provided for FRP composite girders. FRP girders shall be fabricated to meet Fire Resistance Level 90/-/- according to Clause 2.14 of AS1530.4.

Fire testing on FRP composite girders shall be carried out according to Section 2 and 6 of AS 1530.4. The serviceability limit state load shall be used for fire test in accordance with Clause 2.12.1 of AS 1530.4.

FRP composites are not inherently fire-resistant. Combustibility, spread of flame, changes in mechanical properties and toxic fumes need to be considered.

Performance in a fire is generally improved by increased glass fibre content. Using fire retardant resins or resin additives improves fire retardation.

16.8.9 Thermal expansion

Thermal coefficients derived from testing by the Manufacturer shall be used in the design of FRP girders.

The appropriate thermal gradient relevant to the environment that the FRP girders are exposed to shall be incorporated in the design.

Coefficient of thermal expansion of FRP composites vary due to several material constituents in the manufacture of FRP girders. The effects of difference in coefficient of thermal expansion between different materials need to be considered. These includes adhesives, steel, concrete, cores and FRP.

16.8.10 Creep and shrinkage

Creep of FRP girders shall be incorporated into the design according to Clause 4.12 of Eurocomp Design Code.

Adequate measures shall be taken to account for shrinkage of FRP girders in the design.

Changes in shape, hogging, sagging and any member distortion are not permitted above the tolerance provided in Table 7.4, MRTS59: Manufacture of Fibre Reinforced Polymer (FRP) Composite Girders. Dimensional stability shall be maintained at all stages. These stages include production, storage, and installation on site and in service for the design life.

16.8.11 End zones design and connections

16.8.11.1.1 End zone

The designer shall determine the performance of FRP girders at the support.

The designer shall ensure that the end zone design is checked for bearing, web crushing, shear, and buckling. The end zone design shall have sufficient length to accommodate future trimming to reduce the girder length to suit the actual span.

The design shall be verified and certified by testing.

> End Zone is generally a critical part for a FRP girder which needs more detailed design compared with the general section design as it involves much more complex failure mechanisms including shear, crushing and buckling

16.8.11.2 Connections

Connections for FRP composite girders shall be designed according to Section 5 of Eurocomp Design Code.

Bolted joints for shear and tension shall be designed according to Clause 5.2 of Eurocomp Design Code.

Bonded connections shall be designed according to Clause 5.3 of Eurocomp Design Code.

The adequacy of the connection shall be determined by testing.

The FRP composite girder design shall be accompanied by relevant connection details.
FRP composite girder supplier/designer shall submit the relevant calculations to Transport and Main Roads for review prior to manufacture of FRP girders.

Bolted connections shall be used for all main and secondary member connections.

Steel bolts shall comply to MRTS78.

16.8.11.3 Cutting and drilling

FRP composite girder design shall identify the drilling and sawing locations.

Cutting of girders will expose fibres. Cut edges shall be sealed by the site crew as directed by the fabricator.

FRP composite girder design shall have provision to drill on site, as well as at the factory. All cutting and drilling shall be conducted by adequately trained personnel.

> FRP members need site cutting, and the internal reinforcement may be designed to terminate in the end zone. Due to girder fixing details, this may cause potential cracking at the reinforcement termination points under the negative bending moment conditions especially when a long vehicle passes over a pier.
>
> The stress concentration at the edge of solid packers may be critical for some hollow section designs. For these specific issues, the designer needs to ensure all the risks have been addressed through proper design, for example using proper rubber strip bearings.

16.8.11.4 Holes in FRP girders

Holes in FRP composite girders shall be plugged with an approved sealant to:

- avoid ingress of water
- prevent bearing strength reduction due to water ingress
- prevent tearing of fibre due to bolt movement

FRP composite girders shall meet the requirements of ULS and SLS, with holes considered.

16.8.11.5 Edge distance

Minimum edge distance for bolts shall be three times the bolt diameter from the nearer edge of the hole to the edge of the member.

16.9 Design requirements

FRP composite girders to be used as superstructure in a new bridge shall be designed in accordance with Clause 16.5 to 16.9 and additional requirements stated in Clause 16.10.

FRP composite girders that replace timber girders in a timber bridge shall be designed in accordance with Clause 16.5 to 16.9 and additional requirement stated in Clause 16.11.

16.10 Additional requirements FRP composite girders for new bridges

Clause 16.10 is applicable only for FRP girders for new bridges. Refer clause 16.11 for additional requirements for FRP girders for timber bridges.

16.10.1 Traffic loads on new bridges

The loading requirements for design of FRP composite girders for New Bridges shall comply with AS 5100.2.

16.10.2 Load combinations and load factors for design of FRP composite girders

The most adverse design load combination shall be determined according to AS 5100.2.

Load factors and accompanying lane factors for design of FRP composite girders on bridges shall be in accordance with AS 5100.2

The load factor γg for dead load of structure shall be 1.2 for ULD and 1.0 for SLS designs.

The dynamic load allowance for traffic loads shall be applied to both the ultimate and serviceability limit state.

The design action is equal to $(1+\alpha)$ x the load factor x the action under consideration. Dynamic allowance 'α'shall be in accordance with AS 5100.2.

16.10.3 Method of structural analysis and design

Structural analysis and design shall comply with AS 5100.

16.10.4 Design for strength

The FRP composite girders shall be designed for strength as follows:

The Design Action Effects S* (required strength due to factored loads) shall be determined by structural analysis for the appropriate load combinations as stipulated in AS 5100.2.

The Ultimate Strength Ru shall be determined on strain compatibility, internal force equilibrium and controlling mode of failure.

For the Ultimate Limit State, the Design Strength (=$\varphi\ R_u$) shall satisfy the following:

$$\varphi\ R_u \ \geq \ \frac{S^*}{k}$$

Where, the strength reduction factor = 0.25 and k = 0.75.

> Additional reduction factor k is introduced to compensate for lack of existing knowledge to correlate new design capacity with actual capacity.

16.10.5 Deflection

The deflection limits of the bridge shall be in accordance with AS 5100.

16.10.6 Design life

The design life for FRP composite girders on new bridges shall be 100 years.

16.10.7 Fatigue for FRP girders on new bridges

FRP composite girders for new bridges shall be designed according to Clause 6.9 of AS 5100.2.

16.10.8 Vibration

FRP composite girders shall be designed for vibration according to Section 12 of AS 5100.2.

16.11 Additional design requirements for FRP composite girders on existing timber bridges

Clause 16.11 is applicable only for design of FRP composite girders on timber bridges. Refer Clause 16.10 for FRP composite girders for new bridges.

This section shall not apply to FRP composite girders to be used in new bridges.

> FRP composite products intended for timber bridge replacement shall be assessed in a holistic manner, not in isolation. When designing FRP composite girders, the designer shall include relevant:
>
> - connection details
> - installation procedures
> - working drawings.
>
> FRP composite girders shall satisfy both structural and functional requirements.

16.11.1 Performance criteria

FRP composite girders intended for timber replacement shall comply to the performance criteria shown in Table 16.11.1.

Table 16.11.1 - Performance criteria for existing Transport and Main Roads timber bridges

Criteria	Units	Value
Span	m	9.1
Dimension	Depth (m)	450
	Width (m)	350
Target Bending Moment M_{test} $M_{test} \geq M^*/(\phi\ K_{test})$ M* = 447 kNm (from Grillage Model) $\phi = 0.25$ $K_{test} = 1$ for more than 10 successful tests $K_{test} = 0.85$ for more than 5 successful tests $K_{test} = 0.75$ for less than 5 successful tests	kNm	1790 (when 10 or more successful tests) 2105 (when 5 or more successful tests) 2385 (when less than 5 successful tests)
Target Shear V_{test} $V_{test} \geq V^*/(\phi\ K_{test})$ V* = 400 kN ϕ and K_{test} are shown above	kN	1600 (when 10 or more successful tests) 2000(when 5 or more successful tests) 2135 (when less than 5 successful tests)
Target EI	Nmm^2 ($MPa.mm^4$)	5.0×10^{13}
Deflection at Serviceability (at Bending Moment of 330 kNm)	mm	44

16.11.2 Fatigue design of FRP composite girders on timber bridges

FRP girders for timber bridge renewal shall be designed to 1.0×10^6 fatigue cycles and spike load of 100% service load at every 0.2×10^6 cycles.

16.11.3 Design Life of FRP composite girders on timber bridges

The design life for FRP composite girders on Timber bridges shall be 30 years.

Supplementary Reference for Clause 16

ASCE Prestandard (2010): Pre-Standard for Load and Resistance Factor Design (LFRD) of Pultruded Fibre Reinforced Polymer (FRP) Structures (Final). ASCE.

Bakis, C.E et al. (2002), Fibre Composite Polymer Composites for Construction – State-of-the-Art Review, Journal of Composite for Construction, Vol. 6, No. 2.

Bank, L et al (2003), A model specification for FRP composites for civil engineering structures, Construction and Building Materials, 17, pp 405-437.

Bank, L (2006), Composite for Construction – Structural Design with FRP Materials, John Wiley and Sons, Inc.

Bank L (2007), Composite for Construction: The design Basis for Pultruded FRP Members,Composite World, October, www.compositesworld.com/articles/composite-for-construction/.

Chambers, R (1997), ASCE Design Standard for Pultruded Fiber-Reinforced-Plastic (FRP) Structures, J. of Composites for Construction, 2, pp. 26-38.

Ellingwood, B (2003), Toward Load and Resistance Factor Design for Fiber-Reinforced Polymer Composite Structures, J. of Structural Engineering, ASCE, 4, pp 409-458.

Guide for the Design and Construction of Structures made of FRP Pultruded Elements (2007), National Research Council of Italy, Rome, CNR-DT-205/2007

Hillman, J (2001), Investigation of a Hybrid-Composite Beam System, Final Report for High-Speed Rail IDEA Project 23, Transport Research Board, Washington DC.

Keller T (2003), Use of Fibre Reinforced Polymer in Bridge Construction, Structural Engineering Documents 7, IABSE, Zurich, Switzerland.

Kenerson, J .E., (2010), Quality Assurance and Quality Control Methods from Resin Infusion, MSc thesis, The Graduate School, The University of Maine, USA.

National Research Council, Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structures (2004), CNR-Advisory Committee on Technical Recommendations for Construction, CNR-DT 200/2004, Rome, Italy.

National Research Council, Guide for the Design and Construction of Structures made of FRP Pultruded Elements (2007), CNR-Advisory Committee on Technical Recommendations for Construction, CNR-DT 205/2007, Rome, Italy.

National Standard Authority of Ireland, Reinforced Plastics Composites- Specifications for Pultruded Profiles – Part 1 : Designation (2002), EN 13706-1:2002, NSAI, Dublin, Ireland.

National Standard Authority of Ireland, Reinforced Plastics Composites- Specifications for Pultruded Profiles – Part 2: Methods of test and general requirements (2002), EN 13706-2:2002, NSAI, Dublin, Ireland.

National Standard Authority of Ireland, Reinforced Plastics Composites- Specifications for Pultruded Profiles – Part 3: Specific Requirements (2002), EN 13706-3:2002, NSAI, Dublin, Ireland.
NHCRP Report 503 (2003), Application of Fibre Reinforced Plymer Composites to the Highway Infrastructure, Transport Research Board, Washington D.C.
Potyrala, P.B and Casas Rius, J.R (2011), Use of Reinforced Polymer Composite in Bridge Construction. State of the Art in Hybrid and All-Composites, Department of Enginyeria de la Construccio, Universitat Polytecnica de Catalunya.
Tucker et al.(2001), The effect of post-cure duration on the mode I interlaminar fracture toughness of glass-fibre reinforced vinylester, Composites: Part A 32,129-134.

17 Drainage structures

This section is applicable for small drainage structures such as culverts, drainage pits, culvert headwalls, kerb inlets and other precast drainage components, but excluding larger drainage structures such as bridges.

17.1 Design requirements

- Design and durability of steel reinforced concrete and fibre reinforced concrete pipes shall be in accordance with MRTS03, MRTS25 and MRTS26 as applicable. Other pipe materials as permitted by MRTS03 shall be designed in accordance with MRTS03.
- Design and durability of steel reinforced precast concrete Box culverts shall be in accordance with MRTS03 and MRTS24.
- Design for lifting of precast concrete components shall be in accordance with MRTS72.
- All drainage structures must be readily accessible for cleaning and maintenance purposes.

17.2 Design life for drainage structures

Design life for drainage structures shall be as follows.

- Drainage pits, larger external plan dimension is greater than 1.0 m - 100 years
- Drainage pits, larger external plan dimension is less than or equal to 1.0 m - 50 years
- Pipe headwalls for pipe diameter, greater than 800 mm - 100 years
- Pipe headwalls for pipes 800 mm or less in diameter - 50 years
- Culvert headwalls of height, greater than 800 mm - 100 years
- Culvert headwalls 800 mm or less in height - 50 years
- Box Culverts - 100 years
- Other drainage structures not listed in this list or in Table 17.2 - 100 years

Table 17.2 – Other drainage structures with design life less than 100 years

Standard Drawing Number	Detail	Design Life (years)
1033	Kerb and Channel-Kerbs, Channels and Ramped Vehicular Crossings	50
1311	Components except drainage pits Drainage pits	50 Refer Clause 17.2
1312	Components except drainage pits Drainage pits	50 Refer Clause 17.2
1313	Precast Lintel	50
1321	Components except drainage pits Drainage pits	50 Refer Clause 17.2
1322	Components except drainage pits Drainage pits	50 Refer Clause 17.2

Standard Drawing Number	Detail	Design Life (years)
1442	Components except drainage pits Drainage pits	50 Refer Clause 17.2
1443	Roadway Type Precast Inlet Units on Grade	50
1444	Roadway Type Precast Inlet Units in Sag	50
1446	Kerb Ramp - Ramped Kerb Crossing	50
1459	Components except drainage pits Drainage pits	50 Refer Clause 17.2

18 Motor grids

18.1 Design life

Minimum design life for motor grids shall be 50 years.

18.2 Motor grid design criteria

Motor grids shall be designed in accordance with Technical Note 18.

19 Editing register

Reference version – Design Criteria for Bridges and Other Structures – April 2014

Note that typographical changes are not included in this register where the requirements are not changed.

Clause	Editing
Section 4, 10, 12, & 13	The reference is made to Transport and Main Roads *Geotechnical Design Standards-Minimum Requirements* for requirements of geotechnical design, investigation and reporting
1.1 (e)	Included the new Standard Drawing 2053 for Design Assumptions for Transversely Stressed Standard Deck Units
1.2.1.3	Amended to include the " Structural forms requiring approvals"
1.3.6	Amend the clause
2.1	Add the requirement of minimum 100 mm extension of the deck on deck units for aesthetic and 19x19 mm drip groove for drainage
2.2	Added the acceptance of the water based paint to conceal graffiti
3.7.1	Move drainage structures design life requirements to a new Section 17 Design life for gantries including tolling structures is removed as this is now included in Section 10
4.4.1	Add, exclusion of steel liners for durability assessment of concrete piles
4.5	Added "RSS walls outside 10 m clear zone, no impact protection is required"
4.7	Added, Piles manufactured by spinning or rolling is not permitted
4.7.3 (e)	Added: Strands located in corner of ligatures shall not be deboned
4.7.3 (f)	Added, maximum tendon force at transfer for deck units
4.7.4.2	Added, maximum tendon force at transfer for I girders
4.7.5.7	Added: Strands located in corner of ligatures shall not be deboned
4.9.3	Added the requirements for spread footing foundations
4.10.1.4	Amended the finger type expansion joint gap width requirements
4.11.1(d)	Added the requirements of effective lateral restraints to superstructure for jacking
4.11.3.3	Added cover requirements between void and Strands and/or horizontal reinforcement
4.11.4.2	Added the requirement of diaphragms for I girder superstructures
4.11.4.3	Added lifting design requirements for PSC I girders
4.11.4.5.1	Added the Figure 4.11.5 and Table 4.11.5 for T girder dimensions and void arrangements respectively
4.11.3.5	Added the requirements of lifting point designs
4.11.5.7	Added lifting design requirements for PSC T girders
4.11.6.6	Added lifting design requirements for PSC box girders
5.4.1	Added the requirement of inspection during construction
6	Added "RSS walls outside 10 m clear zone, no impact protection is required"

Clause	Editing
9.10.2	Added, No explosives shall be used adjacent to tunnels
9.10.3	Added, conditions for rock blasting and explosives adjacent to tunnels
Section 10	Section rewrite including requirements for gantry structures mounting ITS devices
12	Arches section amended with additional requirements
15.4	Added, No explosives shall be used adjacent to tunnels
5.6	Added, conditions for rock blasting and explosives adjacent to Transport and Main Roads structures
16	New Section 16 was added for design criteria for FRP composite girders
17	New Section 16 was added for design criteria for drainage structures
18	New Section 18 added for design criteria of motor grids