

SUPERSEDED

Manual

Design Criteria for Bridges and Other Structures

March 2020

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Contents

Part A: General	1
1 Preamble	1
1.1 Scope of this document	1
1.2 Format of this document	1
1.3 Acronyms	3
1.4 Design references	4
1.4.1 AS(/NZS) 5100	4
1.4.2 Austroads	5
1.4.3 Department of Transport and Main Roads	5
1.4.4 Other agencies	7
1.4.5 Table of references	8
1.5 Design life	14
1.5.1 Design life – Interpretation	14
1.5.2 Design life for bridges	14
1.5.3 Design life for tunnels	14
1.5.4 Design life for other structures	15
1.5.5 Design life – remedial works	15
1.5.6 Post – franchise design life	15
1.6 Departures and revisions	15
1.6.1 Departures	15
1.6.2 Revisions	15
2 Design review process	17
2.1 Scheme design	17
2.1.1 Objectives	17
2.1.2 Design	17
2.1.3 Preparation of drawings and drafting check	18
2.1.4 Verification	18
2.1.5 Design review	18
2.1.6 Design certification	18
2.1.7 RPEQ certification	18
2.2 Structures directorate review	19
2.3 Structure fixing report	20
2.4 Structure design report	20
2.4.1 Design report contents	20
2.4.2 Design report phases	21
2.5 Conforming product	23
2.6 Alternative product	23
2.7 Innovation	23
2.8 Innovative materials and components	24
2.9 As Constructed drawings and construction handover documents	24
Part B: Bridges	25
3 Bridges – Functional requirements	25
3.1 Scope	25
3.2 Bridges - Scope	25
3.2.1 Introduction	25

3.2.2	<i>Standard bridges – usual configuration</i>	26
3.2.3	<i>Standard bridges – unusual configuration</i>	26
3.2.4	<i>Non-standard bridges</i>	29
3.2.5	<i>Access for people with disabilities to public transport</i>	30
3.3	Bridge Aesthetics.....	30
3.4	Asset management considerations.....	31
3.4.1	<i>Sustainability</i>	31
3.4.2	<i>Value-for-money</i>	31
3.4.3	<i>Lifecycle</i>	31
3.4.4	<i>Whole-of-life costs</i>	31
3.4.5	<i>Maintenance</i>	32
3.4.6	<i>Constructability</i>	32
3.5	Bridge configuration.....	32
3.5.1	<i>Geometric layout</i>	32
3.5.2	<i>Bridge width</i>	33
3.5.3	<i>Spans for overbridges</i>	37
3.5.4	<i>Vertical clearances</i>	37
3.5.5	<i>Geometry, design speed</i>	38
3.5.6	<i>Maintenance and inspection considerations</i>	39
3.5.7	<i>Jacking for bearing replacement</i>	41
3.6	Bridge widening, strengthening and rehabilitation.....	41
3.6.1	<i>General</i>	41
3.6.2	<i>Provision for future widening</i>	41
3.6.3	<i>Widening an existing bridge</i>	42
3.6.4	<i>Widening two bridges on separate carriageways</i>	43
3.6.5	<i>Estimating residual life of existing bridge</i>	43
3.6.6	<i>Working with asbestos in bridge rehabilitation works</i>	44
3.7	Stage construction.....	45
3.8	Load capacity.....	45
3.8.1	<i>Design loads and construction sequence</i>	45
3.8.2	<i>Design traffic loads for new bridges</i>	45
3.8.3	<i>Design traffic loads for widening / strengthening an existing bridge</i>	46
3.8.4	<i>Design traffic loads for damaged bridges</i>	50
3.8.5	<i>Heavy Load Platforms (HLPs)</i>	50
3.8.6	<i>Abnormal loads</i>	50
3.8.7	<i>Lateral restraint conditions for pedestrian and cyclist bridges</i>	51
3.8.8	<i>Design traffic loads for busway bridges</i>	51
3.8.9	<i>Design traffic loads for light rail passenger transit bridges</i>	54
3.9	Construction loads.....	55
3.9.1	<i>General</i>	55
3.9.2	<i>Bridges constructed without incremental launching</i>	55
3.9.3	<i>Incrementally launched bridges</i>	55
3.10	Mining subsidence.....	55
3.11	Hydraulic considerations.....	56
3.11.1	<i>Hydraulic investigation</i>	56
3.11.2	<i>Minimum hydraulic forces on bridges</i>	57
3.11.3	<i>Acceptable level of afflux</i>	57
3.11.4	<i>Protection against scour</i>	57
3.11.5	<i>Handling drainage from adjacent road</i>	59
3.12	Durability.....	59
3.12.1	<i>Introduction</i>	59
3.12.2	<i>Durability for steelwork</i>	59
3.12.3	<i>Durability for concrete</i>	61
3.13	Buried components.....	62

3.14	Aggressive environments	62
3.14.1	<i>Sulphate reducing bacteria</i>	62
3.14.2	<i>Stray currents from electric railway or other sources</i>	63
3.14.3	<i>Bridge components in marine environment</i>	63
3.15	Cracks in concrete at the end of construction	63
3.15.1	<i>Non aggressive areas</i>	63
3.15.2	<i>Aggressive areas</i>	64
3.16	Thermal cracking in large sections	64
3.16.1	<i>Modelling in design</i>	64
3.16.2	<i>Documentation</i>	64
3.17	Safety in design, construction and maintenance	64
3.17.1	<i>Safe access to site</i>	64
3.17.2	<i>Safe access for inspections (stairs, ladders, hatches, anchorage points)</i>	65
3.18	Bridge security	65
3.19	Bridges in close proximity to railways	65
3.20	Anti-graffiti coating	66
3.21	Date plates and survey marks	67
3.22	Post-construction inspections	67
3.23	Special conditions or requirements.....	67
4	Bridges - Details	68
4.1	Introduction	68
4.1.1	<i>Scope</i>	68
4.1.2	<i>Design methodologies</i>	68
4.2	Design life	68
4.3	Spread footing foundations.....	69
4.4	Pile foundations	69
4.4.1	<i>Pile types not accepted by Transport and Main Roads</i>	69
4.4.2	<i>Driven piles</i>	70
4.4.3	<i>Cast-in-place piles</i>	70
4.4.4	<i>Pile design outputs shown in drawings</i>	71
4.4.5	<i>Pile design foundation levels</i>	71
4.4.6	<i>Steel pile foundations</i>	72
4.4.7	<i>Raked piles</i>	72
4.5	Piers.....	73
4.5.1	<i>Headstocks</i>	73
4.5.2	<i>Pier protection of overbridges from traffic impact</i>	73
4.6	Abutments.....	73
4.6.1	<i>Spill-through abutments</i>	73
4.6.2	<i>Abutment protection</i>	74
4.6.3	<i>Abutments designed for soil settlement and movement</i>	77
4.6.4	<i>Reinforced soil structure walled abutments</i>	77
4.6.5	<i>Abutment spread footings</i>	77
4.7	Bearings.....	78
4.7.1	<i>Design life</i>	78
4.7.2	<i>Acceptable types of bearings</i>	78
4.7.3	<i>Arrangement of bearings</i>	78
4.7.4	<i>Provision for jacking and bearing replacement</i>	78
4.7.5	<i>Restraint of elastomeric bearings</i>	79
4.7.6	<i>Allowance for hog</i>	79
4.8	Superstructure elements.....	80

4.8.1	General.....	80
4.8.2	Prestressed concrete deck units.....	82
4.8.3	Prestressed concrete I-girders.....	83
4.8.4	Prestressed concrete Super T-girders.....	84
4.8.5	Sacrificial formwork for precast girders and deck units.....	87
4.8.6	Prestressed concrete box girders.....	88
4.8.7	Steel I-beams.....	91
4.8.8	Steel box girders.....	91
4.8.9	Steel composite bridge deck.....	93
4.8.10	Proprietary bridge deck systems.....	93
4.9	Deck drainage.....	94
4.9.1	General.....	94
4.9.2	Crossfall and longitudinal gradient.....	95
4.9.3	Waterproof membrane.....	95
4.10	Deck wearing surface.....	96
4.11	Bridge traffic barriers.....	98
4.11.1	General.....	98
4.11.2	Functionality and appearance.....	98
4.11.3	Post and rail traffic barriers for afflux reduction.....	98
4.11.4	Concrete barriers.....	98
4.11.5	Precast concrete barriers.....	99
4.11.6	Transition between road and bridge barriers.....	99
4.11.7	Retrofit of barriers.....	100
4.11.8	Design for temporary barriers – worker protection during construction.....	101
4.11.9	Wire rope barriers.....	103
4.11.10	Attachments to barriers on bridges.....	103
4.11.11	Barriers between active users and bridge carriageway.....	104
4.11.12	Barrier protection for new bridge supports.....	107
4.11.13	Barrier protection for existing bridge supports.....	107
4.12	Expansion joints.....	108
4.12.1	General.....	108
4.12.2	Non-conforming joints.....	109
4.12.3	Safety of pedestrians and cyclists.....	109
4.12.4	Noise.....	109
4.12.5	Modular joints.....	109
4.12.6	Finger type expansion joints.....	110
4.12.7	Joints to be detailed on drawings.....	111
4.12.8	Cover plates at joints.....	111
4.12.9	Design for access of safe maintenance.....	111
4.12.10	Open joints.....	111
4.13	Relieving slabs.....	111
4.14	Stay cables.....	112
4.15	Utility services.....	112
4.15.1	Provision of utility services on bridges.....	112
4.15.2	Fixings for services.....	112
4.15.3	Chemical anchors in tension.....	113
4.16	Pedestrian bridges and velobridges for active users.....	113
4.16.1	General.....	113
4.16.2	Design references.....	113
4.16.3	Barriers and balustrades.....	114
4.17	Paint systems.....	114
4.17.1	Initial application to be compatible with future recoating.....	114
4.17.2	Medium exposure.....	114
4.17.3	Very high marine exposure.....	114
4.18	Structural steel.....	114

Part C	Tunnels	116
5	Tunnel criteria	116
5.1	Scope	116
5.2	Design references, standards and reviews	116
5.2.1	General	116
5.2.2	Department of Transport and Main Roads	116
5.2.3	Austrroads	116
5.2.4	Australian Standards	116
5.2.5	Workplace Health & Safety	117
5.2.6	External agency references	117
5.2.7	Miscellaneous references	117
5.2.8	Reviews	117
5.3	Tunnel functionality	117
5.3.1	Design objectives	118
5.4	Geological and geotechnical investigations	119
5.5	Design life – tunnels	120
5.6	Durability	121
5.7	Dislodging of overhead equipment	122
5.8	Hydraulics and drainage	122
5.9	Fire and life safety	123
5.10	Design particulars	125
5.10.1	General	125
5.10.2	Tunnel roofs	126
5.10.3	Hydraulic head	126
5.10.4	Arching	126
5.10.5	Concrete considerations	126
5.10.6	Structural anchors	126
5.10.7	Drainage and waterproofing	126
5.10.8	Property acquisitions and resumptions	127
5.10.9	Road and bus tunnels	127
5.10.10	Driven tunnels	127
5.10.11	Cut and cover tunnel	129
5.10.12	Parametric study	129
5.11	Design loads	129
5.11.1	General	129
5.11.2	Vehicle live loads	129
5.11.3	Loads due to development and surcharge above and/or beside a tunnel	130
5.12	Mechanical and electrical services and ITS	131
5.13	Review of scheme documents	131
5.13.1	General	131
5.13.2	Design report	132
5.13.3	Fire and life safety report	133
5.13.4	Operation, inspection and maintenance manual	133
5.13.5	Incident management and recovery manual	134
5.14	Construction issues	134
5.14.1	Technical specifications	134
5.14.2	Instrumentation	135
5.14.3	Design validation	135
5.14.4	Validation of permanent anchors	135
5.15	Post construction considerations	137
5.15.1	'As Constructed' drawings and construction handover report	137

5.15.2	Level 2 (and Level 3) inspection of tunnel.....	137
Part D:	Other Structures	138
6	Public transport stations and ancillary structures.....	138
6.1	Scope.....	138
6.1.1	In scope.....	138
6.1.2	Not in scope.....	138
6.1.3	Application.....	138
6.2	Design references, standards and reviews	138
6.2.1	General.....	138
6.3	Design life.....	138
6.3.1	General.....	138
6.3.2	100 year design life	138
6.3.3	50 year design life	139
6.4	Design criteria.....	139
6.4.1	General.....	139
6.5	Foundations	139
6.5.1	Types not permitted by the department	139
6.6	Materials	140
6.6.1	Concrete.....	140
6.6.2	Structural steelwork.....	140
7	Gantries and support structures for signage, lighting and ITS	142
7.1	Applicability.....	142
7.1.1	In scope.....	142
7.1.2	Out of scope	142
7.2	Purchasing guidelines.....	143
7.3	Sign categories	143
7.3.1	General.....	143
7.3.2	On-carriageway support structure.....	143
7.3.3	Off-carriageway support structure.....	143
7.4	Design life.....	143
7.5	Aesthetics	143
7.6	Provision of ITS devices	143
7.7	Vertical clearance	144
7.8	Protection of sign support structures from vehicle impact.....	145
7.8.1	General principles.....	145
7.8.2	Barrier deflection restrictions.....	145
7.8.3	Working width restrictions	145
7.8.4	Traffic barrier design criteria.....	146
7.9	Structural design considerations.....	148
7.9.1	General.....	148
7.9.2	Wind loading.....	148
7.9.3	Load combinations	149
7.9.4	Fatigue.....	149
7.9.5	Serviceability deflection.....	149
7.9.6	Vibrations.....	151
7.9.7	Durability considerations	151
7.9.8	Foundations.....	152
7.10	Support structures attached to bridges.....	153
7.10.1	General.....	153

7.10.2	Support structures attached to reinforced concrete traffic barriers on bridges	155
7.10.3	Support structures attached to bridges with steel traffic barriers	155
7.11	Maintenance access	155
7.11.1	General	155
7.11.2	Access to the structure site	156
7.11.3	Maintenance platform	156
7.11.4	Access ladder and landings	157
7.12	Wiring	160
7.12.1	Wiring enclosures	160
7.12.2	Provision for drawing cables and wiring	160
7.13	Fixings	160
7.13.1	Anchor bolt / rod details	160
7.13.2	Base plate	161
7.13.3	Bolts, nuts and washers	161
7.14	Structural steelwork	161
7.15	Drawings and design report	161
7.16	Fabrication of structural steelwork and aluminium components	163
7.17	Installation of structure	164
7.18	Inspection	164
8	Roadside advertising signs	165
8.1	Introduction	165
8.2	Sign licensee	165
8.3	Scope	165
8.4	Sign categories	165
8.4.1	General	165
8.4.2	On-carriageway advertising signs	165
8.4.3	Off-carriageway advertising signs	166
8.5	Aesthetics	166
8.6	Design criteria for on-carriageway advertising signs	166
8.6.1	General	166
8.6.2	Vertical clearance	166
8.6.3	Advertising signs attached to bridges	166
8.6.4	Materials	168
8.6.5	Structural design	169
8.6.6	Corrosion protection and durability	173
8.6.7	Concrete durability	173
8.6.8	Maintenance platform	173
8.6.9	Access ladder and landings	175
8.6.10	Wiring and wiring enclosures	177
8.6.11	Access to the structure site	177
8.6.12	Protection of structures from vehicle impact	178
8.6.13	Transport and Main Roads review of drawings and scheme documents	178
8.6.14	Quality assurance in the documentation	178
8.6.15	Design certification	180
8.6.16	Acceptance for fabrication and construction	180
8.6.17	Fabrication of structural steelwork and aluminium components	180
8.6.18	Installation of the structure	181
8.6.19	Inspection of the installed sign structure	183
8.7	Design criteria for off-carriageway advertising signs	183
8.7.1	Vertical clearance	183
8.7.2	Materials	183

8.7.3	<i>Structural design</i>	184
8.7.4	<i>Corrosion protection and durability</i>	185
8.7.5	<i>Maintenance platform</i>	185
8.7.6	<i>Wiring and wiring enclosures</i>	186
8.7.7	<i>Protection of structures from vehicle impact</i>	186
8.7.8	<i>Construction specifications</i>	186
8.7.9	<i>Transport and Main Roads design acceptance</i>	186
8.7.10	<i>Design certification</i>	186
8.7.11	<i>Fabrication of structural steelwork</i>	187
8.7.12	<i>Construction supervision</i>	187
8.7.13	<i>Inspection</i>	187
8.8	Provisions of fall protection to existing roadside advertising signs.....	188
8.9	Approval flow charts.....	189
9	Buried concrete arches	191
9.1	Scope.....	191
9.2	Design life and serviceability.....	191
9.3	Design documentation.....	191
9.4	Design acceptance process.....	192
9.5	Design requirements.....	192
9.6	Other requirements.....	195
9.7	Concrete durability.....	195
9.8	Development adjacent to arches.....	195
9.9	Arch manufacturing criteria.....	195
10	Retaining structures	196
10.1	Scope.....	196
10.2	Design requirements for retaining walls.....	196
10.3	Design life of retaining structures.....	196
10.4	Design certification.....	196
10.4.1	<i>General</i>	196
10.4.2	<i>Structural design</i>	196
10.4.3	<i>Design certification – additional requirements for construction contractors</i>	197
10.5	Quality assurance for design and construction.....	197
10.6	Design principles for retaining walls.....	197
10.6.1	<i>Aesthetics</i>	197
10.6.2	<i>Flood loading</i>	198
10.6.3	<i>Tiered walls</i>	198
10.6.4	<i>Control joint for prevention of cracks in retaining walls</i>	198
10.7	Retaining wall drainage.....	198
10.8	Design calculations.....	198
10.9	Additional requirements for Reinforced Soil Structure (RSS) retaining walls.....	198
10.9.1	<i>General</i>	198
10.9.2	<i>Impact protection from road traffic</i>	199
10.9.3	<i>Impact protection from rail traffic</i>	199
10.9.4	<i>Mine haul vehicle impact</i>	199
10.10	Additional requirements for piles in retaining walls.....	200
10.10.1	<i>Cast-in place piles for high moment, low axial load applications</i>	200
10.10.2	<i>Contiguous piled walls</i>	200

10.11	Additional requirements for block masonry retaining walls	201
11	Design of Fibre Reinforced Polymer (FRP) composite girders	202
11.1	Scope and application	202
11.2	Design requirements.....	202
11.3	Symbols and notations	202
11.4	Provision for innovation	203
11.5	Maximum operating temperature.....	205
11.6	Exclusions.....	205
11.7	Material properties	205
11.7.1	General.....	205
11.7.2	Reinforcement	205
11.7.3	Polymer matrices.....	206
11.7.4	Core materials	207
11.7.5	Gel coats	207
11.7.6	Laminates.....	207
11.7.7	FRP profiles.....	207
11.8	Design and detailing	208
11.8.1	Design for ultimate limit state	208
11.8.2	Design for serviceability limit state	209
11.8.3	Warning of failure	209
11.8.4	Failure modes.....	209
11.8.5	Design for stability	209
11.8.6	Deformability of FRP composite girders.....	209
11.8.7	Durability.....	210
11.8.8	Fire resistance.....	210
11.8.9	Thermal expansion.....	210
11.8.10	Creep and shrinkage	211
11.8.11	End zones design and connections.....	211
11.9	Additional requirements Category A FRP composite girders for new bridges	212
11.9.1	Traffic loads on new bridges	212
11.9.2	Load combinations and load factors for design of FRP composite girders.....	212
11.9.3	Method of structural analysis and design.....	212
11.9.4	Design for strength	213
11.9.5	Deflection.....	213
11.9.6	Design life.....	213
11.9.7	Fatigue for FRP girders on new bridges.....	213
11.9.8	Vibration	213
11.10	Additional design requirements for Category B FRP composite girders on existing timber bridges	213
11.10.1	Performance criteria	214
11.10.2	Fatigue design of FRP composite girders on timber bridges.....	214
11.10.3	Design Life of FRP composite girders on timber bridges.....	214
12	Drainage structures	215
12.1	Scope.....	215
12.1.1	In scope	215
12.1.2	Out of scope	215
12.2	Design life for drainage structures	215
12.2.1	New structures.....	215
12.2.2	Residual life	216
12.3	Design requirements.....	216
12.3.1	General.....	216

12.3.2	<i>Cast in situ box culverts</i>	216
12.3.3	<i>Precast concrete box culverts</i>	216
12.3.4	<i>Concrete pipes</i>	216
12.3.5	<i>Corrugated metal culverts</i>	217
12.3.6	<i>Lifting of drainage structures</i>	217
12.3.7	<i>Accessibility</i>	217
12.4	Barriers for culverts	217
12.5	Approach settlement adjacent to large culverts	217
12.6	Structural requirements for existing culverts	217
13	Motor grids	218
13.1	General	218
13.2	Motor grid design requirements	218
13.3	Design life	218
14	Noise barriers	219
14.1	Scope	219
14.2	Design life	219
14.2.1	<i>Stand-alone noise barriers</i>	219
14.2.2	<i>Noise barriers on structures</i>	219
14.3	Design Loads	219
14.3.1	<i>Stand-alone noise barriers</i>	219
14.3.2	<i>Noise barriers on structures</i>	219
14.4	Design documentation	219
14.5	Design review and certification	220
15	Fauna crossings	221
Part E: Development applications		222
16	Development applications in the proximity of bridges and other structures	222
16.1	General	222
16.2	Drawings, reports and method statements	222
16.3	Potholing criteria	223
16.4	Demolition phase	223
16.5	Construction phases	223
16.6	Additional criteria for development adjacent to bridges	224
17	Development applications in proximity to tunnels	228
17.1	General	228
17.2	State-controlled tunnels in south east Queensland	228
17.3	Development approval requirements	230
17.3.1	<i>Zone of influence for tunnels</i>	230
17.3.2	<i>Permissible excavation and loading above and beside a tunnel and within the easement area</i>	231
17.3.3	<i>State-controlled future tunnel assessment requirements</i>	232
17.3.4	<i>State-controlled existing tunnel design assessment requirements</i>	233
17.3.5	<i>Building load calculations</i>	235
17.4	Pre-construction, construction and post construction compliance requirements	236
17.4.1	<i>General</i>	236
17.4.2	<i>Potholing</i>	237

17.4.3	<i>Demolition - risk assessment and method statement</i>	237
17.4.4	<i>Foundation excavation survey</i>	237
17.4.5	<i>Tunnel dilapidation survey</i>	237
17.4.6	<i>Tunnel monitoring requirements</i>	239
17.4.7	<i>Ground water monitoring</i>	240
17.4.8	<i>Tunnel movement monitoring</i>	240
17.4.9	<i>Vibration monitoring</i>	241
17.4.10	<i>Crack monitoring device</i>	243
17.4.11	<i>Ground movement adjacent to the tunnel</i>	244
17.5	Additional requirements for tunnels	244
Appendix A:	Matters for resolution to AS(/NZS) 5100:2017	246
Appendix B:	Additional requirements to AS(/NZS) 5100	270

Tables

Table 1.2 – Content structure of manual	1
Table 1.3 – Table of acronyms	3
Table 1.4.5 – Referenced documents	8
Table 3.5.2(a) – Bridge footway / bikeway widths	34
Table 3.5.2(b) – Minimum bridge carriageway widths for freeways and motorways	34
Table 3.5.2(c) - Minimum bridge carriageway widths for national network and state strategic roads ..	35
Table 3.5.2(d) - Minimum bridge carriageway widths for other roads	35
Table 3.5.2(e) - Minimum bridge carriageway widths for single lane rural bridges	36
Table 3.5.4.2 – Minimum vertical clearances for bridges over roads.....	37
Table 3.8.3.2 – Design traffic loads for simply supported spans of less than 50 m (bridge widening / strengthening)	47
Table 3.8.8.5 – Number of stress cycles for fatigue design	53
Table 3.19 – Bridge barrier heights and performance levels	66
Table 4.6.2.2 – Abutment protection type selection criteria	76
Table 4.8.4.3 – Void arrangement of Super T-girders (indicative only)	85
Table 4.8.6.4 – Prestressed concrete box girders design standards	89
Table 4.8.6.5 – Segmental bridge design standards.....	89
Table 4.8.9 – Steel composite bridge analysis method.....	93
Table 4.11.4 – Minimum heights for concrete barriers	99
Table 4.11.8 – Complying criteria for temporary barriers to AS(/NZS) 5100 to protect workers – 45 t semi-trailer and 68 t B-double	102
Table 5.14.4.1(a) – Acceptance testing for service life performance – Example 1	136
Table 5.14.4.1(b) – Acceptance testing for service life performance – Example 2	136
Table 5.14.4.1(c) – Acceptance testing for service life performance – Example 3	136

Table 7.6 – ITS Specifications.....	144
Table 7.9.5(a) – Deflection criteria for portal structures	150
Table 7.9.5(b) – Deflection criteria for cantilever structures.....	151
Table 7.11.4(a) – Details of the fall protections.....	157
Table 7.11.4(b) – Details of the fall arrester system	158
Table 8.6.5.8(a) – Deflection criteria for portal structures	170
Table 8.4.5.8(b) – Deflection criteria for cantilever structures.....	171
Table 8.6.9(a) – Details of the fall protections.....	175
Table 8.6.9(b) – Details of the fall arrester system	176
Table 8.8 – Details of the fall protections (Retrofitting)	188
Table 11.3 – Symbols and notations	202
Table 11.3 – Structural performance matrix for evaluation of innovation.....	203
Table 11.7.2.1 – Minimum fibre properties before processing	206
Table 11.7.3.1 – Allowable properties of resin	207
Table 11.7.7 – Minimum properties of FRP profiles	208
Table 11.10.1 – Performance criteria for existing Transport and Main Roads timber bridges.....	214
Table 12.2 Other drainage structures - design life	215
Table 17.2 – State-controlled tunnels ¹ (as at Jan 2016).....	228
Table 17.3.3- State-controlled future tunnel assessment requirements	233
Table 17.3.4 – State-controlled existing tunnel design assessment requirements	234
Table 17.3.5 – Building load calculation.....	236
Table 17.4.5.3 – Potential tunnel dilapidation survey costs ¹	238
Table 17.4.6.1 – Monitoring requirements for developments adjacent to a tunnel	239
Table 17.4.9.2 – Vibration - alarm limits and responses for bored / driven tunnel.....	242
Table 17.4.9.3 – Vibration alarm limits and responses for cut and cover tunnels.....	243
Table 17.4.10.2 – Tunnel lining cracks, alarm limits and responses	243

Figures

Figure 3.5.2 – Minimum bridge carriageway widths.....	34
Figure 3.5.6.1 – Minimum gap between adjacent bridge decks.....	39
Figure 3.5.6.2 – Typical Under Bridge Inspection Unit (UBIU) arrangement	40
Figure 3.8.3.2 – Details of 6 axle semi, AB triple and AAB quad	49
Figure 3.8.8.2(a) - T44 Truck load.....	52

Figure 3.8.8.2(b) - L44 Lane load	52
Figure 3.8.8.2(c) - 48 t Crane configuration	52
Figure 3.8.9.2(a) – 150 LA light rail traffic loads – axle group loads	54
Figure 3.8.9.2(b) – 150 LA light rail traffic loads – axle group spacing	54
Figure 4.8.4.3 – Dimensions of the Super T-girders	85
Figure 4.8.10.1 – Wide flange I-girder shape	94
Figure 4.10(a) - DWS for two-way crossfall carriageways on PSC deck unit bridges	96
Figure 4.10(b) - DWS for one-way crossfall carriageways on PSC deck unit bridges	97
Figure 4.10(c) - DWS for cast in situ deck slab	97
Figure 4.10(d) - Open graded DWS for cast in situ deck slab	97
Figure 4.11.7 – Flow chart for assessing bridge barriers and transition to roadside safety barriers ..	101
Figure 4.11.8 – Deemed-to-comply temporary barriers to AS/(NZS) 5100 to protect workers – 45 t semi-trailer and 68 t B-double	102
Figure 4.11.11(a) – Barrier between carriageway and shared path	105
Figure 4.11.11(b) – Barrier between carriageway and footpath	106
Figure 4.11.11(c) – No barrier between carriageway and footpath	106
Figure 4.12.6(a) – Gap width of fingerplate expansion joints	110
Figure 4.12.6(b) – Gap width of saw tooth expansion joints	110
Figure 5.3 – Tunnel functionality inputs	118
Figure 5.9 - Tunnel safety inputs	124
Figure 5.11.2 – Design vehicles live loads above tunnels (additional to AS 5100.2)	130
Figure 7.8.3 – Working width	146
Figure 7.8.4.3.2 – Gantry supports designs incorporated within road safety barriers and within the working width	148
Figure 7.9.5 – Camera deflection criteria (deflection criteria are subject to specific camera requirements)	150
Figure 7.11.4 – Parts of the fall arrester system	159
Figure 8.4.3 – Advertising sign structure locations	166
Figure 8.6.9 – Parts of the fall arrester system	176
Figure 11.8.1 – ULS and SLS strain limitations	208
Figure 16.6(a) – Lateral clearance to the bridge structures	225
Figure 16.6(b) – Lateral clearance to the bridge columns located closure to river bank	225
Figure 16.6(c) – Lateral clearance to the bridge columns located away from river bank	226
Figure 17.3.1.1 - Lateral zone of influence for driven tunnels	231

Part A: General

1 Preamble

1.1 Scope of this document

This manual covers requirements for the design of bridges and other transport related structures, namely:

- bridges carrying road traffic
- bridges carrying active users (pedestrians and cyclists)
- bridges carrying light rail traffic
- bridges carrying busway traffic
- underpasses for road traffic
- underpasses for pedestrian and/or cyclist paths
- tunnels for roadway, busway and light rail traffic
- stations, and ancillary structures, for public transport, including buses and light rail
- support structures, including gantries, for traffic signage, lighting and ITS
- roadside advertising sign support structures
- retaining walls and other associated structures
- drainage structures, including culverts
- noise barriers
- fauna crossings
- concrete arches
- submerged structures
- Fibre Reinforced Polymer (FRP) composite (FRPC) structures, and
- Development Applications adjacent to transport infrastructure.

1.2 Format of this document

The content of this manual is arranged as indicated in Table 1.2.

Table 1.2 – Content structure of manual

Chapter	Description
PART A – General	
Chapter 1	<u>Preamble</u> Defines the broad scope and format of the manual, provides a list of acronyms, defines the required design references, and indicates design life parameters
Chapter 2	<u>Design Review Process</u> Describes the process for reviewing design compliance of bridges, tunnels and other structures

Chapter	Description
PART B - Bridges	
Chapter 3	<u>Bridges – Functional Requirements</u> Introduces the bridge types covered and the functional characteristics they are expected to display
Chapter 4	<u>Bridges – Details</u> Reviews the particular requirements for bridge component elements
PART C - Tunnels	
Chapter 5	<u>Tunnel Criteria</u> Considers the design, construction and operation criteria for tunnels
PART D – Other Structures	
Chapter 6	<u>Public Transport Stations and Ancillary Structures</u> Contains the criteria for design of stations and other ancillary structures associated with buses and light rail
Chapter 7	<u>Signage, Lighting and ITS Support Structures</u> Applies to the design of support structures, including gantries, adjacent to and over roads, which are intended to carry signage, toll monitoring devices, lighting, and ITS equipment
Chapter 8	<u>Roadside Advertising Signs</u> Intended to apply to structural elements within the road reserve that carry advertising licensed by the department
Chapter 9	<u>Buried Concrete Arches</u> Provides the criteria applicable to proprietary precast concrete arch elements intended to provide an alternative to a bridge, culvert or tunnel
Chapter 10	<u>Retaining Structures</u> Describes the criteria that apply to a range of retaining structures associated with bridges and road transport infrastructure
Chapter 11	<u>Fibre Reinforced Polymer (FRP) Structures</u> Specifies the minimum requirements for the design of FRP elements used in bridges and other structures
Chapter 12	<u>Drainage Structures</u> Considers design of drainage structures such as culverts, headwalls, drainage pits, road side kerb inlets and other precast drainage elements
Chapter 13	<u>Motor grids</u> Indicates the design criteria to be adopted in the design of motor grids
Chapter 14	<u>Noise Barriers</u> Considers the design requirements for noise barriers
Chapter 15	<u>Fauna Crossings</u> Introduces the design considerations that apply when designing elevated fauna crossings
PART E – Development Applications	
Chapter 16	Describes the process for review of development applications in the proximity of bridges and other structures
Chapter 17	Provides guidelines for the assessment of development applications in the proximity of tunnels

Chapter	Description
Appendices	
Appendix A	Matters for Resolution to AS(/NZS) 5100 <i>Bridge design</i>
Appendix B	Additional Requirements to AS(/NZS) 5100 <i>Bridge design</i>

1.3 Acronyms

Acronyms adopted in this document are listed in Table 1.3.

Table 1.3 – Table of acronyms

Item	Description
AADT	Average Annual Daily Traffic number
AASHTO	American Association of State Highway and Transportation Officials
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ASCE	American Society of Civil Engineers
ASS	Acid Sulphate Soil
BIS	Bridge Information System
CFA	Continuous Flight Auger
CHBDC	<i>Canadian Highway Bridge Design Code</i>
DWS	Deck Wearing Surface
ECI	Early Contractor Involvement
EIS	Environmental Impact Statement
EPM	Electronic Project Model
ETAG	Electronic Free Flow Toll Collection System
FC	Fibre Cement
FRP	Fibre Reinforced Polymer
FRPC	Fibre Reinforced Polymer Composite
GFRP	Glass Fibre Reinforced Polymer
HA	United Kingdom Highways Agency
HAT	Highest Astronomical Tide
HLP	Heavy Load Platform
IDAS	Integrated Development Assessment System
ITS	Intelligent Transport System
LAT	Lowest Astronomical Tide
LRT	Light Rail Transit
LRFD	AASHTO Load and Resistance Factor Design
LTMS	Large Traffic Management Signs
LUMS	Lane Use Management System
MRTS	Main Roads Technical Specification

Item	Description
NAASRA	National Association of Australian State Road Authorities
NSF	Negative Skin Friction
PASS	Potential Acid Sulphate Soil
PDA	Pile Driving Analyser
PHRR	Peak Heat Release Rate
PSC	Prestressed Concrete
QFRS	Queensland Fire and Emergency Services
QR	Queensland Rail
QUT	Queensland University of Technology
RC	Reinforced Concrete
RDM	Transport and Main Roads <i>Road Drainage Manual</i>
RMS	Roads and Maritime Services
RPDM	Transport and Main Roads <i>Road Planning and Design Manual</i> 2nd Edition
RPEQ	Registered Professional Engineer Queensland
RPEQ certification	Refer Section 2.1.7
SID	Safety In Design
SLS	Serviceability Limit State
SRB	Sulphate Reducing Bacteria
SWTC	Scope of Work and Technical Criteria
TBM	Tunnel Boring Machine
UBIU	Under Bridge Inspection Unit
ULS	Ultimate Limit State

1.4 Design references

1.4.1 AS/(NZS) 5100

- a) This set of design criteria is intended to compliment AS/(NZS) 5100 *Bridge design*, which is to be adopted as the principal design reference for bridges and other structures, unless noted otherwise in this document. Where this document and AS/(NZS) 5100 diverge, this document takes precedence, unless otherwise agreed with the department's Engineering and Technology Director (Structures Design, Review and Standards).
- b) AS/(NZS) 5100 is defined as the latest revisions of the AS/(NZS) 5100:2017 series, which comprises the following parts:
 - i. AS 5100.1 *Bridge Design - Scope and general principles*
 - ii. AS 5100.2 *Bridge design - Design loads*
 - iii. AS 5100.3 *Bridge design - Foundation and soil-supporting structures*
 - iv. AS 5100.4 *Bridge design - Bearings and deck joints*
 - v. AS 5100.5 *Bridge design – Concrete*

- vi. AS/NZS 5100.6 *Bridge design - Steel and composite construction*
 - vii. AS 5100.7 *Bridge design – Bridge assessment*
 - viii. AS 5100.8 *Bridge design – Rehabilitation and strengthening of existing bridges*
 - ix. AS 5100.9 *Bridge design – Timber.*
- c) At the start of each bridge design project, the additional requirements in Appendix A of this document, Matters for resolution to AS/(NZS) 5100 shall be either:
- i. supplied by the Principal to the Designer, or
 - ii. a proposal for the contents of Appendix A shall be prepared by the Designer, and submitted to the Director (Structures Design, Review and Standards) for modification (if necessary) and acceptance.
- d) Additional requirements to AS/(NZS) 5100 are set out in Appendix B of this document. This includes those formal Amendments to AS/(NZS) 5100 that have been acknowledged by the department. If no such acknowledgement is indicated the Director (Structures Design, Review and Standards) may be approached for confirmation of the department's position.

1.4.2 Austroads

Austrroads is a national body consisting of state, territory, commonwealth and local government agencies, amalgamated with the purpose of improving Australasian transport outcomes.

Austrroads maintains a suite of guides relevant to the design of bridges and other structures including:

- i. *Guide to Bridge Technology*
- ii. *Guide to Road Tunnels*, and
- iii. *Guide to Road Design*.

In Queensland, these guides are often supplemented by the provisions of documents maintained by the Department of Transport and Main Roads (refer Section 1.4.3), and other agencies (refer Section 1.4.4).

1.4.3 Department of Transport and Main Roads

1.4.3.1 General

The department maintains a raft of references that should be consulted during the design of bridges and other structures including:

- formal policies
- standard drawings
- technical specifications
- technical manuals
- technical guidelines
- technical notes, and
- drafting standards.

The references in this document are to the latest version of these documents, published on the department's website www.tmr.qld.gov.au.

1.4.3.2 Road infrastructure policies

The department has formally adopted several policy positions on a variety of issues relevant to the design of bridges and other structures including:

- asset management
- cycling, and
- roadside advertising.

Designers should carefully consider these policies.

1.4.3.3 Standard Drawings

The Department of Transport and Main Roads maintains a set of Standard Drawings.

The purpose of Standard Drawings is to provide typical standard details for generalised situations.

Where the details shown on a Standard Drawings are adopted for a specific project, the Designer shall ensure that they are suitable for the intended purpose, and are covered by the RPEQ certification for the project design.

1.4.3.4 Technical Specifications

Design shall be in accordance with the suite of Technical Specifications maintained by the department.

Where Technical Specifications appear to conflict with the requirements of this manual, a direction shall be sought from the Director (Structures Design, Review and Standards).

Designers shall ensure that approved deviations from the Technical Specifications are contained within the design documentation.

1.4.3.5 Technical manuals

The department has published a series of manuals to cover elements of infrastructure design that require particular attention, including the:

- Bridge Scour Manual*
This manual is a *Supplement to the Austroads Guide to Bridge Technology*, Part 8, Chapter 5, *Bridge Scour*
- Timber Bridge Maintenance Manual*
- Structures Inspection Manual*
- Road Planning and Design Manual* (2nd edition)
The RPDM (2nd edition) is generally structured to align as far as possible with the *Austroads Guide to Road Design*, although it is supplemented, where necessary, with aspects unique or important to Queensland practice.
- Geotechnical Design Standard – Minimum Requirements.*

1.4.3.6 Technical guidelines

The department has compiled a suite of guidelines on topics of particular relevance to designers of transport infrastructure, including:

- i. *Guideline for the Preparation of Road Structure Durability Plans*
- ii. *Options for Designers of Pedestrian and Cyclist Bridges to Achieve Value-for-Money*
- iii. *Geotechnical Logging*
- iv. *Hydrologic and Hydraulic Modelling*, and
- v. *TMR Risk Management Guide* (internal document).

1.4.3.7 Technical notes

In addition to the design guidance provided in this document, and its technical manuals and guidelines, the department also maintains a series of technical notes.

Where this manual and the technical notes diverge, this document shall be followed, unless agreed otherwise by the Director (Structures Design, Review and Standards).

1.4.3.8 Structural drafting standards

All project drawings shall be completed to the standards of detailing, accuracy and completeness set out in the Transport and Main Roads *Drafting and Design Presentation Standards*, Volume 3, *Structural Drafting Standards*.

1.4.3.9 Products and suppliers

The department maintains lists of registered products and suppliers.

Registered products shall be used as mandated in the department's Technical Specifications (see Section 1.4.3.4). An alternative product shall not be used unless the listed product is unavailable for purchase.

Any proposal to use an alternative product must be approved by the Director (Structures Design, Review and Standards), and any approval will only relate to the project for which approval is sought.

1.4.4 Other agencies

1.4.4.1 General

- a) Where bridges and other structures impinge on the assets, property or responsibilities of other authorities, those agencies may have further requirements, for example:
 - Queensland Rail (refer Section 1.4.4.2).
 - Utility Service authorities (communications, distribution cables, water / sewerage mains and so on).
 - Local Government authorities (for clearances, roadways, water, sewerage, drainage and the like).
 - Commercial authorities (such as mining developments and power stations), where specific conditions on associated roads apply, for example loads or dimensional clearances.
 - Private and corporatised transportation operators such as the rail company Aurizon, and the toll road operator Transurban.

- b) The Designer shall consult relevant authorities for their additional requirements, if these are not explicitly included in Appendix A Matters for Resolution to AS(/NZS) 5100.
- c) Whenever and wherever the Designer consults with another agency or authority, the relevant departmental representative shall be afforded the opportunity to be involved in any meetings and/or other co-ordination activities and shall be kept informed and advised about any such consultation.

1.4.4.2 Queensland Rail

Queensland Rail maintains a suite of Civil Engineering Technical Requirements, namely:

- Civil-SR-001 *Design of Road Overbridges*
- Civil-SR-002 *Work in or about Queensland Rail Property*
- Civil-SR-003 *Requirements for Work in or near High Voltage Overhead Line Equipment and Low Voltage Services*
- Civil-SR-005 *Design of buildings over or near Railways*
- Civil-SR-006 *Design of Footbridges*
- Civil-SR-007 *Design and Selection Criteria for Road/Rail Interface Barriers*
- Civil-SR-008 *Protection Screens*
- Civil-SR-012 *Collision protection of Supporting Elements adjacent to Railways*
- Civil-SR-013 *Advertising Signs on Queensland Rail's Property*
- Civil-SR-014 *Design of Noise Barriers adjacent to Railways, and*
- Civil-SR-016 *Services under Railway Property (Non-Queensland Rail Services).*

These documents refer to Queensland Rail Standard Drawings and other references, which should also be consulted.

1.4.5 Table of references

The following table shows the various documents referred to in this document.

Table 1.4.5 – Referenced documents

Reference	Title
AS 1012	<i>Methods of testing concrete</i>
AS 1101	<i>Graphic symbols for general engineering - Hydraulic and pneumatic systems</i>
AS 1101.3	<i>Graphical symbols for general engineering - Welding and non-destructive examination</i>
AS 1110	<i>ISO metric hexagon bolts and screws - Product Grades A and B</i>
AS 1111	<i>ISO metric hexagon bolts and screws - Product Grade C</i>
AS 1112	<i>ISO metric hexagon nuts</i>
AS 1170	<i>Structural Design Actions (set)</i>
AS 1170.1	<i>Structural design actions - Permanent, imposed and other actions</i>
AS 1170.2	<i>Structural design actions - Wind actions</i>

Reference	Title
AS 1170.4	<i>Structural design actions - Earthquake actions in Australia</i>
AS 1237	<i>Plain washers for metric bolts, screws and nuts for general purposes</i>
AS 1275	<i>Metric screw threads for fasteners</i>
AS 1379	<i>Specification and Supply of Concrete</i>
AS 1428	<i>Design for access and mobility (set)</i>
AS 1530.4	<i>Methods for fire tests on building materials, components and structures - Fire-resistance tests for elements of construction</i>
AS 1579	<i>Arc-welded steel pipes and fittings for water and waste-water</i>
AS 1597.1	<i>Precast reinforced concrete box culverts – Small culverts (not exceeding 1200 mm span and 1200 mm height)</i>
AS 1597.2	<i>Precast reinforced concrete box culverts – Large culverts (exceeding 1200 mm span or 1200 mm height and up to and including 4200 mm span and 4200 mm height)</i>
AS 1657	<i>Fixed platforms, walkways, stairways and ladders – Design, construction and installation</i>
AS 2159	<i>Piling – Design and installation</i>
AS 2312.1	<i>Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 1: Paint Coatings</i>
AS 2832.5	<i>Cathodic Protection of Metals-Steel in Concrete Structures</i>
AS 3000	<i>Australian Wiring Rules</i>
AS 3600	<i>Concrete Structures</i>
AS 3610	<i>Formwork for Concrete</i>
AS 3700	<i>Masonry structures</i>
AS 3972	<i>General purpose and blended cements</i>
AS 4100	<i>Steel Structures</i>
AS 4312	<i>Atmospheric corrosively zones in Australia</i>
AS 4825	<i>Tunnel Fire Safety</i>
AS 5100	<i>Bridge Design (set)</i>
AS 5100.1	<i>Bridge design - Scope and general principles</i>
AS 5100.2	<i>Bridge design - Design loads</i>
AS 5100.3	<i>Bridge design - Foundation and soil-supporting structures</i>
AS 5100.4	<i>Bridge design - Bearings and deck joints</i>
AS 5100.5	<i>Bridge design - Concrete</i>
AS 5100.7	<i>Bridge design - Bridge assessment</i>
AS 5100.8	<i>Bridge design - Rehabilitation and strengthening of existing bridges</i>
AS 5100.9	<i>Bridge design - Timber</i>
AS 61508	<i>Functional safety of electrical/electronic/programmable electronic safety-related systems</i>
AS/CA S009	<i>Installation requirements for customer cabling (Wiring Rules)</i>
AS/NZS 1163	<i>Cold-formed structural steel hollow sections</i>

Reference	Title
AS/NZS 1170	<i>Structural design actions - General principles</i>
AS/NZS 1170.2	<i>Structural design actions - Wind actions</i>
AS/NZS 1252	<i>High strength steel fasteners for structural engineering – Bolts, nuts and washers (set)</i>
AS/NZS 1554	<i>Structural steel welding (set)</i>
AS/NZS 1554.1	<i>Structural steel welding - Welding of steel structures</i>
AS/NZS 1891	<i>Industrial fall-arrest systems and devices (set)</i>
AS/NZS 2041	<i>Buried corrugated metal structures</i>
AS/NZS 3000	<i>Electrical Installations</i>
AS/NZS 3678	<i>Structural steel - Hot-rolled plates, floorplates and slabs</i>
AS/NZS 3679	<i>Structural steel - Hot-rolled bars and sections</i>
AS/NZS 3679.1	<i>Structural steel - Hot-rolled bars and sections</i>
AS/NZS 3679.2	<i>Structural steel - Welded I sections</i>
AS/NZS 3725	<i>Design for installation of buried concrete pipes</i>
AS/NZS 3845	<i>Road Safety Barrier Systems and Devices - Road Safety Barrier Systems</i>
AS/NZS 4058	<i>Precast concrete pipes (pressure and non-pressure)</i>
AS/NZS 4671	<i>Steel reinforcing materials</i>
AS/NZS 4680	<i>Hot-dip galvanized (zinc) coatings on fabricated ferrous articles</i>
AS/NZS 5100.6	<i>Bridge design - Steel and composite construction</i>
AS/NZS ISO 3834	<i>Quality requirements for fusion welding of metallic materials</i>
AS/NZS ISO 9001	<i>Quality Management Systems - Requirements</i>
BA 42/96	<i>UK Highways Agency (HA) Design Manual for Roads and Bridges, Design of Integral Bridges</i>
BS 6164	<i>British Standard - Code of Practice for Safety in Tunnelling in the Construction Industry</i>
BS 8081	<i>British Standard - Code of Practice for Ground Anchorages</i>
BSI PD 6694-1:2011	<i>BSI Published Document Recommendations for the design of structures subject to traffic loading to BS EN 1997-1:2004</i>
Engineering Innovation	<i>Engineering Innovation within the Department of Transport and Main Roads, September 2014</i>
Eurocomp Design Code (1996)	<i>Structural Design of Polymer Composites - Eurocomp Design Code and Handbook (J. Clarke, ed.), E & F Spon, London.</i>
NAASRA Bridge Design Specification	<i>National Association of Australian State Road Authorities (NAASRA) Highway Bridge Design Specification</i>
ISO 2559	<i>E-glass chopped strand mat for the reinforcement of polyester resin systems</i>
ISO 2797	<i>Glass fibre rovings for the reinforcement of polyester and epoxy resin systems</i>
MRTS01	<i>Introduction to Technical Specifications</i>
MRTS02	<i>Provision for Traffic</i>

Reference	Title
MRTS03	<i>Drainage, Retaining Structures and Protective Treatments</i>
MRTS04	<i>General Earthworks</i>
MRTS06	<i>Reinforced Soil Structures</i>
MRTS15	<i>Noise Fences</i>
MRTS30	<i>Asphalt Pavements</i>
MRTS50	<i>Specific Quality System Requirements</i>
MRTS59	<i>Manufacture of Fibre Reinforced Polymer (FRP) Composite Girders</i>
MRTS60	<i>Installation of Fibre Reinforced Polymer (FRP) Composite Girders</i>
MRTS61	<i>Gantries and Support Structures for Road Signs, Tolling Systems and ITS Devices</i>
MRTS63	<i>Cast-In-Place Piles</i>
MRTS63A	<i>Piles for Ancillary Structures</i>
MRTS64	<i>Driven Tubular Steel Piles (with reinforced concrete pile shaft)</i>
MRTS68	<i>Dynamic Testing of Piles</i>
MRTS70	<i>Concrete</i>
MRTS71	<i>Reinforcing Steel</i>
MRTS71A	<i>Stainless Steel Reinforcing</i>
MRTS72	<i>Manufacture of Precast Concrete Elements</i>
MRTS73	<i>Manufacture of Prestressed Concrete Members and Stressing Units</i>
MRTS74	<i>Supply and Erection of Prestressed Concrete Deck and Kerb Units</i>
MRTS75	<i>Supply and Erection of Prestressed Concrete Girders</i>
MRTS76	<i>Supply and Erection of Steel Girders</i>
MRTS77	<i>Bridge Deck</i>
MRTS78	<i>Fabrication of Structural Steelwork</i>
MRTS78A	<i>Fabrication of Structural Stainless Steelwork</i>
MRTS79	<i>Fabrication of Aluminium Components</i>
MRTS80	<i>Supply and Erection of Bridge Barrier</i>
MRTS81	<i>Bridge Bearings</i>
MRTS81A	<i>Stainless Steel Bridge Bearings</i>
MRTS82A	<i>Finger Type Bridge Deck Expansion Joints</i>
MRTS83	<i>Anti-Graffiti Protection</i>
MRTS84	<i>Deck Wearing Surface</i>
MRTS84A	<i>Removal of Bridge Deck Wearing Surface</i>
MRTS85	<i>Repainting Steel Bridges</i>
MRTS86	<i>Widening, Strengthening and Rehabilitation of Bridges</i>
MRTS88	<i>Protective coating for new work</i>
MRTS89	<i>Post Tensioned Concrete</i>
MRTS90	<i>Modular Bridge Expansion Joints</i>

Reference	Title
MRTS91	<i>Conduits and Pits</i>
MRTS92	<i>Traffic Signal and Road Lighting Footings</i>
MRTS94	<i>Road Lighting</i>
MRTS96	<i>Management and Removal of Asbestos</i>
MRTS97	<i>Mounting Structures for Roadside Equipment,</i>
MRTS201	<i>General Equipment Requirements</i>
MRTS202	<i>Variable Message Signs</i>
MRTS206	<i>Provision of Variable Speed Limit and Lane Control Signs</i>
MRTS210	<i>Provision of Mains Power</i>
MRTS225	<i>Imaging</i>
MRTS226	<i>Telecommunication Field Cabinets</i>
MRTS228	<i>Electrical Switchboards</i>
MRTS232	<i>Provision of Field Processors</i>
MRTS234	<i>Communications Cables</i>
MRTS245	<i>ITS Telecommunications Network (ITS TN)</i>
MRTS256	<i>Power Cables</i>
Standard Drawing 1033	<i>Kerb and channel - Kerbs, channels and ramped vehicular crossing</i>
Standard Drawing 1309	<i>Concrete Gully-Field Inlet Type 1</i>
Standard Drawing 1310	<i>Concrete Gully-Field Inlet Type 2</i>
Standard Drawing 1311	<i>Concrete gully - Roadway type channel lip in line</i>
Standard Drawing 1312	<i>Concrete gully - Roadway type kerb in line</i>
Standard Drawing 1313	<i>Concrete gully - Precast lintel details</i>
Standard Drawing 1321	<i>Concrete gully - Precast concrete side inlet gully with precast shaft</i>
Standard Drawing 1322	<i>Concrete gully - Precast concrete side inlet gully with cast in situ pit</i>
Standard Drawing 1442	<i>Concrete gullies - Roadway type at concrete barriers</i>
Standard Drawing 1443	<i>Concrete gully - Roadway type precast inlet units on grade</i>
Standard Drawing 1444	<i>Concrete gully - Roadway type precast inlet units in sag</i>
Standard Drawing 1446	<i>Kerb ramp - Ramped kerb crossing</i>
Standard Drawing 1459	<i>Concrete gully - Roadway type channel lip in line anti-ponding</i>
Standard Drawing 1468	<i>Single slope concrete barrier - Extruded median barrier - Barrier, reinforcing and expansion joint details</i>
Standard Drawing 1561	<i>Road Furniture - Motor Grid - General Arrangement - Drawings 1 of 2 and 2 of 2</i>
Standard Drawing 1562	<i>Road Furniture - Motor Grid - Cast Insitu Abutment</i>
Standard Drawing 1563	<i>Road Furniture - Motor Grid - Cast Insitu Base Slab - Drawings 1 of 2 and 2 of 2</i>
Standard Drawing 1564	<i>Road Furniture - Motor Grid - Precast Base Slab - Drawings 1 of 2 and 2 of 2</i>
Standard Drawing 1565	<i>Road Furniture - Motor Grid - Steelworks</i>

Reference	Title
Standard Drawing 1573	<i>ITS gantries - Lane control/Variable speed limit signs - Without maintenance platform</i>
Standard Drawing 1577	<i>ITS gantries - Lane control/Variable speed limit signs - Walk on gantry</i>
Standard Drawing 1581	<i>ITS - Cantilever - Cantilever structure</i>
Standard Drawing 2005	<i>Standard Bridge Date Plate - General Details</i>
Standard Drawing 2021	<i>550 Octagonal PSC Piles – Earthquake classification BEDC 1, Exposure classification B2</i>
Standard Drawing 2022	<i>550 Octagonal PSC Piles – Earthquake classification BEDC 1, Exposure classification C1 and C2</i>
Standard Drawing 2042	<i>Precast Units – Design assumptions for transversely stressed standard deck units</i>
Standard Drawing 2200	<i>Bridge Traffic Barriers - Post and Rail Traffic Barriers Regular Performance Level - Drawing 1 of 5 to 5 of 5</i>
Standard Drawing 2232	<i>Abutment Protection – Type 1 – Rock Spillthrough – Up to 1700 Clearance</i>
Standard Drawing 2233	<i>Abutment Protection – Type 1 – Rock spillthrough greater than 1700 clearance</i>
Standard Drawing 2234	<i>Abutment Protection – Type 2 – Reinforced concrete over spillthrough up to 1700 clearance</i>
Standard Drawing 2235	<i>Abutment Protection – Type 2 – Reinforced concrete over spillthrough greater than 1700 clearance</i>
Standard Drawing 2236	<i>Abutment Protection – Type 4 – Rockwork over spillthrough up to 1700 clearance</i>
Standard Drawing 2237	<i>Abutment Protection – Type 4 – Rockwork over spillthrough greater than 1700 clearance</i>
Standard Drawing 2238	<i>Abutment Protection – Rock masonry</i>
Standard Drawing 2241	<i>Abutment Protection – Type 7 – Rock filled gabion protection height up to 6 metres</i>
Standard Drawing 2280	<i>FRP Composite Girders for Timber Bridge Rehabilitation - LOC 400 & LOC 420 Installation Details</i>
Standard drawing 2255	<i>Bridge approaches – Relieving slab – 3 metre span</i>
Standard Drawing 2256	<i>Bridge approaches – Relieving slab – 6 metre span</i>
Standard Drawing 2281	<i>FRP Composite Girders for Timber Bridge Rehabilitation - LOC 400 & LOC 420 Installation Procedure</i>
	<i>Timber Bridge Maintenance Manual, Department of Transport and Main Roads, Queensland Government</i>
	<i>AASHTO Load and Resistance Factor Design (LRFD) Specification</i>
	<i>AASHTO Roadside Design Guide</i>
	<i>AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals</i>
	<i>Austrroads Guide to Road Tunnels</i>
	<i>Bridge Scour Manual, Department of Transport and Main Roads, Queensland Government</i>

Reference	Title
	CSIRO (2013) <i>Sea Level Rise: Understanding the past - Improving projections for the future</i>
	<i>Drafting and Design Presentation Standards</i> , Department of Transport and Main Roads, Queensland Government
	<i>Guidance on The Principles of Safe Design for Work</i> (May 2006) by Australian Safety and Compensation Council
	<i>Hydraulic Guidelines for Bridge Design Projects</i> , Department of Transport and Main Roads, Queensland Government
	<i>International Tunnelling Insurance Group, A Code of Practice for Risk Management of Tunnel Works</i>
	<i>IPCC (2013) Working Group I Contribution to the IPCC Fifth Assessment Report</i>
	Road and Traffic Authority, <i>Road Tunnel Design Guidelines</i>
	<i>Safe Design of Structures, Code of Practice</i> , July 2012, Safe Works Australia
	<i>Safe Work Australia Code of Practice</i>
TRUM	<i>Traffic and Road Use Management Manual</i> , Department of Transport and Main Roads, Queensland Government
	UK Highways Agency, BA 42/96: <i>Design Manual for Roads and Bridges, Design of Integral Bridges</i>
	UK Highways Agency, BD 78/99: <i>Design Manual for Roads and Bridges, Part 9 of Section 2 of Volume 2, Design of Road Tunnels</i>
	<i>Safe Work Australia Guide for Tunnelling Work</i>

1.5 Design life

1.5.1 Design life – Interpretation

The design life for bridges and other structures shall be interpreted such that there is a 95% probability that, during the design life, the structure or element will:

- not require major repair or replacement of elements, except to the extent specified at the time of design (for example, replacement of bearings)
- require only normal, routine maintenance
- be fully functional, to the extent intended at design, including any inherent planning for the future, and
- blend and harmonise with the existing surrounds and any planned landscaping, to the extent envisaged at the time of design.

1.5.2 Design life for bridges

Refer to Section 4.2 of this document for the design life of all bridgeworks and ancillary retaining walls.

1.5.3 Design life for tunnels

Refer to Section 5.5 of this document for the design life of tunnel infrastructure and associated attachments, components and related equipment.

1.5.4 Design life for other structures

Design life of other related structures are as follows:

- Public transport stations - refer Section 6.3
- Gantries and support structures - refer Section 7.4
- Roadside advertising signs - refer Sections 8.6.5.1 and 8.7.3.1
- Buried concrete arches - refer Section 9.2
- Retaining structures - refer Section 10.3
- FRP girders on timber bridges - refer Section 11.9.6
- Drainage structures - refer Section 12.2
- Motor grids - refer Section 13.3
- Noise barriers - refer Section 14.2

1.5.5 Design life – remedial works

Design life for remedial works shall be approved by the Director (Structures Design, Review and Standards) prior to the commencement of the design.

1.5.6 Post – franchise design life

Where a bridge, tunnel or other structure is constructed by a franchisee, under licence to the department, the residual life at the eventual handover to the department will be calculated as the design life required less the period of the franchise. For example, designers of a structure, with a design life of 100 years, constructed under a franchise with a period of 30 years, must consider that the residual life of the structure, at hand-over to the department, will be 70 years.

1.6 Departures and revisions

1.6.1 Departures

Where a designer believes a departure from the provisions of this document will improve the outcome of a project, or ameliorate any aspect of it, the department's Engineering and Technology Structures Directorate will consider a formal submission, which shall contain all details of the proposed departure and the purported benefits of it. The process of assessing the submission will be managed by the Director (Structures Design, Review and Standards).

Any departure, so documented, and subsequently approved by the Engineering and Technology Structures Directorate, will be considered current only for both:

- the project involved, and
- in the circumstances for which it was requested and approved.

It shall not be adopted as a precedent for future projects nor for different circumstances within the original project.

1.6.2 Revisions

The department's Engineering and Technology Structures Directorate will consider submissions to revise any provisions of this document.

Requests to revise any provisions of this document must be formally submitted and shall contain all details of the proposed revision and the purported benefits of it. The process of assessing the submission will be managed by the Director (Structures Design, Review and Standards).

Proponents of any request for a revision should understand that the manual is a result of careful and conscious decisions taken by the department's engineers and based on decades of experience in the design and maintenance of bridges and other structures.

Revision requests will be assessed in terms of benefits to the department, for example:

- value-for-money enhancements
- productivity improvements
- workplace health and safety
- end-user utility, and
- road safety.

Any revision request, subsequently adopted by the Engineering and Technology Structures Directorate, will be included in a subsequent update of the manual.

SUPERSEDED

2 Design review process

2.1 Scheme design

2.1.1 Objectives

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 accepted engineering practice, relevant codes and incorporate safety in design principles.

Structures shall be designed collaboratively and integrate the various inputs of all involved disciplines including:

- traffic analysis
- horizontal and vertical alignments
- geotechnical investigations
- hydraulic reports, and
- environmental impacts.

Designers shall take steps to ensure that no structure is compromised by failure to interact collegiately with other disciplines.

All structures shall 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.

The development of all schemes for bridges, tunnels and other structures shall follow a formal process involving design, preparation of drawings, drafting check, verification, design review, and certification.

Complex designs may require 'Proof Engineering', and the Director (Structures Design, Review and Standards) shall be consulted concerning requirements prior to engagement of the proof engineer.

The evolution of all schemes for bridges, tunnels and other structures shall be subject to a staged departmental review process undertaken by the department's Engineering and Technology Structures Directorate, and managed by the Director (Structures Design, Review and Standards).

2.1.2 Design

All bridges, tunnels and other structures shall be designed by an experienced structural engineer who is a Registered Professional Engineer of Queensland (RPEQ), or the designers shall be supervised by an experienced structural engineer who is a Registered Professional Engineer of Queensland (RPEQ), in accordance with Section 2.1.6.

The designer shall ensure that the design intent is adequately contained within the design report and accurately transferred to the drawings.

The design of a bridge, tunnel or other structure may be carried out, collaboratively, by more than one Designer, provided that the overall process and activities are supervised by a person who is RPEQ qualified in the appropriate discipline.

A designer may also be the certifier, provided they possess the relevant RPEQ credentials.

The designer may not be the verifier, nor the reviewer.

2.1.3 Preparation of drawings and drafting check

Preparation of drawings shall be carried out in accordance with Section 1.4.3.8 of this document.

A thorough check of all drawings shall be carried out to determine that they completely, accurately and unambiguously convey all the information necessary to enable construction of the works.

The drafting check will ensure compliance with the project presentation standards.

2.1.4 Verification

All detailed design and drafting shall be verified by a person independent from those activities.

The design verifier may not also be the designer, nor the design reviewer.

The design verifier shall ensure that the correct design process is followed, that it is accurate, and complies with any design management plan prepared for the project.

The verifier may also be the certifier, provided they possess the relevant RPEQ credentials.

2.1.5 Design review

All designs shall be reviewed by an appropriately experienced engineer with relevant RPEQ credentials (refer Table 1.3 and Section 2.1.7). The engineer who undertakes the review shall be different to both the designer and the verifier. The reviewer shall carry out sufficient independent analyses to confirm the efficacy of the design, both in terms of appropriateness and sufficiency.

Depending on the complexity of the design, the reviewer may be either:

- i. from the same office of the same firm
- ii. from a different office of the same firm, or
- iii. from a different firm, or
- iv. as defined in the design brief.

2.1.6 Design certification

Refer to Table 1.3 and Section 2.1.7 for a definition of RPEQ certification in respect of bridge design.

A geotechnical design report, RPEQ certified by an experienced geotechnical assessor, shall be included in the final design report for each bridge, tunnel or other structure.

A structural design report, RPEQ certified by an experienced structural engineer, shall be included in the final design report for each bridge, tunnel or other structure.

A hydraulics design report, RPEQ certified by a suitably experienced hydraulic engineer, shall be included in the final design report for each bridge, tunnel or other structure.

RPEQ design certification is required for each retaining structure (refer Chapter 10).

2.1.7 RPEQ certification

Certification of engineering drawings and reports shall be undertaken by experienced engineers who hold current appropriate RPEQ registration under the Board of Professional Engineers Queensland (BPEQ).

With reference to BPEQ Practice Note Series *Areas of Engineering*, Policy ID: 4.2(2A) issued on the 1 December 2014, the appropriate RPEQ status for structural engineering certification in the context of this Design Criteria is either:

- RPEQ (Civil) who were registered prior to 1 July 2008 in the area of civil engineering (at the time there was no area of structural engineering) and are continuing structural engineering services, or
- RPEQs (Structural) who were registered in the area of structural engineering after 1 July 2008.

2.2 Structures directorate review

The design documentation for all bridges, tunnels and other structures, intended for administration by the Department of Transport and Main Roads, shall be subject to review by the department's Engineering and Technology Structures Directorate.

The minimum scheme documents shall comprise the fixing report (refer Section 2.3), design reports (including project drawings and geotechnical report), supplementary specifications (if applicable) and MRTS annexures (where applicable).

The project drawings and scheme documents shall be reviewed by the department's Structures Directorate and accepted in terms of conformance, cost, safety, durability, future performance, constructability and maintenance.

Design reports and drawings shall be submitted at the following stages:

- structure fixing (scheme conception)
- concept design (15%)
- preliminary design - substantially complete with some unchecked drawings (50%)
- substantial design - essentially complete with checked drawings (85%), and
- final design - completed for formal acceptance and Issued For Construction (IFC) drawings (100%).

Where a bridge, tunnel or other structure is included in a scheme that requires a formal decision-making process within the department, such as a business case, the department's Structures Directorate should be consulted and a brief structure fixing report compiled, to ensure poor structure detailing is not unwittingly formalised (refer Section 2.3 of this document).

The concept design submission (15%) shall involve a meeting and presentation of general arrangement drawings. The drawings shall include all typical project details, which may be a development of an earlier structure fixing report. The design shall not proceed until all issues are resolved.

If a structure fixing report has not previously been issued, the accepted 15% report will constitute the structure fixing report.

At each stage of the design process, the department's Structures Directorate 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.

2.3 Structure fixing report

It is important that the essential features of a bridge, tunnel or other structure be agreed when it is first considered, particularly if the structure forms the basis of a formal decision-making document, such as a business case.

The fixing report is issued when sufficient information has been gathered and the exact location of the bridge, tunnel or other structure can be determined in relation to:

- road geometry (horizontal and vertical)
- AADT
- number and width of lanes, including shoulders
- footway detail (location, width and so on)
- length
- number of spans
- waterway analysis (if required)
- required clearances
- deck level
- skew angle
- superstructure type
- substructure configuration
- foundation data (if available), any
- other pertinent constraints (environmental, utility services, adjacent properties and so on).

Consideration shall be given, at this stage, to minimise the number of bridge bearings, to facilitate jacking for bearing replacement. The need to separate superstructures shall be reviewed (refer Section 3.5.6.1).

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

2.4 Structure design report

2.4.1 Design report contents

A design report for a bridge, tunnel or other structure shall contain, but need not be limited to:

- a) scheme drawings
- b) information relevant to a fixing report (refer Section 2.3), augmented to reflect the design phase under consideration
- c) design codes including date of publications and (any) amendments
- d) date of referenced Transport and Main Roads *Design Criteria for Bridges and Other Structures*
- e) statement for each item in Matters for Resolution by Authority in AS(/NZS) 5100 (refer Clause 1.4.1, c) of this document)

- f) a statement of design loads outlined in Clause 1.2 of AS 5100.2
- g) a statement to confirm the design model and analysis approach used
- h) calculation of the barrier design loads (refer AS 5100.1, Appendix A, adjusted for minimum value specified by the department if applicable)
- i) other referenced documents
- j) design criteria from other stakeholders / authorities
- k) the design methodology, design assumptions, serviceability and ultimate loads
- l) statement of design life of the structure and each sub element
- m) other controls / limits / restrictions (for example; shipping clearance, traffic clearance)
- n) construction methodology (for example; Super-T Girders composite at 200 days)
- o) durability
- p) robustness of design
- q) 'safety in design' considerations for construction, inspection, maintenance and operation (refer Section 3.17)
- r) design data for input into Bridge Information System
- s) *Structures Inspection Manual* considerations, and
- t) assessment data for widened / strengthened bridges for input into the assessment database.

2.4.2 Design report phases

2.4.2.1 Introduction

The design report shall be presented at appropriate stages (15, 50, 85 and 100%) in the design development, with the following purposes in mind:

- a) The separate phases of design development 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.
- b) Where practical, structure information shall be conveyed by drawings and sketches in preference to text.
- c) Design non conformances submitted for acceptance shall be suitably tabulated.
- d) The design report shall be accompanied by the department's commissioning letter, design brief (including attachments) or project SWTC. Subsequent design phase reports shall specifically note any of the conditions in the brief or SWTC that are not being met, or changes requested.
- e) When a project contains multiple bridges / structures, individual design reports shall be prepared for each bridge / structure, unless agreed otherwise by the Director (Structures Design, Review and Standards) in the interests of ensuring project uniformity.

2.4.2.2 Concept (15% complete) design report

At the 15% complete stage, all preliminary investigations should have been completed, including structural design, hydraulics, geotechnical investigations, clearances and other requirements of

relevant authorities. The spans, articulation, substructure and superstructure type will, ideally, have been selected, as have preliminary founding levels. Traffic barrier performance level, drainage, lighting and other service requirements have been agreed.

The 15% report should include any details from an earlier fixing report. Where any revisions to the fixing report are requested, these should only be pursued after approval from the Director (Structures Design, Review and Standards).

Departures from the department's design brief, SWTC and departmental Technical Specifications shall be listed in the design report for review, and acceptance by the Director (Structures Design, Review and Standards).

The details shown on draft drawings shall include:

- general arrangement for each bridge, tunnel or other structure
- abutment and pier elevation and typical sections
- structure cross section(s), and
- exposure classifications, concrete cover to reinforcement, and concrete class for each element.

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

If major changes are subsequently made, a supplementary report shall be sent to Transport and Main Roads, as soon as practical, for acceptance by the Director (Structures Design, Review and Standards).

2.4.2.3 Preliminary (50% complete) design report

The 50% complete stage design report shall be submitted for Engineering and Technology Structures Directorate review. This report shall include:

- a) proposed design changes, if any, from 15% design submission
- b) geotechnical and hydraulic report
- c) durability report, including thermal modelling results of large concrete members, and recommendations if applicable
- d) safety in design report, and
- e) 50% complete detail design drawings.

2.4.2.4 Substantial (85% complete) design report

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

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.

2.4.2.5 Final design report (100% complete)

The final design report shall contain all the previous stage reports including final drawings, cost estimates, steel schedules (if applicable), Electronic Project Model (EPM), where required, and all relevant archival material requested.

The final report should contain all requests for changes to the design standards and technical specifications, and a tabulation of the Matters for Resolution to AS(/NZS) 5100 (refer Section 2.4.1e) of this document).

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

The report shall demonstrate conformance to the project design requirements. Any approved variations from the design brief or SWTC, or similar project document shall be explained in terms of cost, safety, durability, future performance, constructability and maintenance. All variations should have been submitted for prior acceptance by the Director (Structures Design, Review and Standards).

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 / Early Contractor Involvement / Design and Construct type projects, the design report shall be subject to approval by the department prior to commencing the construction.

2.5 Conforming product

'Conforming' materials and products are all materials and products detailed in the department's technical specifications or as amended by the design brief or project SWTC. Any other material or product is deemed to be 'non conforming' and shall only be used on bridges, tunnels and other structures with the prior written acceptance of the Director (Structures Design, Review and Standards) refer Section 2.6.

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

The department maintains a list of registered products for bridges, tunnels and other structures, which designers should consult (refer Section 1.4.3.9).

2.6 Alternative product

Any product or material that is not specified in the department's technical specifications and/or standard drawings, nor listed in its register of products, should not be proposed without the approval of the Director (Structures Design, Review and Standards), which will not normally be granted if a registered conforming product is available (refer Section 1.4.3.9).

2.7 Innovation

The department recognises the potential for innovation in design, materials and products, and has produced a document entitled Engineering Innovation within the Department of Transport and Main Roads, which sets out the process to be followed for the acceptance of innovative products and materials.

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 be durable when exposed to the environment, with an appropriate service life.

Innovations in structural design shall only be adopted by the department for construction after appropriate testing and validation, and acceptance in terms of safety, durability, future performance, constructability and maintenance.

Innovation is best undertaken outside a Contract, as experience has shown that acceptance of innovative design, materials and products may take some time, and may involve extensive testing and development of specifications.

Independent 'proof engineering' of complex innovative designs may be required if requested by the Director (Structures Design, Review and Standards).

2.8 Innovative materials and components

Preparation of inspection and maintenance procedures for innovative materials and components, accepted under the process described in Section 2.7, 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 *Structures Inspection Manual*.
- 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 approved innovation documentation.
- 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 for inspection and replacement of structure bearings, with jacking points and loads shown on the drawings, and
 - a detailed schedule for cleaning, preparation and recoating for any structure with paint or similar protective coating; repainting must be practical without significant interruption to traffic flow.

2.9 As Constructed drawings and construction handover documents

The design documentation for bridges, tunnels and other structures shall ensure that 'As Constructed' drawings and structure construction handover documentation are prepared in accordance with:

- Technical Specification MRTS50 *Specific Quality System Requirements*, and
- *Drafting Design Presentation Standard Manual*, Volume 3, Chapter 1, *Introduction*.

Part B: Bridges

3 Bridges – Functional requirements

3.1 Scope

This chapter is devoted to introducing the bridge types covered by this manual and the functional characteristics they are expected to satisfy.

Requirements for the component elements within a bridge, such as girders and the like, are considered in Chapter 4.

3.2 Bridges - Scope

3.2.1 Introduction

The types of bridges covered in these design criteria are limited by:

- the restrictions imposed under AS/(NZS) 5100, and
- any reservations the department holds about certain structure types, even though they may be permitted in other jurisdictions.

Primarily, this manual refers to bridges of standard types, being those traditionally constructed by the department.

There are two subtypes of standard bridge:

- a) Usual configuration – comprising those bridge types that are routinely employed by the department and are likely to be accepted by its Director (Structures Design, Review and Standards).
- b) Unusual configuration – meaning bridges that have been utilised in the past, and/or could be considered in the future, but are not routinely adopted, and where early review stage approval from the Director (Structures Design, Review and Standards) is required.

Non-standard bridges, which are other than usual or unusual standard bridge types, as defined above, shall be adopted only with the permission of the Director (Structures Design, Review and Standards).

In this context, span lengths can be grouped as follows:

- a) Small span < 20 m
- b) Medium span 20 – 50 m
- c) Long span > 50 m.

All bridges, irrespective of type or span, are subject to an Engineering and Technology Structures Directorate Review, in accordance with Section 2.2.

3.2.2 Standard bridges – usual configuration

3.2.2.1 Standard bridge substructures – usual configuration

The following types of bridge substructures are considered standard, and are adopted routinely, when appropriate:

- a) prestressed concrete driven piles in accordance with Transport and Main Roads Standard Drawings 2021 or 2022 for 550 Octagonal PSC Piles, extended up to headstock, or terminated at a pile cap
- b) reinforced concrete cast in situ columns and headstocks on cast-in-place piles (including pile cap as required) to MRTS63 *Cast-In-Place Piles*, or reinforced concrete footings, and
- c) cast in situ reinforced concrete blade wall abutments and/or piers on spread footings or approved piles as defined in a) and b) above with a pile cap.

3.2.2.2 Standard bridge superstructures – usual configuration

The following types of superstructures are viewed as routinely standard and will normally be considered for acceptance without prior specific approval from the Director (Structures Review and Standards):

- a) Small and medium span bridges with standardised components including:
 - Transversely stressed deck units as detailed on Transport and Main Roads Standard Drawings (refer Section 4.8.2).
 - Deck units (refer Section 4.8.2), with reinforced concrete deck slabs.
 - Super-T girders as defined in AS 5100.5, and Section 4.8.4 of this document, with reinforced concrete deck slab.
 - I girders, similar to AASHTO or NAASRA standard shapes for Prestressed Concrete (PSC) girders (refer Section 4.8.3 of this document), with reinforced concrete deck slab. Designers should be aware that these girders may not be available, any longer, in some markets, and enquiries should be made before proposing their use.
 - Steel I girders for widening existing bridge decks that already contain steel I girders (refer Section 4.8.7).
- b) Short and medium span bridges with proprietary system components approved by Transport and Main Roads as described in Section 4.8.10.
- c) Footbridges, and other active user bridges of conventional design (refer Section 4.16).

3.2.3 Standard bridges – unusual configuration

3.2.3.1 Standard bridge substructures – unusual configuration

The following types of standard bridge substructures will generally only be considered for acceptance when prior specific approval from the Director (Structures Design, Review and Standards) has been sought:

- a) Driven steel tubular piles with reinforced concrete pile shaft

This pile type, as described in MRTS64 *Driven Tubular Steel Piles (with reinforced concrete pile shaft)* may be considered in situations where the depth to competent rock is such that it is

not practical to extend the pile to competent rock and then form a rock socket to construct a MRTS63 *Cast-In-Place Piles* compliant pile.

A minimum reinforced concrete shaft length of 12 m is included in MRTS64, and this will result in an effective minimum steel tube length of > 20.0 m. It is not a requirement to drive the steel tube to competent rock (but this may occur), rather the pile capacity is achieved essentially through friction between the steel tube and the soils, commencing from a point nominally 1.0 m below the base of the scour level to the base of the steel tube.

Where competent rock is encountered, the use of a cast in place pile conforming to MRTS63 would be the preferred option.

Steel tubular piles are not recommended in situations where the pile is used to resist essentially moment loads rather than vertical loads. In such cases, typically required for light-weight structures, the type of pile specified in MRTS63A *Piles for Ancillary Structures* could be more appropriate.

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, prior to approval of the support by the Director (Structures Design, Review and Standards).

The column shall be structurally robust to resist impact because there is no structural redundancy if the single column fails on impact.

If a single column support is situated within the clear zone, as defined in the department's *Road Planning and Design Manual* Edition 2, Volume 3, *Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*, the support and its foundation shall be designed to achieve at least 1.5 times the structural capacity required using Clause 11.2 of AS 5100.2, in addition to the use of barriers for pier protection, unless agreed otherwise with the Director (Structures Design, Review and Standards).

In this context, the clear zone shall be the value calculated, or 10 metres, whichever is the greater.

Reference should be made to Appendix B of this document (Part 2: Design loads, Clause 11.2, Collision load from road traffic) for additional requirements in respect of pier protection from impact.

For this application, blade wall piers shall be considered as a single column when the blade width is either less than 75% of the bridge deck width on skew, or less than 6 metres, whichever is the greater.

To ensure a robust design, the effect of redundancy in substructures should be assessed.

For this reason, single column piers are non preferred, require prior approval, and should be designed for high impact loads.

If required by the Director (Structures Design, Review and Standards) any multi column piers that are particularly vulnerable to head-on collision (refer the NOTE: in Clause 11.2 of AS 5100.2) shall consider the effect of removing any one column due to collision, and the structure designed to resist disproportionate collapse, using alternative load paths, where the ULS load case considered includes dead loads and an agreed proportion of the design traffic load.

3.2.3.2 Standard bridge superstructures – unusual configuration

The following types of standard bridge superstructures, with unusual configurations, will generally only be considered for acceptance when prior specific approval from the Director (Structures Design, Review and Standards) has been sought:

- a) Short and medium span bridges of unusual geometry that require additional design and detailing.
- b) Bridges with one or more of the following characteristics require additional consideration in design to ensure the behaviour of the bridge in service does not create maintenance problems:
 - Extreme skews, over 45°.
 - Pronounced horizontal curvature; where the maximum distance between the arc and the chord over a span exceeds 600 mm.
 - Wide decks, where the transverse width of a concrete deck exceeds 20 m. Transverse concrete creep and shrinkage and temperature movements shall be considered in the design, and the effects reduced as far as practical, with the analyses included in the preliminary design report.
 - 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.
- c) Steel girders in new bridges.
- d) Medium span bridges utilising box girders.
- e) Curved ramp bridges using box girders.
- f) Bridges with 'integral' substructure and superstructure:
 - i. These may be considered in certain situations where:
 - vertical alignment is constrained, and an integral structure would achieve a higher vertical clearance and/or flatter longitudinal grade
 - span capability of a girder can be extended
 - access to inspect and replace bridge bearings is severely restricted, and
 - the foundation material is of competent quality and can limit differential settlement of the abutments and piers to acceptable limits appropriate for the integral structure.

- ii. Integral structure design shall include the effects of additional earth pressure due to 'ratcheting' of the abutment backfill, based on geotechnical investigation and report, and consideration of established guidelines, such as:
 - the UK Highways Agency (HA) *Design Manual for Roads and Bridges, Design of Integral Bridges BA 42/96*, and
 - the BSI published document, PD 6694-1:2011 *Recommendations for the design of structures subject to traffic loading to BS EN 1997-1:2004*.
- iii. Highly skewed and/or long integral bridges are generally considered unsuitable for integral structural form as they are outside the scope of AS(/NZS) 5100. These can result in 'unusual' effects from loads, detrimental effects on the pavement and other effects causing maintenance issues. These need to be addressed, and the design criteria established, during initial option studies for integral bridges and other structural forms.
- iv. A combination of cast in ferrules for reinforcing starter bars, in addition to strands projecting from the end of the girders (or deck units), may be used to reduce the risk of accidental breaking of the strands during handling.
- v. The thermal load effects of placing hot asphalt on an integral bridge shall be considered, with particular attention in the case of a curved bridge.

The Designer shall submit a detailed preliminary design report for any unusual configuration to the Director (Structures Design, Review and Standards). The additional design considerations undertaken, and the reasons for the adopted design solutions, shall be presented for acceptance by the Director (Structures Design, Review and Standards) prior to submission of any preliminary design drawings for acceptance. The appropriate stage would be prior to bridge fixing, or the 15% design stage.

3.2.4 Non-standard bridges

Non standard bridges include:

- all bridges not included in Sections 3.2.2 and 3.2.3
- all bridges outside the scope of AS(/NZS) 5100
- arch bridges
- pedestrian access to railway platforms
- bridges incorporating structural components made from novel or unusual materials
- bridges incorporating novel or unusual structural forms
- long span concrete box girder bridges AS(/NZS) 5100, which may not adequately address shear and torsion in large concrete box girder bridges. AASHTO Load and Resistance Factor Design (LRFD) shall be the basis of the acceptance, unless otherwise agreed with the Director (Structures Design, Review and Standards), and
- steel box girders AS(/NSZ) 5100 does not adequately address the design requirements of this structural form.

Any designer proposing the use of such bridge forms or materials shall submit a detailed proposal before design commences to the Director (Structures Design, Review and Standards) for acceptance, 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 proposal in the use of the materials, structural forms and design standards
- evidence showing that the materials and components will have the specified design life
- one copy of every design standard and material specification adopted, in English and fully legible
- proposals for independent proof engineering of the design by experienced appropriate design consultants with RPEQ, at no cost to the department or Principal, and
- 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 department or Principal.

Design shall not commence until full acceptance is given to use the non standard designs and/or materials.

3.2.5 Access for people with disabilities to public transport

For bridges that are designed to provide pedestrian access to public transport, the bridge design shall comply with the Australian Government's *Disability Standards for Accessible Public Transport, 2002*.

3.3 Bridge Aesthetics

The following bridge aesthetic aspects shall be considered in design:

- a) All structures shall present smooth, clean lines.
- b) Bridges shall have a minimum structural depth consistent with their spans and method of construction.
- c) 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.
- d) Bridge proportions shall represent spanning and supporting requirements and shall respond to the context of the individual bridge localities.
- e) Length of spans shall be maximised where practical, within the context of the necessary bridge length.
- f) Bridge structural elements such as piers, headstocks (including leading edges), sill beams and abutments shall be aesthetically integrated.
- g) 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.
- h) Columns with only two lines of symmetry (that is rectangular or elliptical) must have the longest edge transverse to the deck structure.

- i) All superstructure elements shall follow design vertical and horizontal profiles.
- j) Spill through abutments shall have a batter slope no steeper than 1:1.5.
- k) On all exposed concrete surfaces on structures:
 - finishes and colour shall be uniform, and
 - tie holes shall be aligned in a uniform pattern, and subsequently filled with mortar to achieve a smooth uniform coloured finish.
- l) Structures shall be of uniform colour and surface finish. Repair of defects and patching shall match the appearance of the remainder of the surface.
- m) Roads and Maritime Services (RMS) *Bridge Aesthetics: Design Guidelines to Improve the Appearance of Bridges in NSW* shall be used as a guide to the basic minimum aesthetics standards.

3.4 Asset management considerations

3.4.1 Sustainability

It is mandatory policy of the department to manage its transport infrastructure sustainably over the long term, which is essential to ensuring value-for-money is achieved.

3.4.2 Value-for-money

Maximising value-for money involves accounting for the full cost of providing, holding, using, maintaining and disposing of assets through their lifecycles. Value-for-money will be achieved when these whole-of-life costs are minimised.

3.4.3 Lifecycle

In this context, the terms 'whole-of life' and 'lifecycle' should be interpreted as meaning the design life for the structure. In contractual arrangements, where an organisation may be responsible for maintaining a bridge for a shorter period than its design life, the shorter time frame shall not be allowed to serve as a proxy for either design life or lifecycle.

3.4.4 Whole-of-life costs

Designers should attempt to achieve the highest financial benefit by lowering lifecycle costs.

These whole of life cost considerations should include:

- initial construction expenditure
- inspection regime
- routine maintenance
- timelines for scheduled maintenance
- special maintenance requirements, and
- the potential for damage.

As these potential costs will happen at different stages of the structures design life, they are subject to the time value of money principle, in which the present value of a dollar spent at some time in the future will always be less than a dollar spent in an earlier period.

Value-for money will be highest when initial construction is efficient, long term durability is enhanced, and the timelines for maintenance interventions are extended, thereby minimising the present value of the project.

Bridges with a low initial cost, but high and/or frequent maintenance costs, may not represent value-for-money and should be avoided.

3.4.5 Maintenance

The designer shall make provision for inspection and maintenance operations as part of the design process. The designer must ensure the form of construction allows ease of maintenance for the life of all structures.

The designer shall consider the bridge's future operating environment, as it will be more difficult to obtain closures of bridges carrying heavy traffic, or over busy roads and railways. To reduce the need for closures, the design shall carefully consider the durability of materials.

3.4.6 Constructability

Method of construction shall be considered in the design and described in the design documentation. The construction process assumed in the design shall be reviewed at the pre construction phase and reported. This review is to identify obstacles early in the project, to mitigate or prevent errors, delays, cost overruns and to ensure safety in design.

3.5 Bridge configuration

3.5.1 Geometric layout

Designers must consider the ramifications of the overall geometric road design on any incorporated bridge. Design of the road geometry must not be carried out in isolation from the bridge design, nor vice versa. Any opinion that road geometry is a 'civil design' matter, divorced from the 'structural design' involved in the configuration of any incorporated bridges shall be resisted. The relationship between bridges and associated roadways, both integral and traversed, should be viewed as symbiotic.

The designer's attention is also drawn to the considerations in the Transport and Main Roads *Road Planning and Design Manual*, Edition 2, Volume 3: *Supplement to Austroads Guide to Road Design*, Part 3: *Geometric Design*, including those regarding:

- cross section
- stopping sight distances
- horizontal geometry
- vertical geometry, and
- superelevation.

Designers shall ensure that due cognisance is given to geotechnical, environmental and hydraulic conditions pertaining to any bridge site and ensure that bridge configurations are appropriate to the situation.

3.5.2 Bridge width

In determining bridge width, designers shall consider the following issues:

- 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 prior to commencing bridge design, and the required lane geometry shall form part of the bridge design brief, or project SWTC.
- 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 and shoulder widths, refer to Figure 3.5.2 and Tables 3.5.2(a) to (e).
- e) The design shall include an assessment of the width required for safe inspection and maintenance activities while maintaining traffic flow at reduced speed.
- f) Pursuant to the requirements in Transport and Main Roads *Road Planning and Design Manual*, Edition 2, Volume 3: *Supplement to Austroads Guide to Road Design*, Part 6A: *Pedestrian and Cyclist Paths*, 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.
- g) Concerning provision for cyclists, the requirements of the department's *Cycling Infrastructure Policy* shall also be considered.

Figure 3.5.2 – Minimum bridge carriageway widths

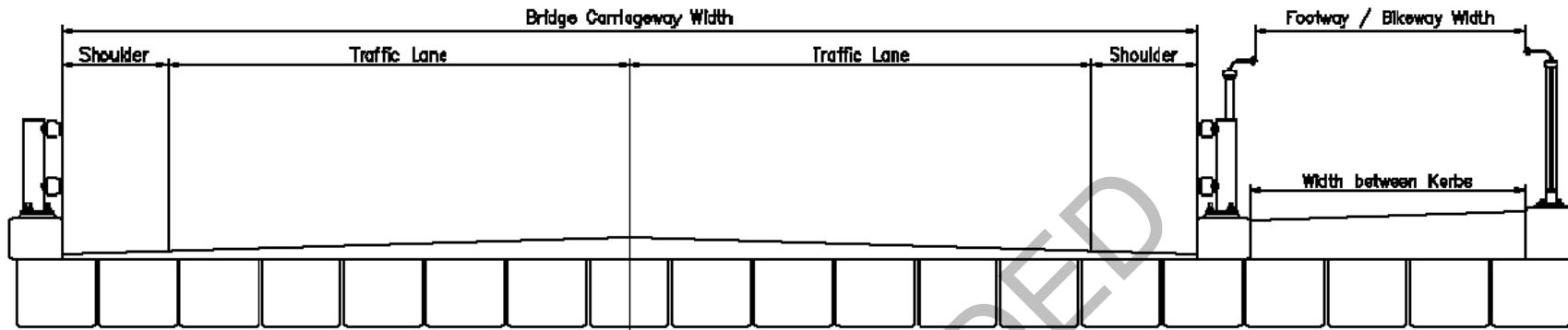


Table 3.5.2(a) – Bridge footway / bikeway widths

Footway type	Minimum footway / bikeway width	Notes
Pedestrian only	1.800	These 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. The widths are clear widths between bridge barriers. Bicycle safety rails are only required on designated bikeways.
One way cycling only (separate bikeway)	2.000	
Two way cycling only (separate bikeway)	3.000	
Cycling and pedestrians (dual use)	3.000	

Table 3.5.2(b) – 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	Dependent on number of traffic lanes	Dependent on number of traffic lanes
	> 50	Any	2.000	3.500	3.500	1.200	Dependent on number of traffic lanes	Dependent on number of traffic lanes

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 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

Table 3.5.2(c) - Minimum bridge carriageway widths for national network and state strategic 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	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	12.000
	> 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	9.400

Table 3.5.2(d) - 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

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)
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

Table 3.5.2(e) - Minimum bridge carriageway widths for single lane rural bridges

Carriageway type	Length (m)	AADT	Shoulder (minimum)	Traffic lane	Shoulder (minimum)	Minimum 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

3.5.3 Spans for overbridges

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.

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

3.5.4 Vertical clearances

3.5.4.1 General

Unless specified elsewhere in the design brief or project SWTC, bridge clearances shall be in accordance with the provisions of Section 3.4.5.2 below.

In circumstances where site conditions prevent provision of the specified clearance, the Designer shall consult with the Director (Structures Design, Review and Standards).

3.5.4.2 Height clearances for bridges over roads

The following guidance applies to height clearances at bridge sites:

- a) The minimum vertical clearances for vehicular bridges over roads are specified in Table 3.5.4.2.

Table 3.5.4.2 – 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

Notes:

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 roads, and 100 mm to 'Other local authority 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, and other active user bridges, over very high clearance routes is 6.8 m (6.5 m vehicular bridge clearance plus 0.3 m) and on 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. Bridges for

local authority roads, footbridges and other active user bridges, should have 1 m greater clearance than any adjacent road bridge structures on the road link, subject to a maximum clearance of 6.5 m. In situations where compliance with this latter requirement is constrained by topographical, alignment and/or access imperatives, designers may seek a formal relaxation from the Director (Structures Design, Review and Standards), provided the vertical clearance proposed is the maximum realistically available under the circumstances. Where an active user bridge is of such dimensions and style that it approaches the robustness of a vehicular bridge, a formal relaxation, from the Director (Structures Design, Review and Standards), may similarly be requested.

- c) For existing bridges, with a height clearance less than the appropriate value in Table 3.5.4.2, which are widened, refurbished or otherwise altered, the existing clearance (as measured on site) is to be maintained.
- d) Where additional lanes are provided under an existing bridge, with a height clearance less than in Table 3.5.4.2, or any allowance for the provision of additional lanes is proposed under these bridges, the existing clearance (as measured on site) is to be maintained.
- e) Where the Director (Structures Design, Review and Standards) has agreed that an existing bridge can be modified, or new bridge provided, with a height clearance less than in Table 3.5.4.2, the following requirements shall apply:
 - i. for existing bridges, a protection beam in accordance with AS 5100.2, Clause 11.3 shall be provided, if required by the department.
 - ii. for new bridges, a protection beam in accordance with AS 5100.2, Clause 11.3 shall be provided, if required by the department, but in any event the bridge superstructure shall be designed for the additional loads in AS 5100.2, Table 11.3, and
 - iii. bridge protection beams and their supports shall be designed to absorb an impact in such a way that the safety of road users is ensured.
- f) Any special clearances shall be in accordance with the design brief, project SWTC, or as otherwise agreed with the Director (Structures Design, Review and Standards).

3.5.5 Geometry, design speed

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 approach 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.

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

The Designer's attention is also drawn to stopping sight distance requirements.

3.5.6 Maintenance and inspection considerations

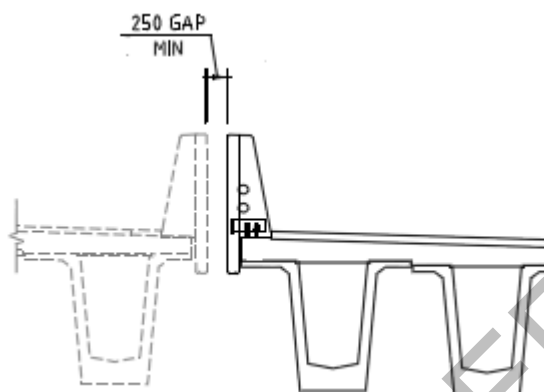
3.5.6.1 Separation of superstructures

The requirements for safe access to carry out inspections and repairs and jacking a bridge to replace bearings shall be considered when deciding on an appropriate width and arrangement of superstructure. This often requires separating a bridge into twin, parallel superstructures.

If there are two or more lanes in each direction and no easy diversion option is available, the bridge must be separated into two superstructures where possible.

The minimum clear gap between bridge decks (refer Figure 3.5.6.1) has to be sufficient for safe construction of the adjacent safety barriers between the bridges and with a minimum of 250 mm. A wider superstructure gap may be required to meet the bridge inspection provisions in accordance with Section 3.5.6.2. Where it is not possible to provide split superstructures with the appropriate gaps, alternative access options shall be assessed and referred to the Director (Structures Design, Review and Standards) for advice.

Figure 3.5.6.1 – Minimum gap between adjacent bridge decks



Usually the network owner requires a road to remain open to traffic during maintenance operations and specifically replacement of bridge bearings. Structural engineering analysis and practical jacking operations, however, require the whole superstructure width to be lifted off the abutment simultaneously to replace bridge bearings, which prohibits traffic from using the bridge during the jacking operation. A side track or traffic diversion onto alternative routes is often not possible due to terrain, property boundaries, detour distances and so on, and the resulting financial and social cost to the community is unacceptable. Separating the superstructure allows traffic to be temporarily diverted onto the adjacent bridge structure using contra-flow. Disruption to the road network is minimised and total road closure, which is increasingly unacceptable to the network owner, is avoided.

Separating a wide superstructure also reduces the risk of cracking in the deck and is beneficial to the structural behaviour of the bridge especially on highly skewed bridges (skewed deck, bearings and substructure).

Separation also simplifies structural analysis and reduces construction risks.

3.5.6.2 Under-bridge access

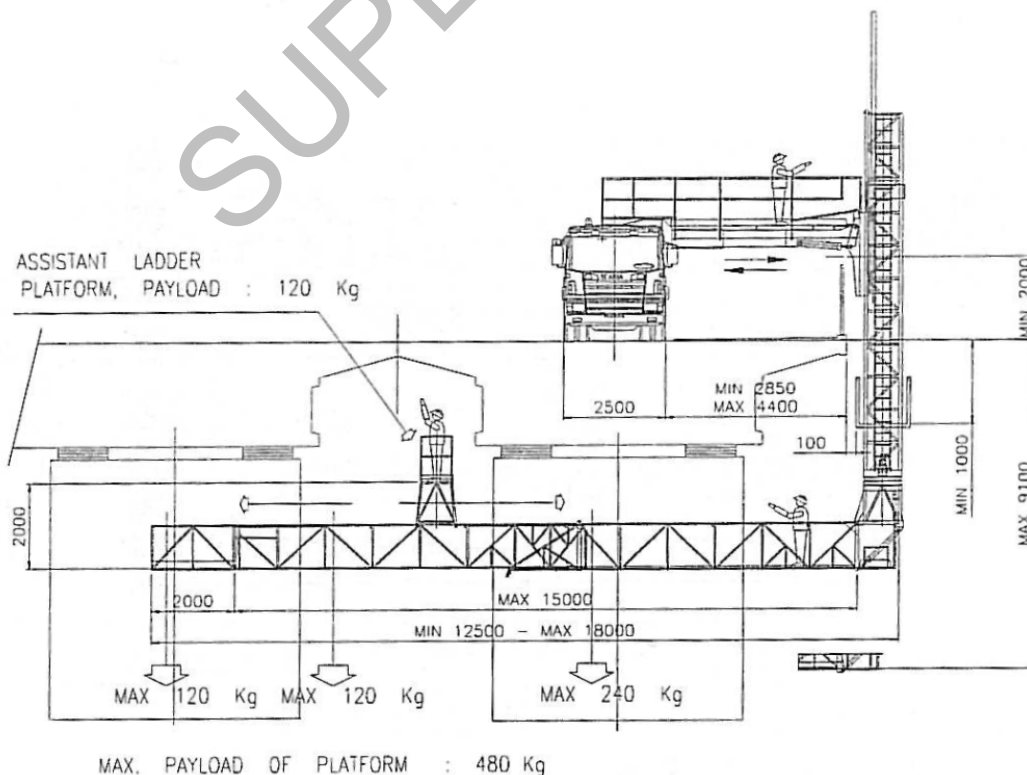
The method of gaining access to the underside of the bridge for inspection and maintenance should consider all relevant factors, including:

- location (over a road, water, rail, adjacent properties)
- access method (from the deck or from below)
- height (for access from below), and
- site specific constraints (access from deck may be the only safe and practical option).

Where maintenance and inspection access is not practical from the ground, under bridge inspection is usually carried out using an Under Bridge Inspection Unit (UBIU). Currently, available UBIU's have a maximum working reach of 15–17 m under the bridge, based on UBIU ABC Unit version ABC 160/LS (refer Figure 3.5.6.2). Bridge superstructures up to 30 m wide can be inspected by positioning the UBIU on each side of the deck to achieve the full coverage, although the vehicle position on the deck has to be considered, which may reduce the width of coverage. When the UBIU vehicle is closer to the edge than the minimum distance of 2.85 m (see Figure 3.5.6.2), the working reach will be less or if there is a pedestrian / bicycle shared path with raised kerb on the deck, the UBIU vehicle will be positioned further away and the maximum outreach distance must be considered.

Wider bridges that do not meet the above criteria for UBIU access shall be divided and designed as separate structures. The minimum clear separation distance between structures shall be as noted in Section 3.5.6.1. Where the combined total width of both structures is more than 30 m the UBIU has to be lowered between the structures to gain access and the clear gap between bridges shall be a minimum of 2.0 m to safely lower the platform and rotate into position. Refer to Section 3.5.7 for additional bridge width limitations to allow for future jacking and bearing replacement.

Figure 3.5.6.2 – Typical Under Bridge Inspection Unit (UBIU) arrangement



3.5.7 Jacking for bearing replacement

Bridge width is a critical parameter for maintenance of bridges which have been designed with bearings. The bearings require replacement during the service life of the bridge and wide bridge superstructures with a large number of bearings potentially cannot be jacked using the current departmental jacking facilities. Transport and Main Roads' current computer controlled jacking system can operate a maximum of 20 jacks simultaneously and use of less than 20 jacks is preferable. For simply supported spans with a continuous deck slab, both sides of the headstock have to be jacked simultaneously with the synchronised jacking facility resulting in a maximum of 10 jacks per span.

Wider bridge superstructures that do not meet these criteria shall be divided and designed as separate superstructures. The minimum clear separation distance between structures shall be as noted in Section 3.5.6.

Due to the quick setting time for the epoxy used to seat the bearings, there is a short time period to replace a bearing and a requirement for a large number of trained skilled workers. Dividing the superstructure has the benefit of reducing the number skilled team members required, substantially reducing the closure time and ensuring a manageable jacking operation.

Refer Section 4.7.4 for further requirements for provision of jacking for bearing replacements.

3.6 Bridge widening, strengthening and rehabilitation

3.6.1 General

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

Design for widening, strengthening and rehabilitation of bridges, including provision for widening in the future, shall be carried out to meet the requirements of Technical Specification MRTS86 *Widening, Strengthening and Rehabilitation of Bridges*.

The design traffic loads to be adopted for widening / strengthening existing bridges are subject to agreement with the Director (Structures Design, Review and Standards), with due consideration given to:

- the minimum loads indicated in Section 3.8.3 of this document
- design loads for the original bridge, and
- structural capacity of the existing bridge.

3.6.2 Provision for future widening

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.

Provision for widening by projecting exposed reinforcement is not permitted.

Future widening by breaking back of concrete to lap reinforcement will be permitted, provided that the proposed detail complies with MRTS86 *Widening, Strengthening and Rehabilitation of Bridges*.

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.

3.6.3 Widening an existing bridge

Refer to Section 8.7 of the department's *Drafting and Design Presentation Standards Manual*, Volume 3, for the survey information required to produce the design and drawings for bridge widening.

A bridge widening shall normally be achieved using the same cross sectional profile of beams and decks or deck units as the original bridge, unless loading or hydraulic requirements require modifications, or the existing deck profile is no longer commercially available.

When a bridge is widened, the new section of deck shall be made integral with the existing deck in accordance with Technical Specification MRTS86. A longitudinal joint in the roadway is not acceptable.

It is desirable that the widened bridge fully conforms to AS 5100.2. When design of the widened bridge to AS 5100.2 is not practicably possible, design traffic loads shall be agreed with the Director (Structures Design, Review and Standards). The minimum design traffic loads for widening existing bridges are provided in Section 3.8.3. Where this is not reasonably achievable, the widened structure shall be designed to accommodate loadings compatible with those applied to the original bridge, which will have been in accordance with the bridge design code current at the time. The widened bridge shall be equal in strength or structurally stronger than the existing bridge.

Where the widened section of the bridge is more than one lane wide, this section of the bridge shall be designed to accommodate all traffic loads in AS 5100, ignoring the effect of the existing bridge.

Footpath width shall desirably conform to AS(/NZS) 5100 requirements. For bridge rehabilitation, a narrower 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(/NZS) 5100 shall only be permitted with the written acceptance of the Director (Structures Design, Review and Standards). Design loading shall conform to AS(/NZS) 5100 as modified by the additional requirements in Appendix B of this document.

The footpath loads for an attached footpath shall be as per AS(/NZS) 5100 as modified by the additional requirements in Appendix B of this document. The addition of a footpath shall not significantly reduce the traffic load capacity of the bridge. However future demand of traffic on the bridge shall be reviewed and considered for the design.

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

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

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 the 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.

When widening existing deck unit bridge decks, the condition of any existing transverse stressing bars shall be assessed, if these are to be extended for the bridge widening. The bars shall be examined for

evidence of bar fracture, grout loss or water staining. The inspection methodology and assessment criteria shall be submitted to the Director (Structures Design, Review and Standards) for acceptance prior to conducting the assessment. Non-destructive methods will only be utilised if there is verifiable evidence that the technique is reliable.

Where existing transverse stressing bars are extended, the design shall include a strategy for removal of any section of the bar subsequently damaged, and the proposed methodology for future removal of the transverse stressing bars shall be clearly shown on the drawings.

3.6.4 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 2.0 m shall be maintained between the two bridges for inspection and maintenance. Where this width of separation is not possible, the options shall be determined and referred to the Director (Structures Design, Review and Standards) for acceptance.

3.6.5 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.

3.6.5.1 Future operating environment

Factors that impact the operating environment are:

- a) operating condition of the road, including usage as heavy vehicle route
- b) hydraulics
- c) location of widening on heavy vehicle route and the residual life of the original structure
- d) difference between local authority roads, service roads and departmental roads
- e) 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, and
- f) design loads applicable to widened bridges (refer to Section 3.8.3).

3.6.5.2 Estimating structural residual life of bridges

Bridges are designed for a nominal design life of 100 years. The nominal residual life of the bridge is the difference between the nominal design life and the age of the structure.

The residual structural life of the bridge shall be determined. The residual structural 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.

The need to rehabilitate existing structures will either:

- be defined in the design brief, project SWTC, or otherwise required by Director (Structures Design, Review and Standards), or

- be advised on completion of condition surveys and the assessment and calculation of the estimated operational residual life.

3.6.6 Working with asbestos in bridge rehabilitation works

3.6.6.1 Identification of the asbestos

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.

Requirements for working with asbestos in bridge rehabilitation works should be undertaken in accordance with the department's *Engineering and Technology Asbestos Implementation Guideline* which details the specific procedure and roles and responsibilities to be applied for the management of asbestos risk.

Asbestos components shall be tested by electron microscopy with dispersive X rays, or equivalent, to identify asbestos fibres as defined in the *Work Health and Safety Act 2011*. Identification of fibres as asbestos using electron microscopy techniques can be undertaken in consultation with Queensland University of Technology (QUT). If asbestos is identified, a written asbestos management plan shall be developed by a qualified person in accordance with *Work Health and Safety Regulation 2011*.

Asbestos can occur in the following locations of existing bridges:

- permanent formwork for insitu 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, and
- miscellaneous packing and sealing products.

3.6.6.2 Asbestos removal and asbestos related works

Management and removal of asbestos shall be in accordance with *MRTS96 Management and Removal of Asbestos*.

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*, and
- *Work Health and Safety Act 2011*.

Asbestos removal shall be carried out by an appropriately licensed asbestos removal contractor, unless exempted by the *Work Health and Safety Regulation 2011* for the size and class of the proposed asbestos work. The type of licence required for transport and disposal of asbestos waste shall be in accordance with the *Work Health and Safety Regulation 2011*.

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

3.6.6.3 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.

3.7 Stage construction

Details of minimum lane widths and minimum number of traffic lanes shall be as required in the design brief or project SWTC.

During the first stage of a bridge constructed by stage construction, the HLP 400 design load may not be required, if the first stage is less than 8 m wide; however, the completed bridge shall be designed for all stage loads, including HLP 400.

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.

Minimum lane widths and minimum number of traffic lanes shall be as detailed in the design brief or project SWTC.

Where a longitudinal stitch pour, in accordance with Technical Specification MRTS68, is required to join reinforced concrete decks or other components subject to traffic movements or vibration, provision shall be made to ensure that the 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.

3.8 Load capacity

3.8.1 Design loads and construction sequence

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

3.8.2 Design traffic loads for new bridges

The design traffic live loads for new bridges are SM1600, W80, A160 and HLP 400 in accordance with AS/(NZS) 5100. Refer to Appendix B (Part 2, Section 7.3) of this document for specific design requirement for placement of Heavy Load Platform (HLP) loads.

These design loads apply to all new road bridges on declared main roads, except in unusual circumstances that have been agreed with the Director (Structures Design, Review and Standards).

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

Refer Section 3.8.8 for design traffic loads for busway bridges.

Refer Section 3.8.9 for design traffic loads for light rail passenger transit (LRT) bridges.

3.8.3 Design traffic loads for widening / strengthening an existing bridge

3.8.3.1 General

The application of these minimum design traffic loads for widening and strengthening existing bridge shall be read in conjunction with Section 3.6.3, which outlines the functional requirements for widening, strengthening and rehabilitation generally.

For widening / strengthening, the design lane, excluding HLP, shall comply with AS(/NZS) 5100. The HLP position shall comply with Appendix B of this document, which provides additional requirements to AS(/NZS) 5100.

Other loading design parameters shall be as follows:

- | | |
|---|----------------------|
| • Ultimate load factors for dead loads and superimposed loads | As per AS(/NZS) 5100 |
| • Ultimate load factor for traffic loads (excluding Cranes, HLP & SM1600) | 2.0 |
| • Ultimate load factor for Cranes | 1.6 |
| • Ultimate load factor for HLP & SM1600 | As per AS(/NZS) 5100 |
| • Dynamic load allowance: | |
| a) for cranes | 0.3 |
| b) AAB quad and HML semi, at speed | 0.4 |
| c) Vehicles specified in AS(/NZS) 5100, at speed | As per AS(/NZS) 5100 |
| d) HLP, at 10 km/hr | 0.1 |
| e) HLP, at speed | 0.3 |
| f) Vehicles at crawl | Zero |
| • Accompanying lane factors | As per AS(/NZS) 5100 |
| • Other parameters | As per AS(/NZS) 5100 |

3.8.3.2 Design traffic loads for simply supported spans of less than 50 m

Except where otherwise agreed with the relevant district and/or region, design traffic loads for widening / strengthening simply supported spans of less than 50 m shall be as shown in the Table 3.8.3.2.

The details of 6 axle semi and AAB Quad load and axle configurations are shown in Figure 3.8.3.2.

Table 3.8.3.2 – Design traffic loads for simply supported spans of less than 50 m (bridge widening / strengthening)

Road classification / name ¹	Design vehicle ¹	Accompanying vehicle
Any bridge constructed since 2004	SM 1600 and HLP 400 to Transport and Main Road's <i>Design Criteria for Bridges and Other Structures</i>	
Any bridge constructed prior to 2004	Design criteria shall be the greater of: 1. original design load, or 2. load specified below.	
<u>Minimum</u> 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	Design criteria shall be the greater of: 1. L44 and multiple T44s with a 3 m (stationary) or 6 m (moving) ² <u>minimum</u> headway between vehicles, located for maximum load effects, or 2. HML AAB quad T2 road train, or 3. 48 t crane in lane at speed, or 4. 79.5 t crane in lane at speed, or 5. Prime mover and 150 t HLP ³	<ul style="list-style-type: none"> HML AAB quad T2 road train
	HLP 320 (+/- 1.0 m centre of 2 marked lanes) at speed	Accompanying vehicle only used in other lanes when 3+ design lanes exist. Half of <i>HML AAB quad T2 road train</i>
<u>Minimum</u> 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)	Design criteria shall be the greater of: 1. L44 and Multiple T44s with a 3 m (stationary) or 6 m (moving)** <u>minimum</u> headway between vehicles, located for maximum load effects, or 2. HML AAB quad T2 road train, or 3. 48 t crane in lane at speed, or 4. 79.5 t crane in lane at speed, or 5. Prime mover and 150 t HLP ³	<ul style="list-style-type: none"> HML AAB quad T2 road train
	HLP 280 ⁴ ± 1.0 m centre of 2 marked lanes) at speed	Accompanying vehicle only used in other lanes when 3+ design lanes exist. Half of <i>HML AAB quad T2 road train</i>

Road classification / name ¹	Design vehicle ¹	Accompanying vehicle
<u>Minimum</u> for Pacific Motorway (Captain Cook Bridge to Gateway Motorway)	Design criteria shall be the greater of: 1. L44 and Multiple T44's with a 3 m (stationary) or 6 m (moving) ² <u>minimum</u> headway between vehicles, located for maximum load effects, or 2. 48 t crane in lane at speed, or 3. 79.5 t crane in lane at speed.	Multiple T44s with a 3 m (stationary) or 6 m (moving) ² <u>minimum</u> headway between vehicles, located for maximum load effects
<u>Minimum</u> for Type 2 road train routes and any other road not specified previously	Design criteria shall be the greater of: 1. HML AAB quad T2 road train, or 2. 48 t crane in lane at speed, or 3. 79.5 t crane in lane at speed, or 4. Prime mover and 150 t HLP ³	<u>Bridges greater than 30 m long</u> HML AAB quad T2 road train
		<u>Bridges less than 30 m long</u> Two HML semitrailers with a 4 m minimum headway between vehicles, located for maximum load effects
	HLP 240 ⁴ (\pm 1.0 m centre of 2 design lanes)	Nil

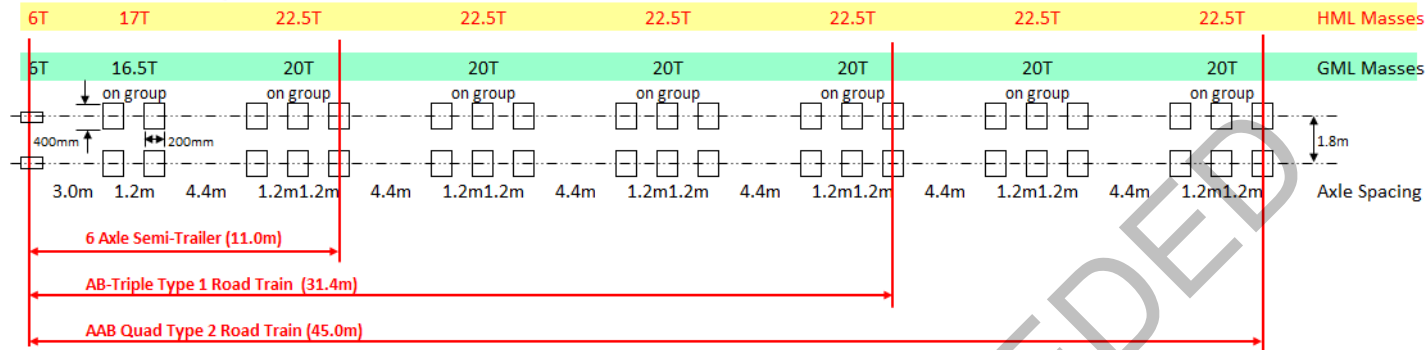
Notes

- All road classifications and design vehicles shall be determined after consultation with the appropriate Region representative.
- Distance between axles of the leading and following vehicles.
- If strengthening to this load is not achievable, the bridge shall be designed for the heaviest possible configuration. The axle layout shall be maintained, and the axle loads reduced until the maximum possible loading is achieved.
- Similar geometry to HLP 320 with axle weight proportionally reduced.

Figure 3.8.3.2 – 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 axes except 6T axle are tandem axes



SUPERSEDED

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

Special criteria apply for widening / strengthening spans over 50 m, or continuous spans.

The design must consider worst effect due to 6 axle semi, or AAB quad and design vehicles, according to the following criteria:

- i. Maximum spacing between axle groups can vary between 4.4 m and 6.0 m for continuous bridges to create the worst load effect.
- ii. 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.

3.8.3.4 Design traffic loads for local authority bridges and culverts

The load rating of a local authority bridge or local authority culvert, subject to alteration, shall be as specified by the local authority but not less than H20-S16.

3.8.3.5 Assessment ratios

The Department of Transport and Main Roads maintains a database of assessment ratios for bridges that are used for the management of heavy vehicles. For example, the ratios assist in determining permit vehicle access and/or determining levels of access across the state road network. If a bridge is strengthened or widened, it is important that, where required, the database is updated so that access decisions are made based on the latest available information.

Assessment ratios, where required, shall be calculated for the strengthened and/or widened components of any bridge following the procedures in the *Bridge Heavy Load Assessment Criteria* document. Not all vehicles have to be assessed and Designers shall consult the design brief, SWTC and/or the Director (Structures Design, Review and Standards) for the appropriate loadings on a case-by-case basis.

3.8.4 Design traffic loads for damaged bridges

For bridges damaged in service, the damaged section shall be reinstated to the pre-existing structural capacity, enjoyed prior to the damage, albeit this may exceed the original design traffic loads. If the superstructure 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, or the design load for the original bridge, whichever is the most severe.

3.8.5 Heavy Load Platforms (HLPs)

HLPs represent the actual configuration of vehicles that travel on the road network, not design simplifications.

On road projects associated with major industrial 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, except where this issue is dealt with in the design brief or SWTC. Typically, such heavier HLP can impose much higher loads (up to 50 tonnes / axle) than normally allowed on bridges (25 tonnes / axle).

3.8.6 Abnormal loads

Any requirements for abnormal loads shall be defined in accordance with the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).

3.8.7 Lateral restraint conditions for pedestrian and cyclist bridges

For the design of a standalone pedestrian and/or cyclist bridge, lateral loads (refer AS 5100.2, Clause 10) are a critical load case.

For new pedestrian and/or cyclist bridge structures the minimum lateral load is 500 kN, unless other agreed with the Director (Structures Design, Review and Standards).

For pedestrian and/or cyclist bridges over waterways and navigable channels, 'ship' / navigational vessel impact shall be in accordance with AS 5100.2, Clause 11.6, and Appendix A of this document (refer Matter for Resolution No. 13, AS 5100.2).

3.8.8 Design traffic loads for busway bridges

3.8.8.1 General

The truck, lane, wheel and crane loads contained in this section only relate to bridges that are exclusively used for busway traffic. Bridges used for both busway traffic and other road traffic shall be designed for the road traffic loads specific to their situation.

The criteria specified hereunder are minimum, generalised provisions. The particulars of any vehicles proposed for any specific busway, for example Brisbane Metro, shall always be considered to ensure that the minimum requirements are sufficient, and any necessary adjustments to design traffic loads are made.

3.8.8.2 Busway traffic loads

As a minimum requirement, busway bridges shall be designed for the T44 truck load. One truck load is applied per lane for simply supported bridges.

For continuous bridges, one T44 truck load per span per lane shall be considered in the design. T44 trucks shall be located on the structural model to impose the worst action effect.

For spans greater than 10 m, bridges shall be designed for either the T44 truck load or the L44 lane load, whichever produces the worst effect.

T44 truck load and L44 lane load shall be in accordance with Figures 3.8.8.2(a) and 3.8.8.2(b) respectively.

Figure 3.8.8.2(a) - T44 Truck load

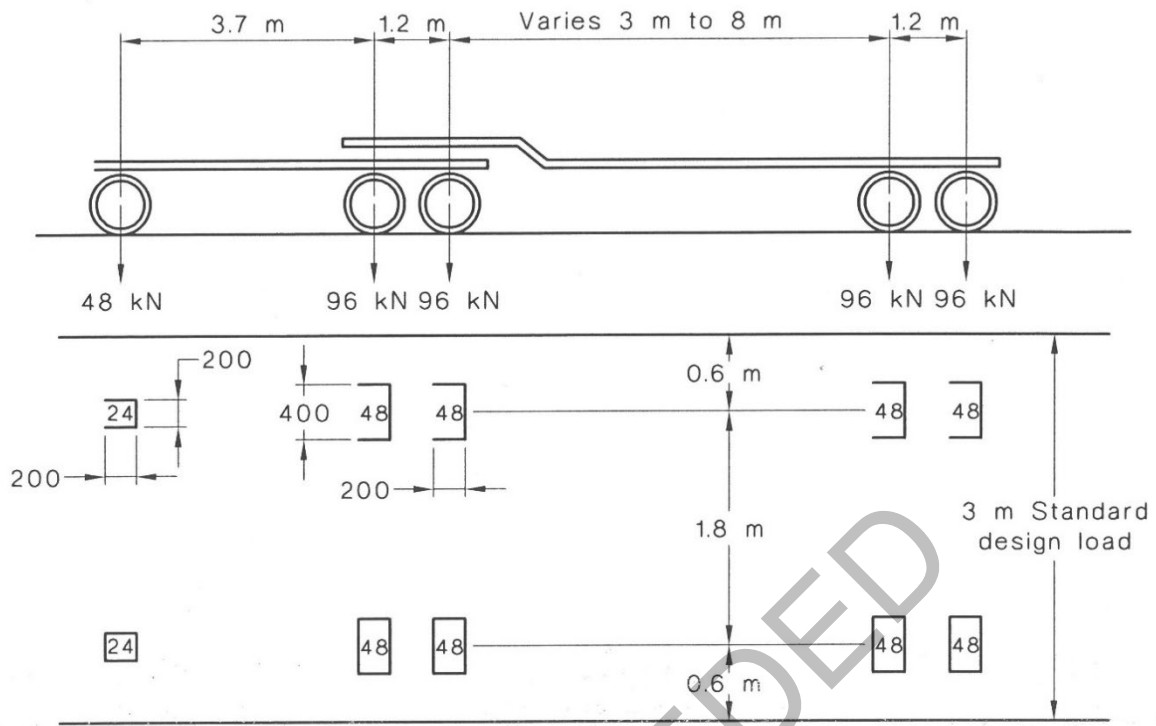
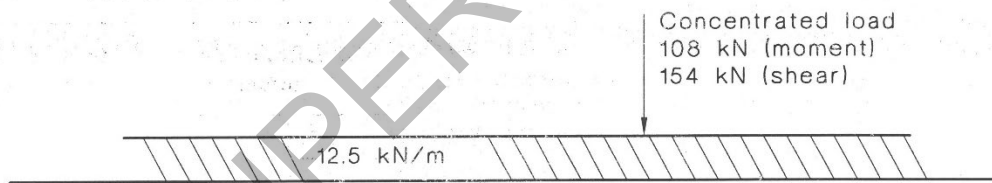
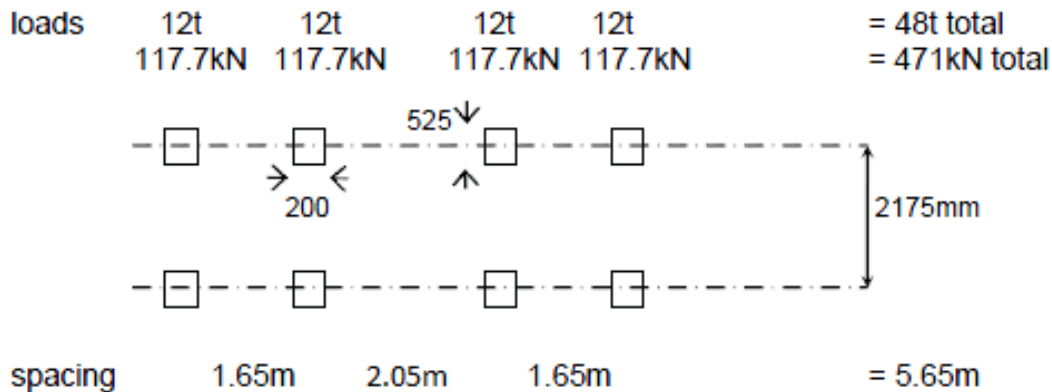


Figure 3.8.8.2(b) - L44 Lane load



In addition, all busway bridges shall be designed to carry one 48 t crane load, as defined in Figure 3.8.8.2(c), placed anywhere on the bridge deck.

Figure 3.8.8.2(c) - 48 t Crane configuration



For all structural elements where the critical load is a wheel load, an additional load effect consisting of a W7 wheel load shall be considered. The W7 wheel load is defined as a 70 kN load over a contact area of 500 x 200 mm, placed to impose the worst effect.

Dynamic load allowance (α) for W7, T44 and L44 traffic load shall be 0.4. Dynamic load allowance (α) for 48 t crane load shall also be 0.4.

Serviceability and ultimate limit state load factors for W7, T44 and L44 shall be 1.0 and 2.0 respectively. Serviceability load factor and ultimate load factor for the 48 t crane shall be 1.0 and 1.8 respectively.

3.8.8.3 Centrifugal forces

Centrifugal forces on busway bridges shall be calculated in accordance with AS 5100.2, Clause 7.8.1, with the T44/L44 vertical load adopted, in lieu of the M1600, for calculation of W_c . The load factor for serviceability limit state shall be 1.0, and the load factor for ultimate limit state shall be 1.8. No dynamic load allowance is to be included.

3.8.8.4 Braking forces

Braking forces for busway bridges shall be calculated in accordance with AS 5100.2, Clause 7.8.2, with the T44/L44 vertical load adopted, in lieu of the M1600, for calculation of W_{BS} & W_{BM} . Load factor for serviceability limit state shall be 1.0, and the load factor for ultimate limit state shall be 1.8. No dynamic load allowance is to be included.

3.8.8.5 Fatigue load effects

Fatigue design load effect shall be determined from the effects of a single W7 wheel, and the T44 or L44 load, whichever is the worst case. A load factor of 1.0 shall be used and the load effect shall be increased by the dynamic load allowance (α).

The number of fatigue cycles shall be determined from an analysis of anticipated bus movements, adopting a process similar to the one described in Clause 7.9, AS 5100.2, where a bus is considered to be a heavy vehicle and the route factor is 0.7. Notwithstanding any objective analysis, the minimum number of fatigue stress cycles to be used for the calculation of fatigue capacity shall be in accordance with Table 3.8.8.5.

Table 3.8.8.5 – Number of stress cycles for fatigue design

Fatigue design traffic load	Number of fatigue cycles (minimum)
W7 wheel load	2 000 000
T44 truck load	500 000
L44 lane load	100 000

The number of stress cycles for fatigue design in Table 3.8.8.5 is based on AS 5100.7(2004), Table A3, adopting road Functional Class 6 for urban busways and Functional Class 1 for rural busways.

3.8.9 Design traffic loads for light rail passenger transit bridges

3.8.9.1 General

The light rail loading criteria provided below are limited to Light Rail Transit (LRT) applications intended for public transport only, and generally follow the guidelines in Clause 9.3 of AS 5100.2.

These criteria are not, however, intended to cover bridges on sugar cane railways, nor light rail systems for the transportation of other goods. The leading axle of the simulated locomotive indicated in Figure 9.2 of AS 5100.2 does not, therefore, apply to LRT bridges intended for public transport.

Loading criteria for light rail goods railways shall be obtained from the relevant agency or operator.

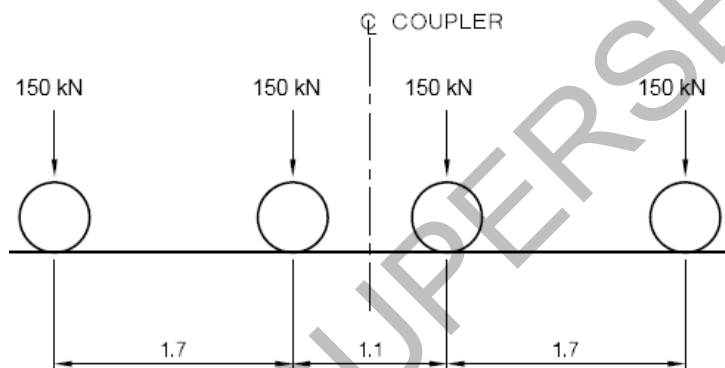
3.8.9.2 Light Rail Transit load

The LRT design load shall be a modified 150 LA, which is based on 50% of the 300 LA rail load as detailed in AS 5100.2. For the purposes of these criteria, the minimum light rail design load shall comprise eight 150 LA axles (that is, the nine axles nominated in AS 5100.2, Clause 9.3 with the simulated locomotive axle removed).

The eight axles of the minimum light rail design load shall comprise two 150 LA axle groups.

Each 150 LA light rail axle group shall consist of four 150 kN axle loads with axle spacing of 1.7 m, 1.1 m and 1.7 m, as shown in Figure 3.8.9.2(a).

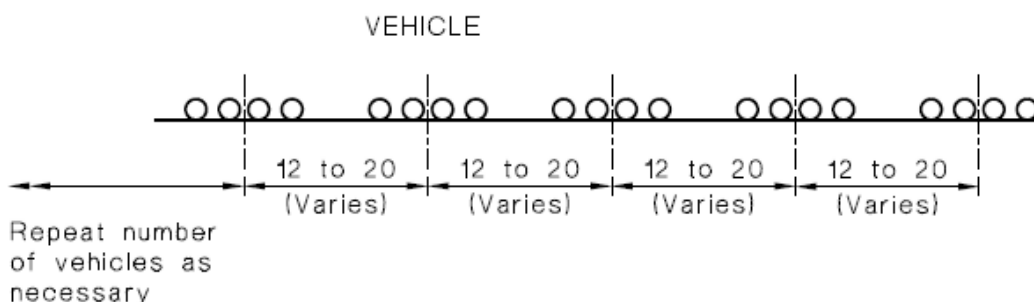
Figure 3.8.9.2(a) – 150 LA light rail traffic loads – axle group loads



The spacing between the centres of each axle groups shall vary between 12 m and 20 m, as shown in Figure 3.8.9.2(b), to give maximum effect in the member under consideration.

In applying the light rail load, there will be no limit on the number of trailing axle groups to allow for longer vehicles and/or queuing. The position of loads and number of axle groups shall be selected so as to give maximum load effects in the structural member under consideration.

Figure 3.8.9.2(b) – 150 LA light rail traffic loads – axle group spacing



3.9 Construction loads

3.9.1 General

For the purposes of determining construction loads, a distinction is made for bridges that involve incremental launching of prestressed concrete superstructures.

3.9.2 Bridges constructed without incremental launching

The minimum loads shown in Table 22.2.1 of AS 5100.2 shall apply during construction of any bridge, except for the launching phase of an incrementally launched bridge.

3.9.3 Incrementally launched bridges

3.9.3.1 Incrementally launched prestressed concrete bridges

When designing incrementally launched prestressed concrete bridges, the standards detailed in Table 22.2.2 of AS 5100.2 must apply during the launching stage.

3.9.3.2 Incrementally launched bridges other than those composed of prestressed concrete

The criteria for other types of incrementally launched bridges shall be subject to written agreement by the Director (Structures Design, Review and Standards).

3.10 Mining subsidence

Mining is a common activity in Queensland, which 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.

The Designer shall ensure that confirmation in writing is obtained from the mine subsidence authority that parameters used in the design are still appropriate for the actual movements being recorded.

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.

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.

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.

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.

The need to accommodate mine subsidence movements may require, but is not limited to, the following:

- 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 bearings
- the use of bedding material under spread footings that will allow rotations to occur without damaging the substructure, and/or
- 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.

3.11 Hydraulic considerations

3.11.1 Hydraulic investigation

3.11.1.1 General

The hydraulic investigation shall be undertaken by one of the three options described in Sections 3.11.1.2 to 3.11.1.4.

The hydraulic investigation shall be considered an integral part of the design process for any bridge affected by a watercourse or other body of water. The bridge designer shall collaborate with the hydraulics advisor to ensure that bridge configurations reflect the hydraulics imperatives at each site.

The effects of climate change on hydraulic conditions at a bridge site shall be considered.

As climate change has the potential to alter the prevalence and severity of rainfall extremes, storm surge and floods, it needs to be considered when designing roads and bridges for the department. For design rainfall events, the relevant increase in rainfall intensity and sea level rise must be determined in accordance with the latest relevant State policies and/or the recommendations in *Australian Rainfall and Runoff* and be approved by the department prior to commencement of any project.

3.11.1.2 Option 1

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 for all floods up to the 1% AEP event, where AEP is defined as the Annual Exceedance Probability. This term expresses the probability of an event being equalled or exceeded in any year in percentage terms, and
- b) Ultimate limit state of bridges 0.05% AEP flood. The overtopping event shall also be considered if this is less than the 0.05% AEP flood. The overtopping event will typically cause critical conditions in terms of peak velocities, and greatest flood forces.

The study shall be carried out with reference to the department's technical guideline, *Hydrologic and Hydraulic Modelling* (refer Section 1.4.3.6.v). The hydraulic investigation report should be submitted to Transport and Main Road's Director (Hydraulics and Flooding) for review and acceptance.

3.11.1.3 Option 2

The hydraulic investigation report shall be supplied to the Consultant.

3.11.1.4 Option 3

Hydraulics investigation is not required in the project.

3.11.2 Minimum hydraulic forces on bridges

For robustness, the minimum hydraulic force on a bridge pier shall be the greater of:

- i. 75 kN per pier, or
- ii. the force determined by hydraulic analyses.

The minimum water flow velocity (V), as defined in Clause 16.2 of AS 5100.2, for calculating hydraulic forces, shall be 2.0 m/s. This minimum water flow velocity shall apply irrespective of a lower velocity being suggested by hydraulic analysis.

The minimum water flow velocity criteria is imposed to ensure a robust structure, and is not intended for used in the estimation of scour or the provision of scour protections.

The minimum debris depth shall be determined as follows:

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

Refer to Book 6, Chapter 6 of *Australian Rainfall and Runoff, A Guide to Flood Estimation, 2016 (ARR16) – Blockage of Hydraulic Structures*, for further information on blockage of hydraulic structures due to urban debris.

In locations subject to tidal inundation or backwater inundation, flood forces may be applied on either side of the bridge structure.

3.11.3 Acceptable level of afflux

In urban areas, the main restraint on hydraulic design is to minimise afflux when this would adversely affect adjacent upstream properties and cause actionable damage.

Permissible afflux effects shall be set in accordance with the project requirements.

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 potential of abutments, stream bed and banks downstream.

3.11.4 Protection against scour

3.11.4.1 Scour estimation

The design scour event (that is, the event producing the highest velocity and greatest bed shear) may be a smaller event than the 0.05% AEP flood event. Therefore, a range of floods up to and including that event shall be evaluated. Further guidance on the appropriate selection of a scour design event and determination of depth of scour is included in the department's *Bridge Scour Manual*.

3.11.4.2 Scour at abutments and piers

The scour potential at abutments and piers shall be minimised.

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.

For new bridges, the design of bridge piers shall not rely on pier scour protection, even where scour protection is warranted and is provided. The structural integrity of new bridges shall be ensured by designers estimating the maximum scour depth at piers and then making judicious decisions about substructure types and founding depths thereby, safeguarding the bridge under the action of scour.

Bridge abutments shall be designed by taking into consideration possible scour. Depth of scour shall be determined by scour analysis. Abutments and road approaches shall be adequately protected to prevent scour for floods up to the SLS event. However, any scour protection designed for SLS conditions, shall not be relied upon at the ULS event. Excluding spread footings founded on solid rock, minimum scour depth for ultimate limit state design shall be 2 m measured from the bottom of the headstock. The bridge, and its approaches, shall be designed for the worst ultimate flood forces up to 0.05% AEP event without relying on abutment protection. If the bridge is closed to traffic under ULS conditions, the accompanying traffic loads on the bridge can be excluded. In addition to the scour analysis conducted by the hydraulic engineer, a geotechnical engineer shall be consulted when determining the maximum design scour depths at the bottom of the abutment headstock to use for bridge design. The work in both disciplines shall be conducted under the direction of an experienced RPEQ engineer in each field.

Abutment scour protection shall be in accordance with Section 4.6.2.2.

The design life for an abutment / pier protection system in streams subject to scour is 50 years. The design must provide for replacement or repair of the scour protection at the end of its service life or after a flood event.

Scour protection at abutments and piers shall be designed for the maximum of average cross sectional velocities for floods between 1 EY (63.21% AEP) and 1% AEP (where EY has the meaning defined in *Austrroads Guide to Bridge Technology Part 8: Hydraulic Design of Waterway Structures*), and shall consider situations such as:

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

If the overtopping event is greater than the 1% AEP event and less than the 0.05% AEP event, the Designer shall conduct a risk assessment to determine if the scour protection should be designed to withstand the overtopping event. The risk assessment should take into account the criticality of the link and availability of alternative routes, and potential cost of repairs versus the cost of scour protection.

The design life of scour protection (50 years) refers to the durability of materials used in construction of scour protection and shall not be confused with flood probability that the protection can be exposed. Design life of the protection is not possible to define with flood events because any flood event at the bridge has a certain AEP.

The protection system should be able to sustain higher probable flood events to avoid frequent repairs; therefore, design criteria recommend designing the scour protection for the maximum velocities for floods between 1 EY and 1% AEP.

3.11.4.3 Design scour on drawings

The levels of scour, calculated by the Designer, shall be shown on the project design drawings.

3.11.5 Handling drainage from adjacent road

Roadside 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 Durability

3.12.1 Introduction

Where Transport and Main Roads' *Structures Inspection Manual* does not explicitly cover the inspection and maintenance of any bridge component or novel material or coating, the Designer shall provide procedures for inspection and maintenance for the novel aspects of the design.

3.12.2 Durability for steelwork

3.12.2.1 Galvanising steel structures

In accordance with MRTS78, and unless approved otherwise by Director (Structures Review and Standards), all steelwork shall be hot dip galvanised to AS/NZS 4680 *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles*, with a minimum coating in accordance with Table 1 of AS/NZS 4680.

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.

Material with a silicon and phosphorous content less than the following may need to be whip blasted to create a surface profile prior to galvanising. These requirements shall be included on the drawings:

- %Si < 0.04%
- %Si + (2.5 x %P) < 0.09%

Adequate vent and drainage holes for the galvanising process shall be detailed and shown on the drawings.

Galvanising of fasteners shall be in accordance with MRTS78.

When detailing structural steelwork for galvanising, the recommendations of the Galvanizers Association of Australia provide a useful guide.

3.12.2.2 Painting steel structures

Painting, as the primary corrosion protective coating, will only be accepted when hot dip galvanising is not practical or cost effective.

Approval shall be obtained from the Director (Structures Design, Review and Standards) for the paint coating system, which shall be selected in accordance with Section 4.17 of this document.

Shop painting and proper careful detailing shall give a minimum life to first major repaint of 30 years, subject to regular inspections and routine minor repair interventions as required by AS 2312.1. Field applied paint coatings, if done before full breakdown of initial paint system, may be assumed to last up to 15 years.

Paint coating systems shall be selected to provide the longest practical service life before recoating. Repainting in the field must be practical, without the need to grit blast to remove the original paint if sound.

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

Surface coatings require the analysis of whole of life costing refer (Section 3.4) 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.

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

3.12.2.3 Steel fitments

The durability of the materials used for fitments (includes anchor bolts, traffic barrier connections, anchorage points, bearing bolts, machine screws and so on) must consider the exposure conditions, as defined by the corrosivity categories in AS 4312.

As a minimum protection against corrosion, steel fitments shall be galvanised.

In saline corrosivity zones (Category C3 and above), Grade 316 (A4) stainless steel fitments shall be used.

Stainless steel fitments will reduce long term maintenance costs. The cost of replacement can be disproportionately high compared to the extra cost of a more durable material.

Ferrules or sockets cast into concrete shall be hot dipped galvanised, as a minimum protection.

In saline corrosivity zones (Category C3 and above), Grade 316 (A4) stainless steel cast in ferrules or sockets shall be used in marine or corrosive environments.

3.12.2.4 Detailing steelwork for durability

In non galvanised painted steel structures, welded joints shall be used where practicable in preference to bolted joints to reduce corrosion risk.

Bolts are better than welds for fatigue design. Welded connections, however, are preferred by Transport and Main Roads if a paint system (not hot dipped galvanising) is used for corrosion protection of steelwork. The reason is that the design life of paint system on steelwork is less than hot dipped galvanising.

When the paint system reaches the end of its design life, it needs to be repainted. The process of removing existing paint (for example, sand blasting) on steelwork may damage the galvanising coating of the bolt thread and will lead to corrosion.

All edges shall have a minimum radius of 2 mm. These requirements shall be included on the engineering drawings.

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

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.

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

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

All hollow sections shall be joined using full penetration butt welds. Fillet welds are not acceptable for this application as they encourage crevice corrosion resulting in premature failure.

3.12.3 Durability for concrete

3.12.3.1 Components with 100 year design life

For road bridges and pedestrian / cyclist bridges, with 100 year design life, durability requirements shall be determined, generally, in accordance with Section 4 of AS 5100.5. The minimum exposure classification shall be B2, except for reinforced concrete decks in remote areas where the appropriate exposure classification shall be selected after discussions with the Region, and subsequently confirmed by the Director (Structures Design, Review and Standards).

Further to Table 4.3 of AS 5100.5, soffits of bridges and ancillary structures which are in occasional contact with sea water or brackish water shall be exposure classification C1.

Cover to reinforcement shall be as defined in AS 5100.5 except for driven prestressed concrete piles, where minimum cover to reinforcement shall be:

- 50 mm for exposure classification B2, and
- 70 mm, with rigid formwork and intense vibration, for all exposure Class C applications, including C1 and C2.

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.

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 (minimum) above HAT.

The underside of cast in situ decks, cast directly onto deck units, girders and any incorporated in-fill sheets, and not subsequently exposed, may have the cover to reinforcement for that surface determined as if the exposure classification for that surface was B1, provided that in all other circumstances the deck is designed for B2 conditions.

Bridge deck shall be waterproofed in accordance with MRTS84 *Deck Wearing Surface*.

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. Preferably, such evaluation shall be undertaken before a construction contract is awarded. If a requirement of proprietary high performance waterproofing membrane has been identified at the concept design stage, the proposal to use such a system shall be advised in writing to the Director (Structures Director, Review and Standards) for review and acceptance. The examples of special circumstances where proprietary high performance waterproofing membrane system shall be required:

- transversely stressed deck unit bridges
- rehabilitation of transversely stressed deck unit bridges
- where bridge decks are suffering from high alkali silica reactivity
- rehabilitation of decks where the deck reinforcing steel has been damaged or exposed, and
- bridge decks in salt spray susceptible areas.

Rail bridges shall conform to the relevant rail authority requirements.

3.12.3.2 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 Section 4, AS 3600:2018 *Concrete*. The minimum exposure classification shall be A2.

3.12.3.3 Requirements for concrete strength, grade and mix design

Concrete shall be to the department's technical specification MRTS70 *Concrete*.

3.13 Buried components

Additional requirements for durability of buried components, where no inspection or maintenance access is practicable, shall be in accordance with relevant Australian Standards and Technical Specifications maintained in the department.

3.14 Aggressive environments

3.14.1 Sulphate reducing bacteria

Different types of Sulphate Reducing Bacteria (SRB) occur in many environments. The SRB most critical to steel bridge substructures are located in the rocks and soils of tropical Australia and Asia.

The department's Technical Note 99 *Sulphate Reducing Bacteria on Steel Structures* provides advice on the subject.

Refer also to Sections 4.4.1 and 4.4.6 of this document for limitations on the use of steel piles.

Steel liners of cast in place piles are considered as sacrificial formwork with no long term structural capacity.

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

Sulphate reducing 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.

3.14.2 Stray currents from electric railway or other sources

Bridges 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).

3.14.3 Bridge components in marine environment

Cast in situ concrete elements located in the tidal splash zone or zones subject to repeated wetting or drying in saline water (chloride content above 6000 ppm), shall be designed for C2 exposure classification (refer to Section 3.12.3.1) with a minimum 28 day characteristic strength of 50 MPa to MRTS70 *Concrete*. Except where stainless steel is adopted for the principal reinforcement, a suitable outer layer of stainless steel reinforcement shall be provided, extending to at least 3 m above HAT and 1 m below LAT, in addition to the inner layer of carbon steel reinforcement with excess cover. Stainless steel reinforcement shall conform to MRTS71A *Stainless Steel Reinforcing* and have sufficient cover to fully develop bond strength and ensure adequate placement and compaction of concrete. Cover to stainless steel reinforcement shall be 55 mm minimum. The gap between carbon steel and stainless steel shall be 50 mm minimum.

Carbon steel shall have provision for possible future cathodic protection and assessment of all concrete piles, pile caps, headstocks and piers. This shall include providing electrical continuity of all non stressed and stressed reinforcement, fitments and anchor plates. Anchors for metal items attached to concrete with a large exposed surface area must be electrically isolated from the surrounding reinforcement. The electrical continuity for all concrete piles, pile caps, headstocks and piers must be capable of demonstration. The electrical continuity shall be tested in accordance with AS 2832.5 *Cathodic protection of metals – Part 5: Steel in concrete structures*. These requirements shall be included on the appropriate project drawings.

This section is not generally applicable to prestressed concrete piles and other precast items.

3.15 Cracks in concrete at the end of construction

3.15.1 Non aggressive areas

Any finished concrete, in a non-aggressive area (exposure classification B2 or less), with a crack more than 0.3 mm wide, but less than 0.5 mm wide shall be inspected by an experienced designer (who shall be an appropriate RPEQ), preferably the designer for the bridge or associated structure, 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 the Director (Structures Design, Review and Standards) who shall determine whether the crack shall be repaired or the member replaced, and
- concrete elements with cracks greater than 0.5 mm shall be rejected.

3.15.2 Aggressive areas

Any finished concrete, in an aggressive area (Exposure Class C mixes), with a crack more than 0.15 mm wide but less than 0.3 mm wide shall be inspected by an experienced designer (who shall be an appropriate RPEQ), preferably the designer for the bridge or associated structure, 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 the Director (Structures Design, Review and Standards) who shall determine whether the crack shall be repaired or the member replaced, and
- concrete elements with cracks greater than 0.3 mm shall be rejected.

3.16 Thermal cracking in large sections

3.16.1 Modelling in design

Any concrete section with a thickness or minimum dimension greater than 1 m, or in other circumstances where thermal cracking is a possible outcome, shall be thermal modelled by a recognised method to determine thermal gradient and maximum temperature due to heat of hydration. The maximum temperature of the concrete shall not exceed 75°C, and the thermal gradient from centre to surface shall not exceed 25°C.

3.16.2 Documentation

When the risk of thermal cracking requires consideration during construction, the designer shall ensure that the design documentation contains sufficient supplementary specifications, MRTS annexures, and drawing notes to alert prospective contractors.

3.17 Safety in design, construction and maintenance

Safety in design shall conform to:

1. *Work Health and Safety Act 2011*
2. *Work 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 endorsed by Queensland but is best practice in the absence of a local Code of Practice.
4. Legislative guide – *Designer written report for a structure (LG-DR1)*, Workplace Health and Safety Queensland.

3.17.1 Safe access to site

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

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.

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

A bridge shall be designed with provision for maintenance access.

Provisions for under bridge inspection requirements are defined in Section 3.5.6.2.

Provisions for abutment bearing inspection are defined in Section 4.6.1.2.

3.18 Bridge security

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

- a) 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)
- b) consideration of the redundancy of members and in spans
- c) installation of security cameras, and/or
- d) restricted access to site, typically around abutments.

3.19 Bridges in close proximity to railways

This section only applies to road, bus, light rail, cycle or pedestrian bridges near or over railway lines and is not applicable to railway bridges.

Further to the requirements of Section 1.4.4.1, bridges and ancillary works near or over a railway shall meet the requirements of the relevant rail authority.

In addition to AS/(NZS) 5100, bridges and ancillary works over and/or adjacent to a railway administered by Queensland Rail shall be designed in accordance with the current versions of its *Civil Engineering Technical Requirements* (refer Section 1.4.4.2), including:

- Civil-SR-001 Design of road overbridges
- Civil-SR-002 Work in and about Queensland Rail property
- Civil-SR-003 Requirements for work on or near high voltage overhead line equipment and low voltage service
- Civil-SR-006 Design of Footbridges
- Civil-SR-007 Design and selection criteria for road / rail interface barriers, and
- Civil-SR-012 Collision protection of supporting elements adjacent to railways.

These documents refer to Queensland Rail Standard Drawings and other references, which should also be consulted.

Civil-SR-007 referred to in Section 3.19(b) shall be amended as follows:

- i. The requirements of the guideline are in addition to AS/(NZS) 5100 and AS/NZS 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 shall be designed for impact loads 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(/NZS) 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 7 (annotated as Table 5) in Civil-SR-007 shall be replaced by Table 3.19 which follows.

Table 3.19 – 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 and 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 transverse barrier design load in accordance with Table 8 (annotated as Table 6) of CIVIL-SR-007, while Special is 750 kN.

3.20 Anti-graffiti coating

The accessible surfaces of all bridge and ancillary structures, shall be treated with non sacrificial anti graffiti coating, if required by the design brief, project SWTC, or otherwise by the Director (Structures Design, Review and Standards). If so specified, the anti graffiti coating shall accord with the following requirements:

- i. anti graffiti coating shall not be applied on galvanised steelworks
- ii. the anti graffiti coatings shall match the adjacent surface, and the colour appearance of the structure shall not be altered by the application of the coating
- iii. treatment of the surfaces must be to a minimum height of 3 m above the surrounding reinstated ground levels or any accessible footholds
- iv. where part of an element of a structure requires treatment on the basis of the height criteria in Section 3.20 iii., then the whole element must be treated, and

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

The design of bridges and ancillary structures shall consider and address the aesthetic impact of anti graffiti coatings on the element, the structure and the family of structures.

Subject to Transport and Main Roads' regional 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.

3.21 Date plates and survey marks

A date plate (Standard Drawing 2005) and a survey mark shall be detailed in the design documents and affixed to each bridge.

3.22 Post-construction inspections

The Designer shall ensure that the following requirements for inspection upon completion of all bridges, or parts thereof, shall be included in the project documentation:

- a) the new bridge construction work shall have a Level 2 inspection carried out by a qualified inspector on completion of the construction in accordance with the department's *Structures Inspection Manual* and the results entered into the department's Bridge Information System (BIS)
- 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, and
- c) on multi span bridges, the Level 2 inspection shall be commenced after construction of a few spans to identify issues early and avoid repetition of errors on the remaining spans.

3.23 Special conditions or requirements

The department reserves the right to impose special conditions, including aesthetics for the bridge design. Where deemed necessary, the special conditions will be imposed in the design brief, project SWTC, or otherwise by the Director (Structures Design, Review and Standards).

4 Bridges - Details

4.1 Introduction

4.1.1 Scope

This chapter is devoted to the requirements for bridge components, namely:

- foundations
- piers
- abutments
- bearings
- superstructures
- decks
- traffic barriers
- active user considerations
- paint systems, and
- materials.

The bridge types covered by this manual, and the functional characteristics they are expected to satisfy, are considered in Chapter 3.

4.1.2 Design methodologies

It is expected that designs will be carried out in accordance with the requirements contained in Section 1.4 of this document, and that due consideration be given to the variations contained in this document generally, including Appendices A & B.

Foundation design, including design methodology, geotechnical investigations, design documentations, pile testing and so on, shall be in accordance with the department's *Geotechnical Design Standard – Minimum Requirements*.

4.2 Design life

Further to Part A, Section 1.5 of this document all bridgeworks and ancillary retaining walls, except for the sub-elements noted below, shall be designed and detailed to ensure an operational design life of 100 years, without major repair requirements.

For critical bridges the required design life may be greater than 100 years, in specific cases, where stipulated in the design brief, SWTC, or as otherwise requested by the Director (Structures Design, Review and Standards).

Repainting of steel structures may be considered normal maintenance. Repainting, however, should not cause significant traffic disruption. It should always be anticipated that repainting will occur during the day, to avoid condensation issues if painting is attempted at night. Designers should consider the future complications introduced by proposing painted steel structures over busy and/or difficult to access locations.

Sub-elements of bridges, for which the design life may be less than 100 years and design life of other related structures are as follows:

a) Expansion joints	40 years
b) Rubbers in expansion joints	20 years
c) Drainage systems (replaceable elements only)	50 years
d) Steel bridge traffic barrier, safety (anti-throw and anti-jump) screens and fencing	50 years
e) Light poles and signs on side of bridge	40 years
f) Bearings with provision for simple replacement	40 years
g) Bearings with no practical means of replacement (for this application, stainless steel pot bearing is mandatory)	100 years
h) Abutment and pier scour protections	50 years
i) Median slabs	50 years

4.3 Spread footing foundations

Structural design of spread footings shall be in accordance with Section 4.1.2 of this document.

Where spread footings are used as the abutment foundation, the requirements stated in Section 4.6.5 of this document shall also be met.

4.4 Pile foundations

4.4.1 Pile types not accepted by Transport and Main Roads

The following foundation types are not accepted for use in bridge foundations:

- a) Steel screw piles.
- b) Continuous Flight Auger (CFA) piles.
- c) Precast reinforced concrete piles.
- d) Steel piles, except:
 - i. for Western Queensland, refer Section 4.4.6
 - ii. where incorporated in those pile types specified in MRTS63, 63A and 64.
- e) Precast, reinforced or prestressed, concrete piles manufactured by spinning or rolling.
- f) Micropiles.
- g) Piles constructed with bentonite or polymer slurry, and
- h) Bored piles without permanent steel or concrete liners.

Any proponent who believes the use of such piles is cost effective, and will achieve the strength, durability and design life required, may prepare a written submission for assessment by the department's Director (Structures Design, Review and Standards).

The Transport and Main Roads' publication *Engineering Innovation* outlines the steps involved in the innovation process, which takes time and should ideally be done outside of a contractual situation, at the concept design stage (refer Section 2.7).

4.4.2 Driven piles

Structural design of driven piles shall be carried out in accordance Section 4.1.2 of this document.

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

Prestressed concrete piles (PSC) piles shall be designed with a concrete strength at transfer of 35 to 40 MPa.

The concrete strength at transfer has been assessed by Transport and Main Roads and casting yards as being suitable for a 24 hour turnaround cycle of a typical precasting yard using steam curing. Departmental evidence suggests that higher transfer strengths will affect precasting yard preferred production cycles, resulting in significant cost increases.

As a minimum, driven PSC piles shall conform to:

- Standard Drawing No. 2021 550 *Octagonal PSC Piles – Earthquake classification BEDC 1, Exposure classification B2*
- Standard Drawing No. 2022 550 *Octagonal PSC Piles – Earthquake classification BEDC 1, Exposure classification C1 and C2.*

Designers shall make any necessary amendments to the details shown on Standard Drawings nominated in Section 4.4.2d), to ensure the requirements of earthquake classifications higher than BEDC1 are met, while maintaining the implied durability conditions.

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.

For abutment piles, displacement restraint and rotational restraint at the pile head must be minimised to reduce the internal pile forces (bending moments and 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.

Lifting points for PSC piles shall be designed and RPEQ certified by the Designer in accordance with MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

The design documentation shall indicate a design hammer, its mass and the input energy required for driving each pile, together with an indication of the final set per blow required for the proposed hammer.

4.4.3 Cast-in-place piles

The minimum internal diameter of steel liners for cast in place piles for traffic bridge foundations shall be 900 mm.

A cast-in-place pile diameter less than 600 mm may be considered in the case of pedestrian or cyclist bridges (refer Section 4.16.1).

In situations that require a safety shield for inspection and certification, the steel liner shall have a minimum diameter of 1200 mm.

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.

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

- i. the condition of the drilled hole (for example, clean or full of debris) cannot be determined
- ii. any water ingress may adversely affect the quality of grout
- iii. the integrity of the grout over the length of the pile cannot be guaranteed, and
- iv. the reinforcing bar cannot be located centrally in the hole unless specialised fitments of proven performance are used.

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

Permanent steel liners of cast in place piles are considered as temporary formwork with no long term structural capacity.

4.4.4 Pile design outputs shown in drawings

The Designer shall calculate the following critical design loads for each pile for both serviceability and ultimate load cases, 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:

- a) axial compression
- b) axial tension (if applicable)
- c) bending moments (in two directions)
- d) impact loads or lateral shear forces
- e) scour design assumptions on maximum depth
- f) moment fixity in rock if required, and
- g) minimum penetration of the pile into the founding strata.

4.4.5 Pile design foundation levels

The Designer shall consider the bore logs and geotechnical report and shall include on the drawings adequate information to guide the construction supervisors. This shall include:

- i. minimum depth / penetration of pile
- ii. most probable founding level considering scour, axial and moment effects
- iii. the founding layer or strata as described in the bore logs, and
- iv. the likely geological requirements to achieve required geotechnical strength (service and ultimate).

Foundations are to be assessed on site, and certified, by an experienced RPEQ geotechnical assessor.

4.4.6 Steel pile foundations

Steel piles are generally not permitted for bridge foundations (refer Sections 3.14.1 and 4.4.1), except where they are incorporated in pile foundations involving the following technical specifications:

- MRTS63 *Cast-in-Place Piles*
- MRTS63A *Piles for Ancillary Structures*, and
- MRTS64 *Driven Tubular Steel Piles (with reinforced concrete pile shaft)*.

In dry western areas of Queensland, steel piles, in accordance with MRTS66 *Driven 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. Prior written acceptance for the use of steel piles must be obtained from the department's Director (Structures Design, Review and Standards), whose decision will be based on technical merit, safety, constructability (hard driving conditions), maintenance, coatings and durability.

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

4.4.7 Raked piles

Raked piles may be used to provide lateral resistance of bridges. The structural effects on raked piles due to large settlement needs to be assessed at the concept design. Excessive loads on the raked piles may exclude the use of raked piles in those situations.

The Designer shall assess all load conditions in the temporary and permanent stages. The structural effects on raked piles due to any significant ground settlement has to be assessed at the concept design stage as excessive ground movement induced loads on raked piles may exclude their use in these situations. Also refer to Sections 4.3.2(e) and 4.5.3(b) of this document.

Constructability of driving raked piles shall be considered by the Designer at the concept design stage. Consideration shall be given to:

- a) Rake angle, which should generally be limited to the range 1:8 to 1:10. Maximum rake angle shall be 1:8.
- b) Proximity of adjacent bridges or structures which may affect the working space to drive raked piles.
- c) Adjacent live traffic introducing higher safety risks.
- d) Spacing and offset of opposing rakers affecting access to drive adjacent piles after initial piles have been driven and to minimise trimming of piles to gain access to the next pile offset and spacing also have to be balanced and matched pairs used to avoid introducing additional bending, torsion and shear effects in the pile cap.
- e) Sequence of installation, which may limit the use of raked piles; if other piles in the group have already been driven, it may not be possible to drive the last pile if it is raked.
- f) Layout of raked piles shall allow rig to be positioned for driving away from rig where possible; if driving PSC piles with an inward or lateral rake is unavoidable, Designer to ensure the pile design is constructible.

- g) Short raked piles are preferable to long piles which may require special measures for pitching and driving. Also, longer piles have a higher risk of damage due to lateral forces on the raked pile during driving, and
- h) Pile splicing should be avoided where possible. If splicing is necessary, it is better to locate the splice in the lower section with a short starter pile. This will position the joint further down the pile during the harder driving phase when bending moments may be introduced due to the inclined driving.

It should be noted that the hammer efficiency will be reduced due to friction in the ram guides and it may be necessary to use a more powerful hammer than that required for driving vertical piles to the same depth. Raked piles shall be Pile Driving Analyser (PDA) tested and the results verified by testing of vertical piles in the group or structure.

4.5 Piers

4.5.1 Headstocks

4.5.1.1 Non-permitted headstocks

Use of the following headstock types is not permitted:

- inverted T-headstocks, and
- thin bearing shelves designed as corbels.

4.5.1.2 Precast headstocks

The use of precast headstocks or abutments is generally not permitted.

If there is a compelling site constraint, any proponent who believes the use of precast headstocks is the safest, most practical manner of executing the works may prepare a written submission for assessment by the department's Director (Structures Design, Review and Standards).

Any proposal must be cost effective and achieve the strength, serviceability, and durability required.

4.5.2 Pier protection of overbridges from traffic impact

Refer to Appendix B, Part 2: Design Loads, Clause 11.2 of this document for the department's requirements concerning protection of bridge supports from collision loads resulting from road traffic.

Refer also to Section 3.2.3.1 b) for protection of single column piers.

4.6 Abutments

4.6.1 Spill-through abutments

4.6.1.1 Batter slope

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

4.6.1.2 Access for inspections

An access platform with a minimum width 750 mm shall be incorporated at or near the top of the batter slope, for access to inspect and maintain bearings. Platform requirements include:

- i. drains shall be covered with grating to prevent trip hazard
- ii. stairways to access locations and on batter slopes to access abutments
- iii. ladders, fixed where this is appropriate, or attachments to stabilise temporary ladders

- iv. hatchways to provide access and prevent unauthorised entry: hatchways shall be a minimum width of 750 mm
- v. anchorage points for inspection scaffold or safety harness
- vi. where required, appropriately designed handrails shall be provided, and
- vii. access to inspection platforms shall not be provided from the road under the bridge to restrict unauthorised person access to the steps and inspection platform.

The installation of support points to support future maintenance activities shall be considered. Approved cast-in ferrules, with M20 collared eye bolts inserted, shall be installed into batter slopes and/or the sides of abutment headstocks, for attachment of safety lines for inspections and maintenance, if no other access provision is available. Ferrules and eye bolts, where provided, shall be 316 grade stainless steel, with a minimum load rating of 21 kN, in accordance with AS/NZS 1891.2, and spaced at maximum centres of 1500 mm.

On major bridges, the design shall consider the provision of access gantries for future maintenance.

4.6.2 Abutment protection

4.6.2.1 General

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

Abutment protection for bridges on waterways shall comply with Section 4.6.2.2.

Abutment protection for widened bridges shall comply with Section 4.6.2.3.

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. Protection shall be provided along the embankment to at least past the back of the relieving slab unless otherwise shown in Standard Drawings. A suitable toe shall also be provided.

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.

The material for the abutment slope protection shall:

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

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

Abutment slope protection shall be designed in accordance with the minimum standards of MRTS03 *Drainage, Retaining Structures and Protective Treatments*.

4.6.2.2 Abutment scour protection

Bridges over waterways shall be assessed for the need to provide scour protection. For general scour protection requirements refer to Section 3.11.4 & 3.11.5 of this document.

The department's *Bridge Scour Manual* provides guidance on how to assess and accommodate scour into bridge design. This manual shall be consulted for detailed guidance regarding abutment slope protection.

Table 4.6.2.2 shows the referenced Standard Drawings for abutment scour protection types and provides selection criteria.

SUPERSEDED

Table 4.6.2.2 – Abutment protection type selection criteria

Reference Standard Drawing No	Drawing description	Non expansive soils ^(b)			Expansive soil ^(b)	Applications in exposure classification C to AS 3600
		Overpasses ^(e)	Stream velocity ^(a) V ≤ 2.0 m/s	Stream velocity ^(a) V > 2.0 m/s		
2232	Type 1 – Rock spillthrough up to 1700 clearance	✓	✓	×	×	✓
2233	Type 1 – Rock spillthrough greater than 1700 clearance	✓	✓	×	×	✓
2234	Type 2 – Reinforced concrete over spillthrough up to 1700 clearance	✓	✓	×	×	×
2235	Type 2 – Reinforced concrete over spillthrough greater than 1700 clearance	✓	✓	×	×	×
2236	Type 4 – Rockwork over spillthrough up to 1700 clearance	✓	✓	×	×	✓
2237	Type 4 – Rockwork over spillthrough greater than 1700 clearance	✓	✓	×	×	✓
2238	Rock masonry	✓	✓	×	×	✓
–	Type 6 – Interlocking blockwork over earth spillthrough ^{(c), (d)}	✓	×	×	×	×
2241	Type 7 – Rock filled gabion protection height up to 6 metres	×	✓	✓	✓	×
–	Solid concrete block protection ^{(c), (d)}	✓	✓	✓	✓	✓
–	Riprap protection ^(c)	×	✓	✓	✓	✓

a) Stream velocity (V) = Average stream velocity at bridge cross section.

b) Subgrade soil condition shall be determined in consultation with project geotechnical engineer.

c) Currently there is no Transport and Main Roads Standard Drawing for this protection type. Project specific design to be developed to suit.

d) Preferable to use for repair of damaged bridges, not for new bridges and widening.

e) Flood free overpasses.

4.6.2.3 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.

4.6.3 Abutments designed for soil settlement and movement

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 Table 2.2 Settlement Criteria, as specified in the department's *Geotechnical Design Standard - Minimum Requirements* (refer Part A, Section 1.4.3.5 of this document).

Raked piles shall not be used where significant settlement is expected unless a full analysis of long term ground movements confirm that the abutment pile forces are within safe limits. Refer to Section 4.4.7 for general raked pile requirements.

4.6.4 Reinforced soil structure walled abutments

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.

Refer Chapter 10 for RSS wall design requirements.

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.

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 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.

4.6.5 Abutment spread footings

Abutments shall only be supported on spread footings (refer Section 4.3) where they can be founded on competent rock acceptable to the Transport and Main Roads Director (Geotechnical).

Abutments shall not be founded on rock or soil that is strengthened by rock or soil anchors or by other means.

In the absence of competent rock for spread footings, abutments shall be founded on piled foundations.

4.7 Bearings

4.7.1 Design life

Refer Section 4.2 for the design life of bearings.

4.7.2 Acceptable types of bearings

In general, bearings complying with AS 5100.4 are acceptable, with the following provisos:

- a) Disc bearings (using proprietary plastic type discs) are not permitted.
- b) Spherical bearings are generally acceptable. The department does not, however, have a technical specification for their application. If there is a compelling site justification, any proponent who believes the use of spherical bearings is the most efficient and practical manner of articulating the works may prepare a written submission for assessment by the Director (Structures Design, Review and Standards). Any proposal must be cost effective and achieve the strength, serviceability, and durability required.

4.7.3 Arrangement of bearings

4.7.3.1 Edge distance

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

4.7.3.2 Widened bridges

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

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/NZS 4680 or stainless steel. Bridge substructures shall be designed for the load effects of jacking of superstructure to replace bearings.

4.7.3.3 New bridges

The following requirements apply to the bearing arrangement for new 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 span length of 21 m or greater, each end of the deck unit shall be supported on a suitable bearing
- c) for transversely stressed deck units with span length of less than 21 m, the deck units may be supported on either mortar pads (preferred) or bearings, and
- d) all other superstructure types shall be supported on bearings.

4.7.4 Provision for jacking and bearing replacement

Bridge superstructures and substructures must be designed to allow for future jacking and replacement of bearings. A jacking procedure including number of jacking points shall be included in the design report and drawings at the concept design.

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.

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.

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.

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.

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.

Where the superstructure span is fixed at one end (for example, continuous deck structure or deck structure integral with pier), the member stress limits contained in these design criteria and AS(/NZS) 5100 must not be exceeded at any time during jacking of the free end for bearing replacement or maintenance.

4.7.5 Restraint of elastomeric bearings

Elastomeric bearings shall be in accordance with AS(/NZS) 5100. Elastomeric bearings including strip bearings, shall be restrained from creeping in any direction. This can be achieved by one of the following methods:

- i. Installing steel bearing restraint plates attached to the underside of girders.
- ii. 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.

4.7.6 Allowance for hog

4.7.6.1 General

When configuring bearing arrangements, designers shall make due allowance for any hog in PSC girders and deck units.

Design hog values at various stages (transfer, erection, deck casting and so on of construction), and the elastic modulus used for the hog calculation, shall be shown in the project drawings.

4.7.6.2 PSC deck units on elastomeric bearings

Designs shall allow for a layer of epoxy paste with a thickness not greater than 5 mm 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, as described in MRTS74 *Supply and Erection of Prestressed Concrete Deck and Kerb Units*. Notes to this effect should be included on the project drawings.

4.7.6.3 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 top attachment 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.

4.8 Superstructure elements

4.8.1 General

4.8.1.1 Superstructure types

The section relates to the provision of the principal superstructure elements in a bridge, which may be:

- PSC deck units
- PSC I-girders (if available)
- PSC Super T-girders
- PSC box girders
- Steel I-beams
- Steel box girders
- Wide flange PSC I-girders

4.8.1.2 Half-joints not permitted

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

4.8.1.3 Positive connection requirements

Bridge superstructures shall be positively connected to the substructure. Acceptable means include:

- reinforced concrete shear blocks with vertical dowels
- restraint angles
- holding-down bolts, and
- shear blocks with pins.

Floating superstructures on bearings, which only rely on friction for restraint, are not permitted.

Positive hold down connection shall be provided where required to resist uplift.

The design of temporary girder restraints required during construction are dependent on the construction methodology and, as such are part of the Contractor's temporary works design. Permanent restraints would not normally be suitable for use as temporary restraint purpose as they are required to allow certain free movements which are not acceptable for temporary works. However, if the girder permanent restraints are to be used for temporary restraint, they must be designed and certified by appropriately experienced RPEQ permanent works Designer as suitable for the permanent loads and movements as well as temporary construction loads and movements.

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.

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

Cast in restraints shall be galvanised or stainless steel (refer Section 3.12.2.3).

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

4.8.1.4 External post-tensioned concrete superstructures

Permanent external prestressing for superstructures is not permitted.

4.8.1.5 Transfer strength of prestressed concrete superstructure elements

The following PSC superstructure elements shall be designed with concrete strength at transfer greater than or equal to 35 MPa, and less than or equal to 40 MPa:

- deck units
- I-girders
- Super T-girders, and
- wide flange I-girders.

The upper limit of concrete strength at transfer has been assessed by Transport and Main Roads as being suitable for a 24 hour turnaround cycle of a typical precasting yard using steam curing. Departmental evidence suggests that higher transfer strengths will affect precasting yard preferred production cycles resulting in significant cost increases. Designers shall obtain approval from the department for transfer strengths in excess of 40 MPa.

4.8.1.6 Prestressing strand

Notwithstanding the provisions of Table 3.3.1 in AS 5100.5, any 7 wire ordinary strand used in PSC superstructure elements shall be Registered Prestressing Strand in accordance with the Registration Scheme *Suppliers and Products for Bridges and Other Structures* (refer Section 1.4.3.9).

4.8.1.7 Partial prestress

Partial prestress, in accordance with the provisions of Clause 8.6.2 of AS 5100.5, is not permitted, except for the HLP 400 load case (refer Appendix B).

4.8.1.8 Cast insitu decks

The maximum time that can elapse between the casting of precast girders or deck units, and the subsequent placing of a cast insitu reinforced concrete deck, shall be 200 days.

4.8.2 Prestressed concrete deck units

4.8.2.1 General

The design of transversely stressed prestressed concrete deck units shall be based on Standard Drawing 2042 *Precast Units – Design Assumptions for Transversely Stressed Standard Deck Units*.

The standard deck unit width shall be 596 mm.

The nominal spacing of deck units, measured at the centre line of the holding down bolts, shall lie between a minimum of 621 mm and a maximum of 626 mm, normal to the centre line of the units.

For wide deck bridges that utilise deck units, and where maximum jack requirements in accordance with Section 3.5.7 of this document cannot be met, a spaced deck unit arrangement will be accepted, provided the maximum clear distance between deck units does not exceed 250 mm. Spaced deck units require end diaphragms at abutments and piers to provide adequate end restraint, and uniform distribution of loads during jacking.

The thickness of the wearing surface on deck unit bridges shall comply with Section 4.10 of this document, with particular consideration being given to wide deck bridges where excessive thicknesses need to be controlled, particularly at joints.

4.8.2.2 Transfer strength

Refer to Section 4.8.1.5 for the transfer strength requirements for PSC deck units.

4.8.2.3 Prestressed concrete deck unit ligatures

The ligatures in PSC deck units are typically placed above 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. The 'end length' comprises the first debonding length plus development length of the strand (60 x strand dia.) or 1000 mm whichever is greater.

Designers shall be aware that the effective depth used in torsion and shear calculations needs to be reduced accordingly.

The rationale 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.

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

Strands located in the corner of ligatures shall not be debonded.

4.8.2.4 Skew angle considerations

Where transversely stressed deck unit bridges are designed on a skew ranging between 30° - 45°, longitudinal shear must be addressed in the design, including consideration for shear keys, as required by Standard Drawing 2042.

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

When the skew of the superstructure unavoidably exceeds 45°, the deck units shall be installed on the actual skew, but ends of the deck units shall be detailed at 45° (acute angle of the girder ends), as required in Clause 4.8.2.4(b).

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

Sharp corners shall be truncated.

4.8.2.5 Voids in prestressed concrete deck units

Maximum void length in PSC deck units shall be 2.0 m.

Skewed deck units require skewed voids. Sharp points on highly skewed void formers shall be truncated with a 50 mm chamfer to avoid the corner breaking off during casting.

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.

4.8.2.6 Lifting of prestressed concrete deck units

The design of lifting points for PSC deck units shall RPEQ certified by the deck unit designer in accordance with MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

4.8.2.7 Waterproof membrane

A waterproof membrane in accordance with MRTS84 *Deck Wearing Surface* shall be provided for the entire bridge deck for all deck unit bridges.

4.8.2.8 In-fill sheets

In cases where the deck units are spaced apart, the permanent formwork for the deck slab shall be in accordance with Section 4.8.5.6.

4.8.3 Prestressed concrete I-girders

4.8.3.1 General

Standard sections for PSC I-girders are provided in Appendix D of AS 5100.5.

Standard section PSC I-girders, may not be available in all markets, and designers shall make enquiries about availability before proposing their use.

Bespoke I-girder profiles shall be subject to acceptance by the Director (Structures Design Review and Standards).

4.8.3.2 Transfer strength

Refer to Section 4.8.1.5 for the transfer strength requirements for I-girders.

4.8.3.3 Diaphragms

I-girder superstructures shall be designed with a diaphragm between girders at each pier and abutment to provide torsional restraint and 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.

4.8.3.4 Lifting of prestressed concrete I-girders

The design of lifting points for PSC I-girders shall be RPEQ certified by the girder designer in accordance with MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

4.8.4 Prestressed concrete Super T-girders

4.8.4.1 General

Notwithstanding the standard sections for PSC Super T-girders provided in Appendix D of AS 5100.5, the dimensions for Super T-girders shall comply with the provisions of Section 4.8.4.3.

4.8.4.2 Transfer strength

Refer to Section 4.7.1.5 for the transfer strength requirements for PSC Super T-girders.

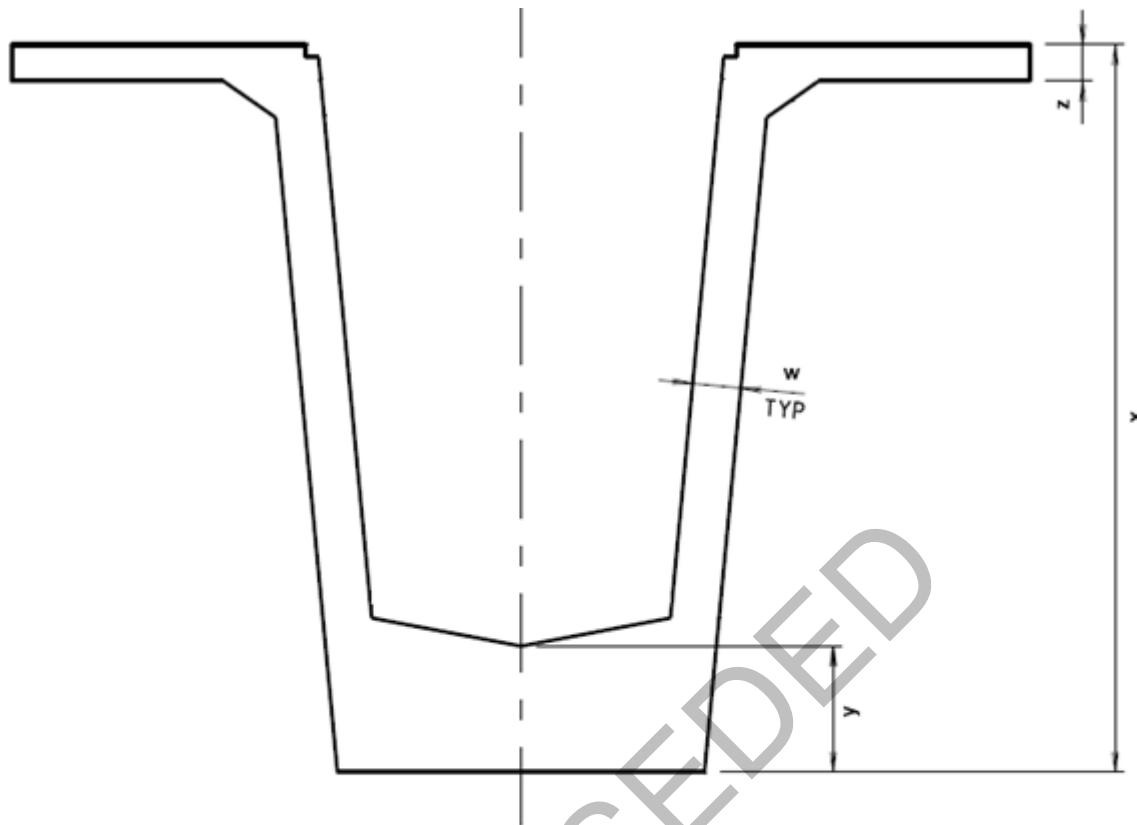
4.8.4.3 Super T-girder dimensions

Closed flange Super T-girders are not permitted.

Super T-girders shall have internal diaphragms and the maximum void length between diaphragms shall be 5.0 m.

Super T-girder section dimensions and void arrangements shall be in accordance with Figure 4.8.4.3 and Table 4.8.4.3 respectively.

Figure 4.8.4.3 – Dimensions of the Super T-girders



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

Table 4.8.4.3 – Void arrangement of Super T-girders (indicative only)

Nominal length (m)	Super 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	19,950
21	3	0	2	2825	20,950
22	3	1	3	2000	21,950
23	3	1	3	2500	22,950
24A	3	1	3	3000	23,950
24B	4	0	3	1750	23,950
25	4	0	3	2250	24,950

Nominal length (m)	Super 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)		
26	4	0	3	2750	25,950
27	4	1	4	1925	26,950
28	4	1	4	2425	27,950
29	4	1	4	2925	28,950
30	5	0	4	2175	29,950
31	5	0	4	2675	30,950
32A	5	0	4	3175	31,950
32B	5	1	5	1850	31,950
33	5	1	5	2350	32,950
34	5	1	5	2850	33,950
35	6	0	5	2100	34,950
36	6	0	5	2600	35,950

4.8.4.4 End diaphragms

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

Super 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.

4.8.4.5 Maximum skew angle

Concrete trough and Super T-girders shall not be cast with skews exceeding 45° . This requirement relates to practicality of casting yards.

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

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*, Volume 3 - *Structural Drafting Standards*, Chapter 14 for typical reinforcement arrangement at the skew ends of the girders.

Sharp corners shall be truncated

4.8.4.6 Debonding of strands

Strands located in the corners of ligatures shall not be debonded.

4.8.4.7 Lifting of prestressed concrete Super T-girders

The design of lifting points for PSC Super T-girders shall be RPEQ certified by the girder designer in accordance MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

4.8.5 Sacrificial formwork for precast girders and deck units

The sacrificial formwork for the in-situ reinforced concrete deck over precast PSC girders and deck units, and between the separated flanges of Super T-girders shall comply with the following requirements.

4.8.5.1 Design loads and load combinations

The design loads to be applied to the formwork are:

- i. self-weight, and
- ii. construction loads.

The limit state design factored load combinations for strength, stability and stiffness (deflection) shall be in accordance with AS 3610 *Formwork for Concrete* Table 4.5.1.

4.8.5.2 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.

Stage 1 loads:

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

Stage 2 loads:

- i. wet concrete
- ii. concentrated load which shall be in accordance with AS 3610.

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.

4.8.5.3 Edge support of formwork

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

4.8.5.4 Acceptable deflection

The deflection of sacrificial formwork shall be determined in conjunction with the load combinations specified in AS 3610 Table 4.5.1. The maximum allowable deflection for all stages of construction shall be $\text{span}/360$ for all products.

4.8.5.5 Strength limit state design

The maximum ultimate limit state stresses for load combinations in AS 3610, Table 4.5.1 for all stages of construction shall be less than the specified design flexural strength of the material.

4.8.5.6 In-fill sheets

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

- the deflection shall be in accordance with the acceptable deflection criteria
- the ultimate design stresses shall not exceed the design flexural strength of the panels, and
- safely support construction personnel and loads.

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

- plywood and wood based panel products; because moisture ingress degrades the material, which may then block drainage of the cells in the girder, and
- cold formed steel sheet sections; due to deformation of profile during loading.

Any alternative product proposed by the designer, except those listed under Section 4.8.5.6 b) may be considered as an alternative product for in fill sheets, subject to acceptance by the Director (Structures Design Review and Standards). Any alternative product shall:

- i. resist the design loads
- ii. be durable for 100 years
- iii. satisfy the deflection criteria outlined previously, and
- iv. not change shape when the formwork is loaded; testing may be required to verify the section does not deform.

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

4.8.6 Prestressed concrete box girders

4.8.6.1 General

All permanent prestressing shall be internal.

Grouting of internal prestressing ducts shall be in accordance with MRTS89 *Post Tensioned Concrete*.

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.

4.8.6.2 Segmental superstructures

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.

Match cast segmental superstructure construction may be used only in exceptional circumstances, subject to departmental acceptance by the Director (Structures Design, Review and Standards). The criteria listed in Sections 4.8.6.3 and 4.8.6.4 shall be used as the basis of a submission to use match cast precast concrete boxes.

Where approved, match cast segments shall be cast superstructure in accordance with MRTS72 *Manufacture of Precast Concrete Elements*.

4.8.6.3 Durability

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

All concrete shall be cured in accordance with MRTS70 *Concrete*. No reduction in curing standard will be permitted.

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

All prestressing ducts shall be in accordance with MRTS89 *Post-Tensioned Concrete* (steel ducts are not permitted).

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

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.

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 MRTS84 *Deck Wearing Surface* is not permitted.

4.8.6.4 Design

The standards which shall be used in the design of PSC box girders are listed in Table 4.8.6.4.

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

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

Table 4.8.6.4 – Prestressed concrete 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 C	Design of segmental bridges

The standards which shall be used during the erection stage of match cast concrete box girders are listed in Table 22.2.2 of AS 5100.2.

4.8.6.5 Additional segmental bridge design standards not covered in AS(/NZS) 5100

AS(/NZS) 5100 and the previous criteria shall be the main reference for design. Where these standards do not specifically address match cast box girders, however, AASHTO LRFD *Bridge Design Specification* may be used.

The standards which shall be used for segmental bridge design and construction of prestressed concrete segmental bridges are listed in Table 4.8.6.5.

Table 4.8.6.5 – 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

AASHTO LRFD Section 4.6.2.9 relates to:

- specific requirements for the analysis of time dependent effects
- specific requirements for transverse analysis of box sections, and
- specific requirements for erection analysis.

AASHTO LRFD Section 5.14.2 refers to:

- 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, and
- specific requirements for segmental bridge substructures.

4.8.6.6 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
- construction loads.

4.8.6.7 Lifting of prestressed concrete box girders

The design of lifting points for PSC box girders, where applicable, shall be designed and RPEQ certified in accordance with either MRTS72 *Manufacture of Precast Concrete Elements* or MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* as applicable.

4.8.7 Steel I-beams

Steel I-beams are generally less durable than prestressed concrete girders unless galvanised and/or regularly painted and maintained.

Steel I-beams are generally acceptable when widening an existing steel I-beam bridge superstructure and shall be galvanised, where possible.

For new bridges, steel I-beams shall be hot-dip galvanised. Painted girders (refer Section 4.17) are generally not preferred because of the ongoing costs of regular inspection, cleaning and repainting, including the cost of traffic control and disruption to traffic when painting steel superstructures over busy roads. Painting may be considered in situations where galvanising would be impracticable or cost ineffective, and where future re-painting can be achieved without major disruption to traffic.

Any proposal to utilise steel I-beams in a bridge is subject to departmental acceptance by the Director (Structures Design, Review and Standards).

4.8.8 Steel box girders

4.8.8.1 Cost benefit analysis

Steel box girder construction may be used only in exceptional circumstances, subject to departmental acceptance by the Deputy Chief Engineer (Structures) prior to commencing the design, based on an examination of value-for-money criteria and available alternatives.

The selection of a steel box girder design option will be based on the whole of life cost (refer Section 3.4), as well as any constraints on the use of concrete girders.

The Designer shall submit the whole of life cost for this option and an alternative non steel option (for example, concrete box girder option, open steel girders, and so on).

4.8.8.2 Design criteria

The criteria for steel box girder design shall include but not be limited to the following:

- a) Design life – the design life shall imply a 95% probability that, during the design life of the structure or element, it:
 - will not require major maintenance or replacement
 - will be functional
 - will require minimal maintenance, and
 - will blend and harmonise with the existing surrounds and planned landscaping.
- b) Durability.
- c) Robustness.
- d) Access for inspections.
- e) Access for maintenance to re apply protective coatings if not hot dipped galvanised.
- f) Constructability during fabrication and erection.
- g) Compliance with MRTS78 *Fabrication of Structural Steelwork*.

4.8.8.3 Design standards

Steel bridges are to be designed in accordance with AS (N/ZS) 5100. For the design of steel box girders, the minimum construction loads detailed in Table 22.2.2 of AS 5100.2 must apply during the erection stage.

4.8.8.4 Maintenance access

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.

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

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

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

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.

Access holes must be provided in all diaphragms.

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

Access provisions must comply with the *Work Health and Safety Act 2011* and the *Work Health and Safety Regulation 2011*, which include, but are not limited to, the provisions for the design of confined spaces.

4.8.8.5 Ventilation and drainage

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

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

4.8.8.6 Durability

All steel surfaces are to be protected from corrosion.

All steelwork, including internal faces, shall preferably be protected by hot dip galvanizing to AS/NZS 4680. Refer to additional requirements in Section 3.12.2.1, for steel with low silicon and low phosphorous contents.

All steel surfaces protected from corrosion by a paint system, shall comply with MRTS88 *Protective Coating for New Work*, and Technical Note 144 *Paint Systems for MRTS88*, subject to approval by the Director (Structures Design, Review and Standards). Refer also Section 4.16 of this document

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.

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

The coating system shall be shop applied.

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

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

The coatings shall have a 25 year design life, in accordance with AS 2312.1 as defined in Annexure MRTS88.1 to MRTS88 *Protective Coating for New Work*. The paint coating system shall include the recoating procedure for maintenance.

4.8.9 Steel composite bridge deck

The methods of analysis for steel composite bridges are covered in AS/NZS 5100.6, the analysis method being selected according to Table 4.8.9 in this document.

Table 4.8.9 – 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

The following issues are to be considered in the analysis of steel composite girder decks utilising reinforced concrete:

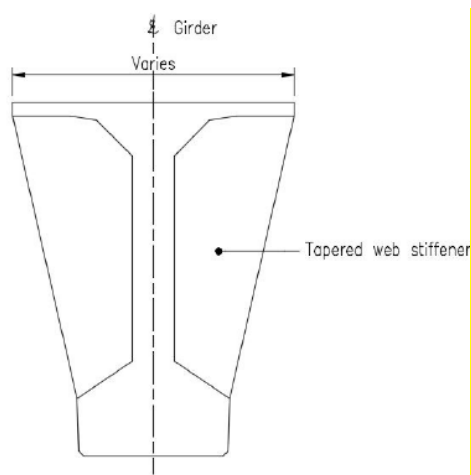
- shear lag (effective flange widths)
- ratio of elastic modulus between concrete and steel
- concrete cracking (in particular over pier supports for continuous bridges)
- torsional and distortional warping for box sections
- plate slenderness limits (compact vs non compact sections)
- element buckling
- member buckling (for example, lateral torsional buckling), and
- construction stage analysis.

4.8.10 Proprietary bridge deck systems

Proprietary bridge deck systems shall be a Transport and Main Roads approved product. The departments approved proprietary bridge deck systems and suppliers are listed in *Proprietary Design Index for Bridges and Other Structures*.

4.8.10.1 Wide flange I-girders

A sample Wide Flange I-girder type shape is shown in Figure 4.8.10.1.

Figure 4.8.10.1 – Wide flange I-girder shape

The department is procuring the complete structural system for the specific project, not just the girder. The selection of the deck system using this girder type shall consider the following:

- Implications on vertical and horizontal alignment.
- Transportability and handling from precast yard to the site.
- Feasibility and stability / safety of erecting the girders.
- Girder design shall ensure that the appropriate type of bridge bearings (such as pot bearings for large loads) are used. Also selected bearing type shall offer low maintenance and ease of bearing replacement options.
- Differential heights between adjacent girders for superelevation.
- Use of end diaphragms for torsional stability, and
- Effects of skew.

For shorter spans, the flange width would be wider than for longer spans, due to the use of fewer girders per span for short spans.

In comparison with other standard girder types, if the technical capability and functionality is the same, the most cost-effective utilisation / application of girder type will dictate the preferred design.

Bridge deck system using Wide Flange I-girders shall be designed in accordance with this document and the registered supplier's technical manual.

4.9 Deck drainage

4.9.1 General

The drainage system must be designed so that the amount of water flowing across deck joints is minimised. All drainage structures and associated pipework must be readily accessible for cleaning and maintenance purposes.

In general, bridges over roadways and railways shall incorporate a drainage collection and pipework disposal system that prevents stormwater from discharging onto carriageways and traffic below the bridge.

Bridge drainage over streams shall satisfy the requirements of the Environmental Management Plan (EMP).

In general, collection and treatment of drainage water over streams is not required unless specified in the EMP.

Where drainage pipes are required, they must be capable of being cleaned effectively, and placed between beams or behind an edge skirt to maintain clean lines on the bridge profile.

Drainage pipes should, where possible, contain an overflow system that prevents inundation of bridge decks if the pipework becomes blocked or overloaded.

To prevent structural overloading from flooding due to leaks and breakages in the pipe, stormwater pipes shall, preferably, not penetrate into the voided cell of Super T-girders and deck units. If unavoidable, a 100 mm diameter drain hole shall be detailed in the bottom flange of the cell containing the pipe, subject to approval by the Director (Structures Design, Review and Standards).

Drain pipes inside any void, cell or box girder shall be galvanised (hot dipped) steel pipe or stainless steel.

4.9.2 Crossfall and longitudinal gradient

4.9.2.1 New bridges

The crossfall and gradient on all new bridges shall be compatible with the geometric road design.

The minimum crossfall on new bridges shall be 2.5%.

If the bridge can potentially be submersed, then zero longitudinal gradient is acceptable, as this will minimise undesirable turbulence effects when the bridge is progressively inundated.

4.9.2.2 Widened bridges

The minimum crossfall shall be similar to the existing bridge deck.

The preferred minimum crossfall is 2.5%.

The existing deck wearing surface (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 (refer Section 4.10). Milling shall be in accordance with MRTS84A *Removal of Bridge Deck Wearing Surface*.

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 adversely affected, and the proposal is accepted by the Director (Structures Design, Review and Standards).

4.9.3 Waterproof membrane

A bituminous waterproof membrane in accordance with MRTS84 *Deck Wearing Surface* shall be provided for the entire bridge deck of all bridges.

For bridges with a footway, which is 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.

4.10 Deck wearing surface

The Deck Wearing Surface (DWS), where applicable, on all road bridges must be asphaltic concrete and must have a minimum design life as specified in *MRTS30 Asphalt Pavements*.

The asphalt used in DWS shall comply with *MRTS30 Asphalt Pavements*.

Construction of DWS shall be in accordance with *MRTS84 Deck Wearing Surface*.

On PSC deck unit bridges without a cast in situ deck slab, the DWS shall consist of a dense graded asphalt corrector course followed by a 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 shall note that the waterproof membrane could be removed during resurfacing and would need reinstatement.

On bridges with a cast in situ deck, the DWS shall consist of a 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 under the waterproof membrane to protect the deck during removal of the open graded asphalt and the maintenance requirements shall note that the waterproof membrane could be removed during resurfacing and would need reinstatement.

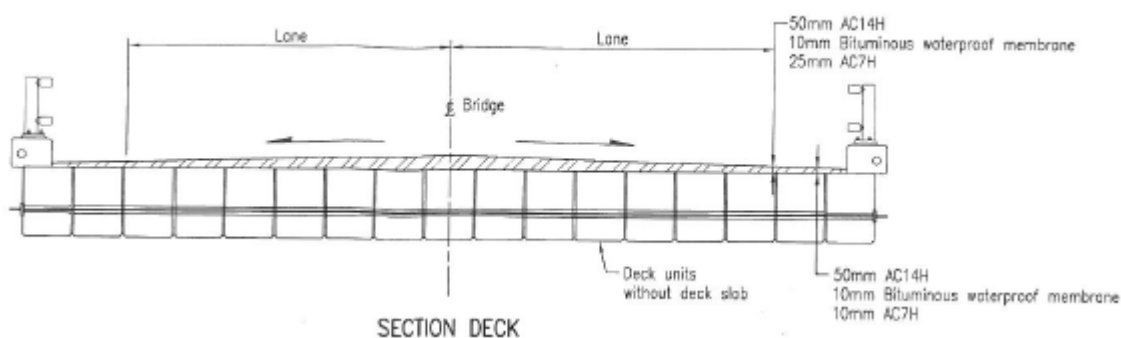
The minimum thickness of DWS (excluding bituminous waterproof membrane and corrector course as noted above) on bridges shall comply with *MRTS30 Asphalt Pavements*.

The minimum DWS thickness to be allowed in design shall be in accordance with *MRTS30 Asphalt Pavements* Table 8.6.1 and as noted below:

- i. For two way crossfall carriageways on PSC deck unit bridges without a cast in situ deck slab, the minimum DWS thickness shall be 85 mm on trafficked lanes (70 mm at kerb). This minimum DWS shall comprise:
 - 25 mm minimum AC7H corrector course (10 mm at kerb)
 - 10 mm waterproof membrane, and
 - 50 mm AC14H surfacing layer.

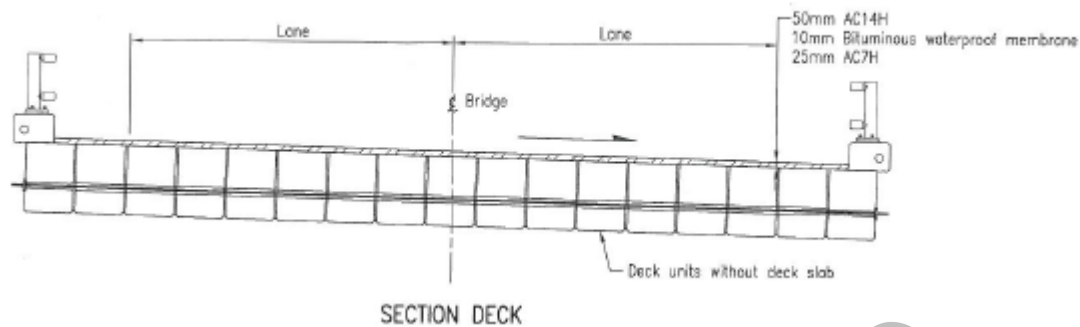
The Designer shall increase the DWS thickness, if necessary, to ensure minimum 25 mm thick corrector course under the traffic lanes allowing for crossfall and minimum thickness at kerb (refer Figure 4.10(a)).

Figure 4.10(a) - DWS for two-way crossfall carriageways on PSC deck unit bridges



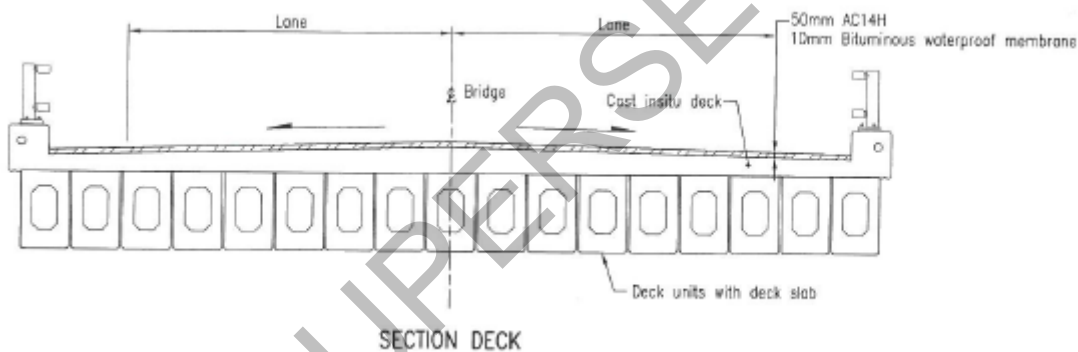
- ii. For one-way crossfall carriageways on PSC deck unit bridges without a cast insitu deck slab, the minimum DWS thickness shall be 85 mm. This minimum DWS consists of 25 mm minimum AC7H corrector course, 10 mm waterproof membrane and 50 mm AC14H surfacing layer (refer Figure 4.10(b)).

Figure 4.10(b) - DWS for one-way crossfall carriageways on PSC deck unit bridges



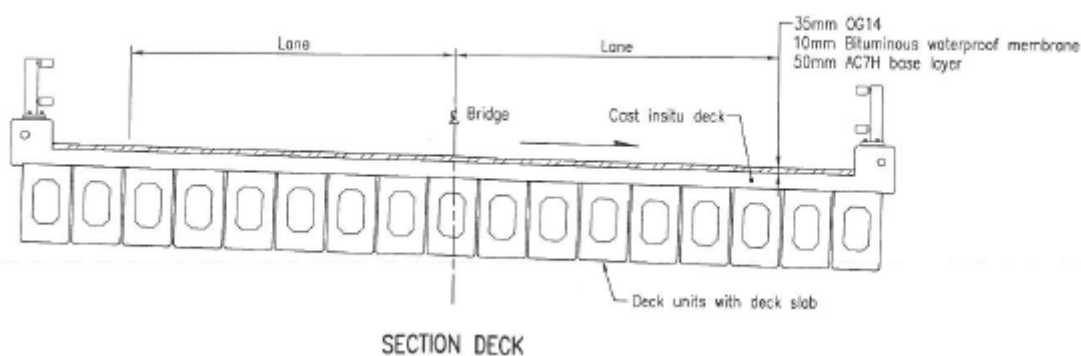
- iii. For bridges with a cast in situ deck slab, the minimum DWS thickness shall be 60 mm. This minimum DWS consists of 10 mm waterproof membrane and 50 mm AC14H surfacing layer (refer Figure 4.10(c)).

Figure 4.10(c) - DWS for cast in situ deck slab



- iv. For bridges with a cast insitu deck slab where the final layer is OG asphalt, the minimum DWS thickness shall be 95 mm. This minimum DWS consist of 50 mm AC14H base layer, 10 mm waterproof membrane and 35 mm OG14 surfacing layer (refer Figure 4.10(d)).

Figure 4.10(d) - Open graded DWS for cast in situ deck slab



- v. The DWS thickness for wide deck unit bridges will require careful consideration to ensure that joint nosing thicknesses fall within specified limits. Design nosing thicknesses outside the limits specified on the joints supplier's technical data sheets will be subject to specific written approval by the supplier.

4.11 Bridge traffic barriers

4.11.1 General

Bridge traffic barriers shall be provided in accordance with this section.

The requirements for barriers to other (non bridge) structures shall comply with the department's *Road Planning and Design Manual Edition 2, Volume 3, Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*.

All new bridge traffic barriers shall conform to:

- AS(/NZS) 5100, and
- any further requirements detailed in Appendix B Additional requirements to AS(/NZS) 5100 *Bridge Design*.

The minimum design load for barriers on new bridges shall be 'regular' level to AS(/NZS) 5100.

For details for bridge widening and replacement of existing barriers, refer to Appendix A Matters for Resolution to AS(/NZS) 5100.

4.11.2 Functionality and appearance

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

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 1 (V) to 10 (H).

Frangible attachments, defined as having a maximum section dimension of 90 mm with 5 mm wall thickness for square, rectangular or circular sections in accordance with AS/NZS 1163, shall have a maximum slope of 1 (V) to 2(H).

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

4.11.3 Post and rail traffic barriers for afflux reduction

In situations where afflux is a design constraint, on bridges over streams, creeks and rivers with a flood immunity of less than 0.05% AEP (2000 year ARI), steel post and rail bridge traffic barriers shall be used to reduce its effect.

4.11.4 Concrete barriers

Concrete traffic barriers shall be used on overpass bridges. Details of cover plates at expansion joints are provided in Section 4.12.

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

- slip forming of concrete traffic barriers and median barriers, and
- extruding concrete barrier.

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.

In accordance with the Matters for Resolution in AS 5100.1 (refer Appendix B of this document), the minimum height of a concrete barrier shall be as shown in Table 4.11.4.

Table 4.11.4 – Minimum heights for concrete barriers

Barrier performance level	Minimum height (m)
Low	1.1
Regular	1.1
Medium	1.2
Special (44 t articulated van)	1.5
Special (36 t articulated tanker)	1.8

4.11.5 Precast concrete barriers

Precast concrete traffic barriers shall conform to the following requirements:

- Precast barriers fixed to the bridge deck with only concrete stitch pours or joints are not acceptable. A precast outer face with a cast in situ concrete inner face (each part with 100 mm minimum thickness) 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.
- Reinforcing bars connecting the barrier to the deck are to be uniformly spaced, approximately 150 mm apart.
- Grouting reinforcing bars in small holes does not guarantee quality, hence, these designs are not acceptable.
- Recessed holes are not acceptable.
- 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 as clarified in Appendix A Matters for Resolution to AS/(NZS) 5100, or as required in the design brief, project SWTC, or as agreed with the Director (Structures Design, Review and Standards).
- In addition to the requirements in this document, precast barriers shall be designed and manufactured to MRTS72 *Manufacture of Precast Concrete Elements*, where applicable, including requirements for lifting.

4.11.6 Transition between road and bridge barriers

The transition from road barriers to bridge barriers must ensure:

- 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, and
- d) refer to Appendix B Additional Requirements to AS(/NZS) 5100 in 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 crossover crashes / incidents. The approach barrier shall stop 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 contained in the department's *Road Planning and Design Manual Edition 2, Volume 3, Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*.

The balustrade may narrow the footpath width. Additionally, a balustrade may pose a hazard to cyclists. These issues shall be carefully considered to avoid conflicts with active users.

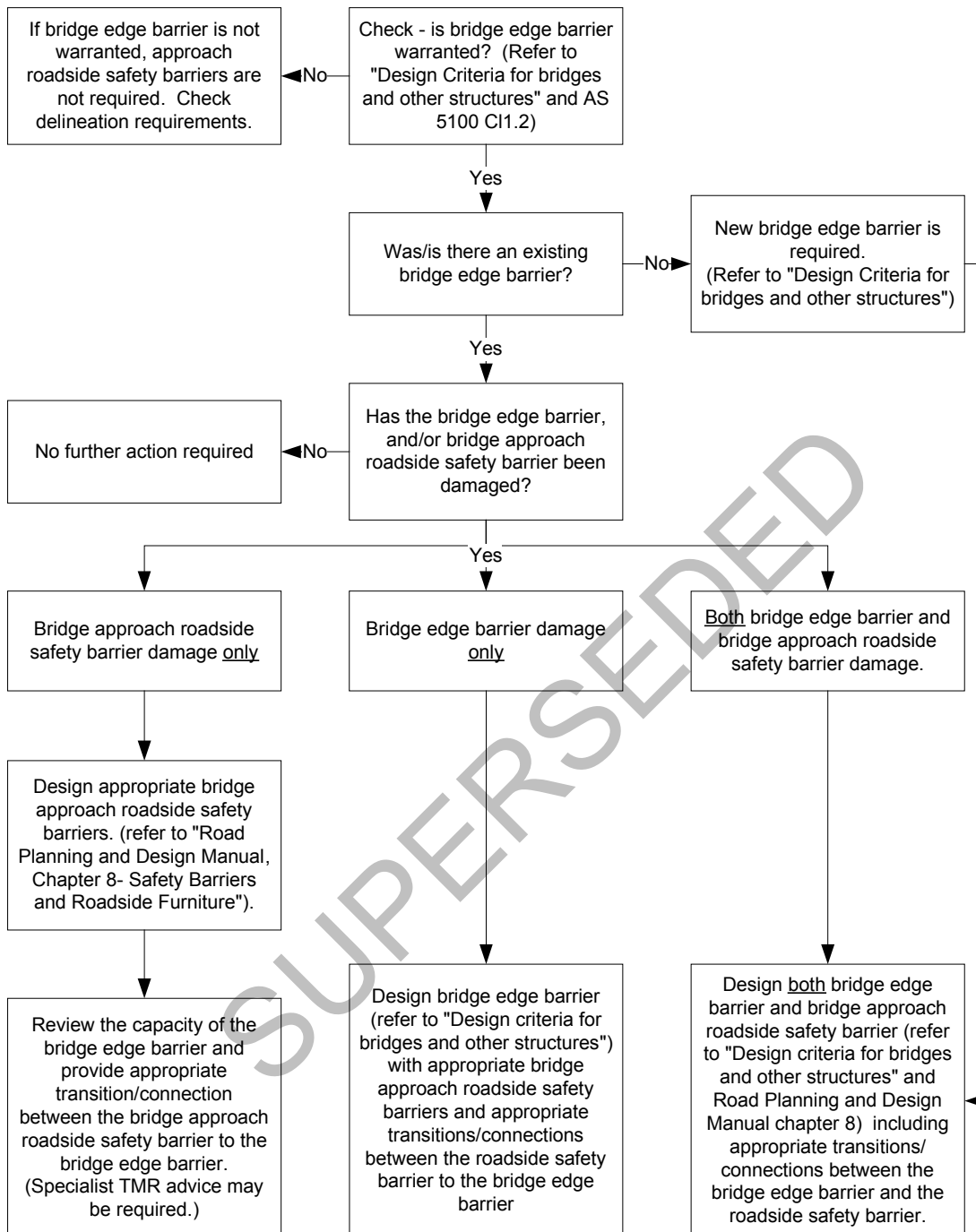
4.11.7 Retrofit of barriers

With regard to design for retrofitting existing barriers and installing new barriers on existing bridges and approaches, the following shall apply:

- a) Balustrades are on the outside of footpaths.
- 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 shall not be connected to the end of a balustrade.

For the assessment process refer to Figure 4.11.7.

Figure 4.11.7 – Flow chart for assessing bridge barriers and transition to roadside safety barriers



4.11.8 Design for temporary barriers – worker protection during construction

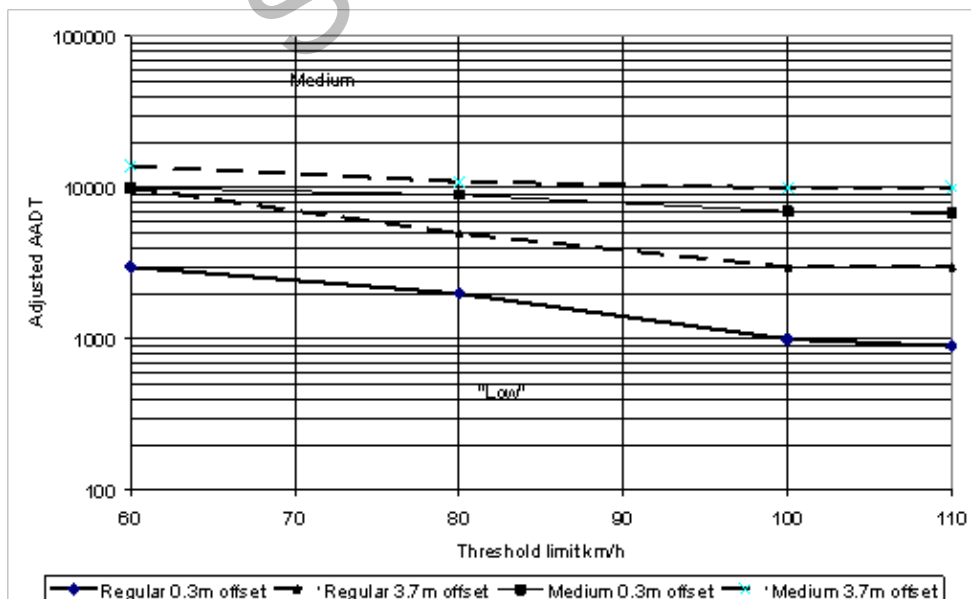
When workers and/or work areas are behind the barrier, both the designer and the contractor have safety in design obligations under legislation. Additionally, due to safety in design considerations, the designer has a duty to ensure that there is no foreseeable risk to the workers during construction. Temporary barriers shall be designed to comply to the provisions in accordance with AS 5100.1 Appendix A, except Figures A5 to A8 are replaced by Table 4.11.8 and Figure 4.11.8.

While design of temporary barriers may be the responsibility of the contractor, the permanent Works designer has a safety in design responsibility to ensure the Works can be carried out safely. This shall be addressed in Safety In Design (SID) workshops during the design phase. For example, assess the safety aspects during staged construction or widening of bridges while under traffic and incorporate control measures for identified risk. The permanent Works designer has to allow for all temporary work load effects in the permanent Works design.

Table 4.11.8 – Complying criteria for temporary barriers to AS(/NZS) 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
60	< 3000	< 10,000	Low
	≥ 3000 and < 10,000	≥ 10,000 and < 14,000	Regular
	≥ 10,000	≥ 14,000	Medium
80	< 2000	< 5000	Low
	≥ 2000 and < 9000	≥ 5000 and < 11,000	Regular
	≥ 9000	≥ 11,000	Medium
100	< 1000	< 3000	Low
	≥ 1000 and < 7000	≥ 3000 and < 10,000	Regular
	≥ 7000	≥ 10,000	Medium
110	< 900	< 3000	Low
	≥ 900 and < 6800	≥ 3000 and < 10,000	Regular
	≥ 6800	≥ 10,000	Medium

Figure 4.11.8 – Deemed-to-comply temporary barriers to AS(/NZS) 5100 to protect workers – 45 t semi-trailer and 68 t B-double



4.11.9 Wire rope barriers

Wire rope barriers shall not be used on bridges.

4.11.10 Attachments to barriers on bridges

In certain circumstances it is necessary to include ancillary road infrastructure on a bridge, including:

- noise barriers
- safety screens (anti-throw and/or anti- jump)
- electrification barriers
- lighting
- signage, and
- ITS equipment.

Where noise barriers, safety screens, and electrification barriers must be continuous across a bridge, it is a requirement that the barriers, screens, panels and posts 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.

Other ancillary items shall be attached in such a way that they cannot be struck by traffic impacting the barrier.

The requirement for, and design criteria for, anti-throw screens must be in accordance with the following departmental documents, and accepted by the Director (Structures Design, Review and Standards):

- *Technical Guidelines for the Treatment of Overhead Structures – Objects thrown or dropped, and*
- *Reduction of risk from Objects thrown from overpass structures onto roads policy.*

Any provision for anti jump screens shall be subject to:

- Risk analysis shall be undertaken to assess whether anti jump screens are required to reduce the risk of jumping from high structures.
- The methodology shall be similar in principle as that used for anti throw screening on overpass structures.
- Factors to consider include:
 - height of bridge / structure (>25 m), geographical location, social economic situation, and
 - whether the structure is iconic / landmark that effects undesirable attention and so on.
- Options to consider include:
 - installation of anti jump screens in the current project at the time of construction, or
 - make provisions in the structure for easy / practical installation of anti jump screens in future, should the need arise, and
- In any case, the structure shall be designed to include loads resulting from the anti jump screens.

4.11.11 Barriers between active users and bridge carriageway

Active users are pedestrians (including disabled users) and cyclists. Active user paths are also frequently referred to as footpaths.

A traffic barrier is required between any active transport paths on a bridge and the traffic carriageways, unless agreed otherwise with the department's Director (Structures Design, Review and Standards), who may consider a relaxation of the barrier requirement if:

- the speed limit of the road is 60 km/hr or less, and
- the active user path will not be used by a significant percentage of children or students (for example, the path is not located near a school, park, sports facility or the like).

In such cases a formal dispensation is required from the Director (Structures Design, Review and Standards).

A barrier between an active user path and carriageway shall be a rigid traffic barrier with a pedestrian / cycleway balustrade constructed to the appropriate height above the traffic barrier as shown in Figures 4.11.11(a) and 4.11.11(b), as appropriate. Generally, the height of the balustrade shall be in accordance with AS 5100.1. Where cyclists may use the path, the balustrade height should be 1.4 m, unless the designer considers the bicycle crash risk factors at the site are low, in which case a minimum height of 1.2 m may be considered. Compounding risk factors that would require a 1.4 m high barrier include:

- proximity to hazards that are likely to cause serious or fatal injury
- tight curves that may increase the likelihood of a cyclist being launched over a barrier
- steep gradients that encourage high speeds and increase the risk of launching, and
- likelihood of head on collision with the barrier.

Where these risk factors are low, a 1.2 m barrier may be considered, especially if the higher barrier has an unacceptably negative effect on cyclist sightlines.

These barriers shall have the following characteristics:

- The front face of the pedestrian rail shall be set back a minimum of 100 mm behind the road face of the traffic barrier.
- The front face of the cycleway barrier (for shared paths) shall be so arranged that either:
 - It's leading edge is set forward 150 mm in front of the inside edge of the raised kerb. If this is achieved by a safety rail, as shown in Figure 4.11.11(a), the rail shall be set at a height of 1.2 – 1.4 m, or.
 - The barrier provides a relatively flat panel surface.

Recent research carried out by the Department of Transport and Main Roads suggests that cycle safety rails set at a height of 1.4 m (as shown in Figure 4.11.11(a)) may not suit all user types, particularly children. Designers should give some consideration to the height of bicycle safety rails with respect to the user mix anticipated, irrespective of the height of barrier chosen. For example, a risk analysis may suggest a barrier height of 1.4 m, while an analysis of the user mix might suggest the safety rail be set at a height of 1.2 m.

- Where a traffic barrier has an additional high rail for pedestrian / cycle safety, this rail, including its connections and joints, shall be designed so that it shall not come loose in the event of a vehicle impact and spear into the vehicle.
- Where a footpath is used by a significant percentage of young children (for example, the path is located near a school), a non-climbable 'protection panel' shall be attached to the bridge barrier on the footpath side. This protection panel shall start at 150 mm clear from the top of the concrete kerb and extend up to the pedestrian safety rail as shown in Figures 4.11.11(a) and 4.11.11(b). The protection panels shall be galvanised for durability and made of:
 - vertical rods of 16 mm diameter minimum at 150 mm spacing, or
 - steel perforated sheet of 1.6 mm thickness.

Barriers, balustrades and railings shall be designed for loads in accordance with AS 5100.2.

Where a barrier between footpath / cycle path and carriageway is not required, a 300 mm high non mountable kerb with a vertical face as shown in Figure 4.11.11(c) shall be provided. A balustrade shall be provided at the edge of the bridge and no bridge traffic barrier is required. The kerb shall be flushed with the shared path pavement surface level to avoid pedestrian trip hazard.

Figure 4.11.11(a) – Barrier between carriageway and shared path

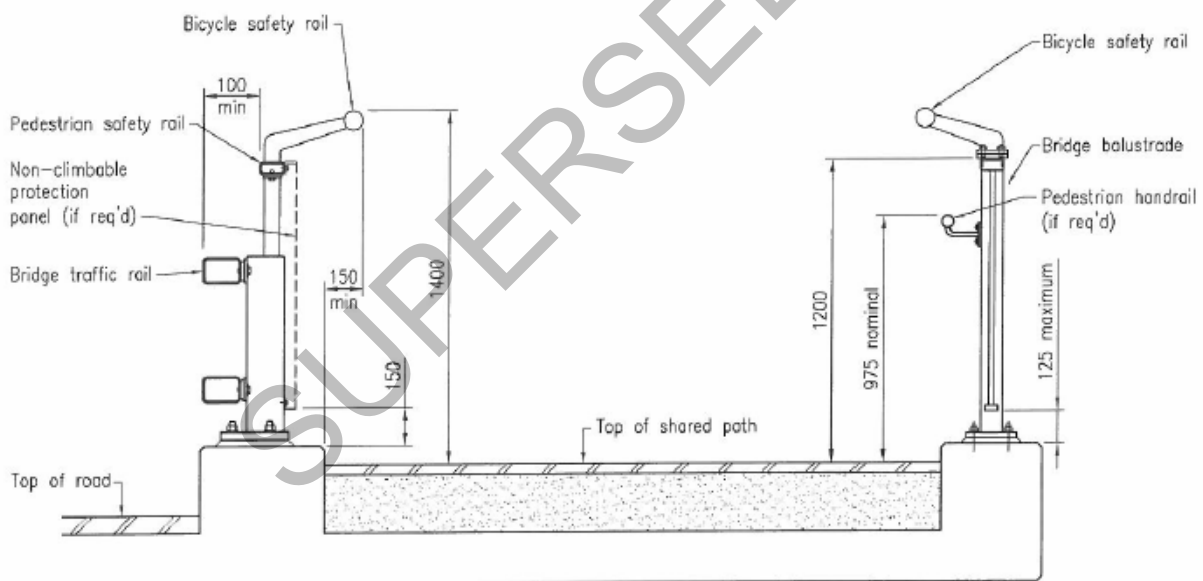
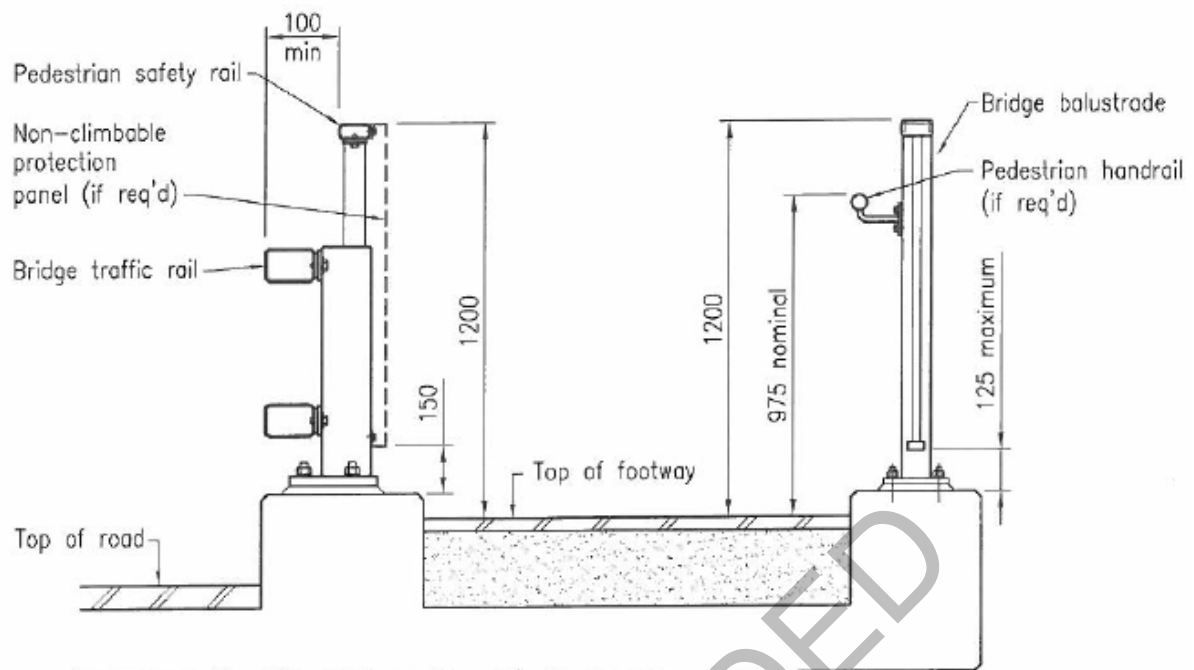
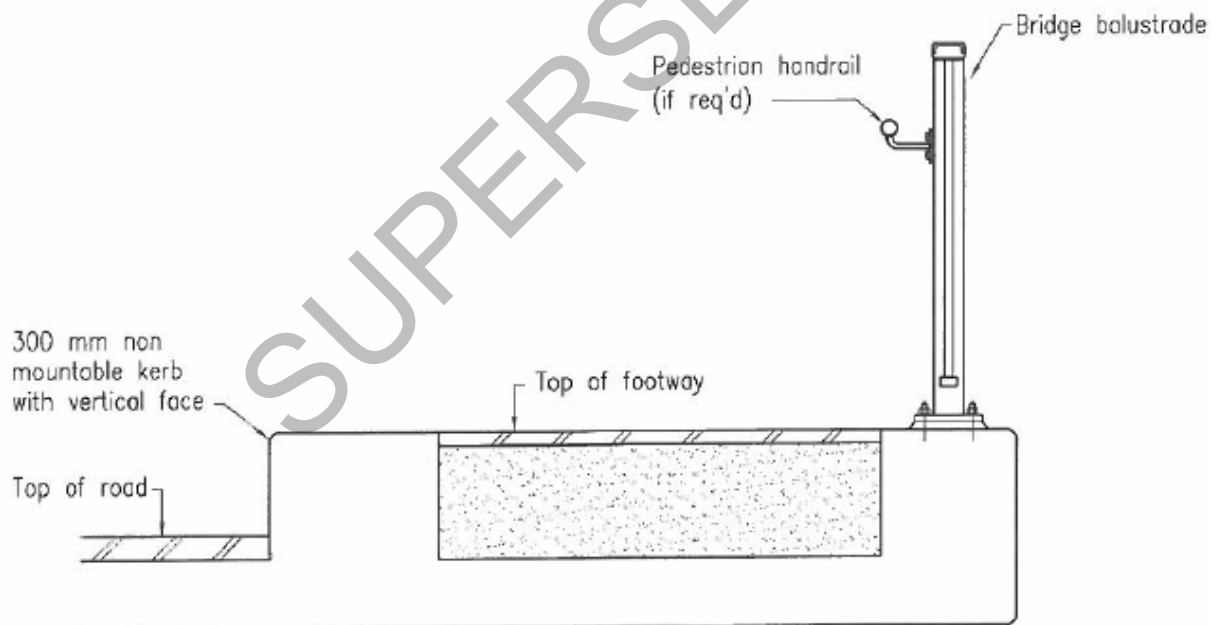


Figure 4.11.11(b) – Barrier between carriageway and footpath**Figure 4.11.11(c) – No barrier between carriageway and footpath**

Rigid traffic barriers should have transition in the vertical plane at a maximum slope of 1 in 10.

Frangible attachments in traffic barriers shall have a maximum slope of 1 (V) to 2 (H).

The pedestrian barrier shall have transition at 1 in 10 in the vertical plane if it is non frangible.

Frangible barriers can transition in a vertical plane.

Frangible barriers are defined as 90 mm maximum dimension with 5 mm wall thickness for square, rectangular or circular section based on AS/NZS 1163.

Barriers should not present as a spearing or snagging hazard.

4.11.12 Barrier protection for new bridge supports

Refer to AS(NZS) 5100 and Appendix B to this document for requirements to protect new bridge supports. Section 3.2.3.1 b) also applies for single column piers.

For the purposes of protecting new bridge supports, the minimum extent of the clear zone shall be 10 m, unless calculations indicate a clear zone of more than 10 m is appropriate.

4.11.13 Barrier protection for existing bridge supports

4.11.13.1 General

Where a road upgrade project is carried out adjacent to an existing bridge, or an existing bridge is to be widened, a review of the bridge's resistance to impact shall be undertaken.

Existing bridge supports that are within the road reserve shall be protected from vehicle impact using an appropriate barrier system as required in Sections 4.11.13.2 & 3 below.

In addition to the protection barrier, the bridge support shall be checked for the following impact loads:

- for vehicle speed equal to 100 km/hr or higher, the bridge support shall be checked for an impact load of 2700 kN
- for vehicle speed less than 100 km/hr, the impact force can be reduced by a factor $(V/100)^2$, where V is the vehicle speed, but the minimum impact force shall not be less than 1000 kN.

The possible angle of impact shall be determined by a risk analysis, but the minimum impact angle shall be 15° from the direction of the road centre line passing under the bridge. The load shall be applied 1.2 m above ground level. The effective contact length of the load is the smaller of the contact length on the support (for example, 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.

Where bridge support capacity is not sufficient, strengthening may be required.

If the existing bridge piers and abutments consist of column type structures, strengthening may require retrofitting with reinforced concrete 'infilling' between individual columns to provide a blade structure for robustness and structural adequacy for impact resistance, provided the impact load can be satisfactorily distributed to the retrofitted foundations.

Where considered necessary, by the constructing authority, a benefit cost analysis may be carried out, in accordance with an approved SFAIRP guideline, to confirm whether strengthening works are required to achieve an acceptable level of risk management.

4.11.13.2 Protection of existing bridge supports within the 10 m clear zone

For the purposes of protecting existing bridge supports, the minimum extent of the clear zone shall be 10 m, unless calculations indicate a clear zone of more than 10 m is appropriate.

Bridge supports that are within the clear zone (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 80 km/h as a minimum barrier requirement complying with the requirements of Section 11.2 of AS 5100.2 with appropriate approach treatment. The barriers shall be designed so as to not transmit the barrier design load to the bridge supports. However, the design barrier performance level shall be

determined using the barrier selection method in AS/NZS 3845 and the department's RPDM (Edition 2). 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.

A rigid barrier 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.

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

The protection barrier shall extend at least 6 m beyond the end of the protected structure in both directions, or longer if required by the risk assessment, and a transition provided to standard road barrier for continuation to the total length. 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 Edition 2, Volume 3, Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*.

4.11.13.3 Protection of existing 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 minimum clear zone of 10 m, as defined in Section 4.11.13.2.

The selection of barrier type is subject to the results of a risk analysis taking into account the modification factor for horizontal curve, slopes and so on in the department's *Road Planning and Design Manual Edition 2, Volume 3, Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*. The minimum acceptable barrier is the G9 (modified) Thrie beam.

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

The protection barrier shall extend at least 6 m beyond the end of the protected structure in both directions, or longer if required by the risk assessment, and a transition provided to standard road barrier for continuation to the total length. For road safety requirements, the barrier alignment and total length of barrier shall be in accordance with the department's RPDM (Edition 2).

4.12 Expansion joints

4.12.1 General

Expansion joints design shall conform to AS/(NZS) 5100 and the following additional requirements:

- a) Bolted-in extruded aluminium expansion joints 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.
- b) The design of expansion joints shall include provision for the joint's replacement 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.

- c) Joint seals on all bridges (including bridge widenings) must be continuous across the width of the bridge and any edge upturns.
- d) 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.
- e) Where bearings are used at abutments, a joint must be provided to enable jacking for bearing replacement.
- f) 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.
- g) The design of joints must not inhibit the proper placement and compaction of deck concrete during construction.
- h) Joints must have adequate access for inspection and maintenance.
- i) 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.

4.12.2 Non-conforming joints

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

- Multiplex™ and WABOFLEX™ joints are not acceptable due to the high noise level produced on previous departmental projects
- flush seals that are flush with the deck wearing surface shall not be used for aluminium strip expansion joints for skew greater than 20°
- bonded steel plate / rubber type joints, or
- simple open joints, as they are not waterproof.

If a designer believes there is evidence, supported by design change, in service performance and independent assessment and testing, a designer may submit such information to the Director (Structures Design, Review and Standards) with a request accept the use any of the joints listed above.

4.12.3 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.

4.12.4 Noise

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

4.12.5 Modular joints

Modular joints shall be designed in accordance with Clause 20 of AS 5100.4.

Design of modular joints shall ensure the Quality Assurance provisions of MRTS90 *Modular Bridge Expansion Joints* are satisfied.

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.

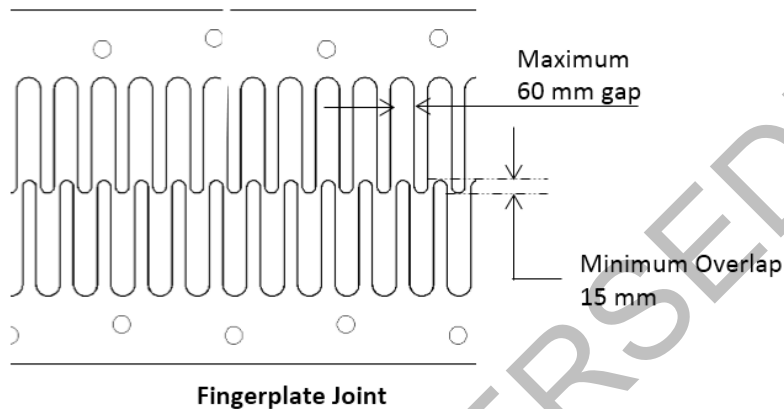
4.12.6 Finger type expansion joints

Finger type joints such as finger plate or saw tooth expansion joints shall be designed in accordance with MRTS82A *Finger Type Bridge Deck Expansion Joints* and Clause 19 of AS 5100.4.

Gap width of fingerplate joints shall be as follows:

- For fingerplate joints, the gap width specified in AS 5100.4 Section 19.3.5 shall be adopted as the maximum opening between fingers between adjacent fingers on the same side of the joint, that is, 60 mm with a minimum overlap of the fingers on the opposite side of the joint of 15 mm. This is shown in Figure 4.12.6(a).

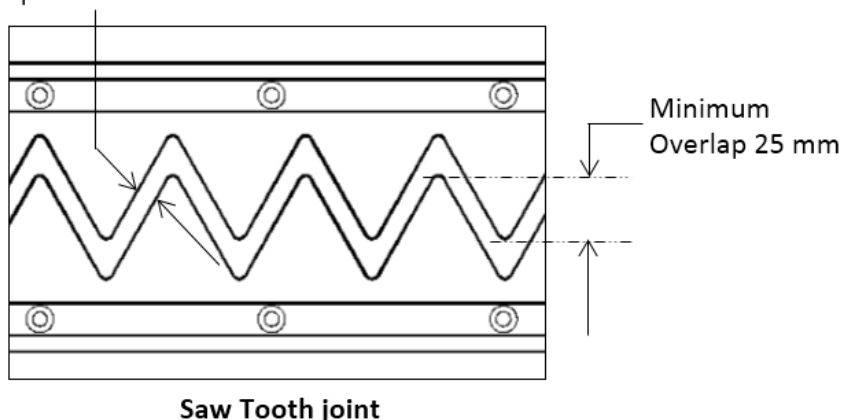
Figure 4.12.6(a) – Gap width of fingerplate expansion joints



- 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 Figure 4.12.6(b).

Figure 4.12.6(b) – Gap width of saw tooth expansion joints

Maximum 60 mm gap in the perpendicular direction



4.12.7 Joints to be detailed on drawings

Expansion joints shall be fully detailed on the project drawings.

4.12.8 Cover plates at joints

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.

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

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

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.

4.12.9 Design for access of safe 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.

4.12.10 Open joints

Open joints are prohibited.

4.13 Relieving slabs

Relieving slabs shall be provided at both abutment ends of any road bridge

Except where otherwise required and/or approved by the Director (Structures Design, Review and Standards) relieving slabs shall be in accordance with Standard Drawing 2256 *Relieving slab – 6 metre span*, to prevent disproportionate settlement of the road surface adjacent to the structure.

Over recent years, the Department of Transport and Main Roads has become increasingly concerned at the propensity for relieving slabs to settle beyond anticipated limits. The move to standardise the six metre span relieving slab is an attempt to arrest that development. The traditional three metre span relieving slab may be adopted in certain approved situations on a limited range of roads (refer Section 4.13(g)).

Relieving slabs must be designed to bridge any granular or other coarse graded backfill material intended to provide drainage behind an abutment, and to this end shall be supported at both:

- the abutment ballast wall, and
- on a compacted zone of the approach earthworks.

Relieving slabs shall be fixed to the bridge abutment ballast wall, with the typical detail in Standard Drawing 2256 which allows limited rotation under settlement.

The portion of a relieving slab founded on the approach earthworks shall extend a minimum of 600 mm onto:

- compacted fill in an embankment situation
- treated subgrade, where the approach earthworks are in a cutting.

The Director (Structures Design, Review and Standards) may require a bespoke relieving slab design, greater than 6 metres long, in situations where the bridge superstructure is relatively deep, resulting in an abutment wall for which the standard provisions described above do not prevail.

Relieving slabs may only be provided in accordance with Standard Drawing 2255 *Relieving Slab – 3 metre span* if the following conditions are satisfied:

- the bridge is not situated on a national highway, motorway, freight route, state strategic road, or district road linking regional centres
- the approach embankments is less than 6.0 m high and/or residual future settlement is expected to be low
- design change of grade over the length of the relieving slab due to differential settlement during design life of the road pavement be limited to 0.5%, and
- the proposal is approved by the Director (Structures Design, Review and Standards).

4.14 Stay cables

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.

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.

4.15 Utility services

4.15.1 Provision of utility services on bridges

The bridge 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.

4.15.2 Fixings for services

Fasteners for attaching utility services shall be cast into bridge concrete, wherever possible. The use of post-installed fasteners in new construction shall be avoided by careful planning.

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 corrosive environments (C3 and above in accordance with AS 4312), the fittings shall be marine grade (Grade 316) stainless steel.

The criteria need 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
- for bridges over streams, the services are positioned above the soffit of the superstructure to ensure there is no additional blockage of the waterway area 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 in accordance with Section 3.4.1(b)
- services shall be supported on the abutment or extend behind the abutment
- services that are attached to the bridge deck (including between the deck units or girders) shall not be encased in concrete
- gas pipes shall be located in well ventilated open areas of the bridge, and
- where light posts are to be fixed to the bridge, the junction box shall be located not greater than 500 mm away from the centre of the post base plate fixed to the bridge.

4.15.3 Chemical anchors in tension

As noted in Section 14.5.2, permanent fixtures should be cast into concrete for service support, and chemical anchors avoided.

Chemical anchors in tension (for example, to suspend a pipe underneath an existing bridge deck) are not permitted.

Chemical anchors, installed in existing concrete are acceptable for fixings loaded in shear.

4.16 Pedestrian bridges and velobridges for active users

4.16.1 General

This section relates to the following structures, intended for access by active users:

- bridges designed exclusively for pedestrians (including disabled users), sometimes also referred to as footbridges
- bridges designed exclusively for cyclists, occasionally referred to as velobridges, and
- bridges designed for both pedestrians (including disabled users) and cyclists, which can be classified as shared active use bridges.

The department recognises that special conditions may apply for these active user bridges, especially shorter span, narrow bridges not over road or rail corridors, and in certain cases relaxation of the design criteria may be justified, if agreement can be reached with the Director (Structures Design, Review and Standards). For example, certain bridges could be designed for bored piles or cast in place piles with a minimum diameter of 600 mm, or less, in accordance with MRTS63A *Piles for Ancillary Structures*.

4.16.2 Design references

Designers of active use bridges should consult a variety of references, including:

- AS(/NZS) 5100
- Appendix A to this document

- Appendix B to this document
- the department's *Road Planning and Design Manual Edition 2: Volume 3, Supplement to Austroads Guide to Road Design Part 6A: Pedestrian and Cyclist Paths*
- the department's *Technical Guideline Options for Designers of Pedestrian and Cyclist Bridges to Achieve Value for Money*, and
- the department's Technical Note 38 *Longitudinal Grades for Footpaths, Walkways and Bikeways*.

4.16.3 Barriers and balustrades

Refer to Section 4.11.11 for additional discussion of barriers and balustrades for active user bridges.

4.17 Paint systems

4.17.1 Initial application to be compatible with future recoating

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 onsite 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, and
- all coatings shall be capable of application by airless spray, brush, roller, and air. The first coating system must be applied in the shop. Recoats would be field applications.

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.

All bolts, rivets and edges shall be stripe coated. All paint shall be applied in accordance with MRTS88 *Protective Coating for New Work*.

4.17.2 Medium exposure

In a medium exposure application (C3 to AS 2312 and AS 4312) 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 the department's Technical Note 144 *Paint Systems for MRTS88*.

4.17.3 Very high marine exposure

In a very high marine exposure application (C5M to AS 2312 and AS 4312) where a 25 year life is required, acceptable paint systems for fabricated steelwork are listed in the department's Technical Note 144 *Paint Systems for MRTS88*.

4.18 Structural steel

Structural steel material shall meet the following requirements:

- a) All cold formed structural steel hollow sections shall be to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel.
- b) 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 *Cast-In-*

Place Piles. Rolled plates shall be manufactured in accordance with MRTS63 *Cast-In-Place Piles* 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.

- c) All hot rolled steel plates shall be to AS/NZS 3678.
- d) All structural steel hot rolled sections shall be to AS/NZS 3679.1.
- e) Structural steel welded sections shall be to AS/NZS 3679.2.
- f) 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.
- g) 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 XXXL0 where XXX is the grade of the steel, and
- h) Spirally wound fabricated circular hollow sections are not permitted.

Designers of structural steel bridge elements shall ensure that the conditions for brittle fracture are fully assessed and accounted for in accordance with AS/NZS 5100.6, with due regard to:

- design service temperature
- material thickness, and
- steel type.

Designers are cautioned that steel grades with impact test designations (for example, L0) are often only available in relatively large quantities (greater than 20 tonnes) which should be considered in the design and specification of steel elements.

Part C Tunnels

5 Tunnel criteria

5.1 Scope

The scope of this section includes:

- a) immersed tube tunnels
- b) driven tunnels
- c) cut and cover tunnels
- d) tunnel shafts
- e) internal tunnel structures
- f) cast-in situ tunnels in a waterway using coffer dams
- g) tunnels for the cartage of dangerous goods; such goods being transported on designated alternative open road routes, and
- h) tunnels for public transport stations.

5.2 Design references, standards and reviews

5.2.1 General

This Part C should be read in association with Part A to this document.

This part is supplementary to the department's *Road Planning and Design Manual* (2nd Edition), and the *Austrroads Guide to Road Tunnels*.

The design of tunnels is subject to the provisions of several Australian Standards, to statutory workplace health and safety requirements, and to the technical specifications of other agencies where these are considered the best available reference.

5.2.2 Department of Transport and Main Roads

Road Planning and Design Manual (2nd Edition): Volume 4: Road Tunnels.

5.2.3 Austrroads

Austrroads Guide to Road Tunnels – Part 1: Introduction for Road Tunnels

Austrroads Guide to Road Tunnels – Part 2: Planning, Design and Commissioning

Austrroads Guide to Road Tunnels – Part 3: Operation and Maintenance

Austrroads Guide to Road Tunnels – Part 4: Retrofitting Existing Tunnels.

5.2.4 Australian Standards

- a) AS ISO 31000 *Risk Management - Guidelines*
- b) AS 4825 *Tunnel Fire Safety*
- c) AS/(NZS) 5100 *Bridge Design*, and
- d) AS 3600 *Concrete Structures*.

5.2.5 Workplace Health & Safety

Safe Work Australia, *Guide for Tunnelling Work* 2013.

5.2.6 External agency references

Roads and Maritime Services (RMS), *QA Specification B82, Shotcrete Work*.

5.2.7 Miscellaneous references

The following documents are also considered useful references for tunnel designers:

- a) British Standard, BS 6164, *Code of Practice for Health and Safety in Tunnelling in the Construction Industry*
- b) UK Highways Agency, *Design Manual for Roads and Bridges*, Part 9, Section 2 of Volume 2, *Design of Road Tunnels*, BD 78/99
- c) International Tunnelling Insurance Group, *A Code of Practice for Risk Management of Tunnel Works*
- d) British Standard, BS 8081, *Code of Practice for Grouted Anchors*
- e) British Tunnelling Society and The Institution of Civil Engineers, *Specification for Tunnelling* (Third Edition)
- f) National Fire Protection Association, NFPA 502, *Standard for Road Tunnels, Bridges and Other Limited Access Highways*
- g) Manuals and reports of the Permanent International Association of Road Congresses (PIARC), and
- h) Reports and guidelines of the International Tunnelling and Underground Space Association (ITA-AITES).

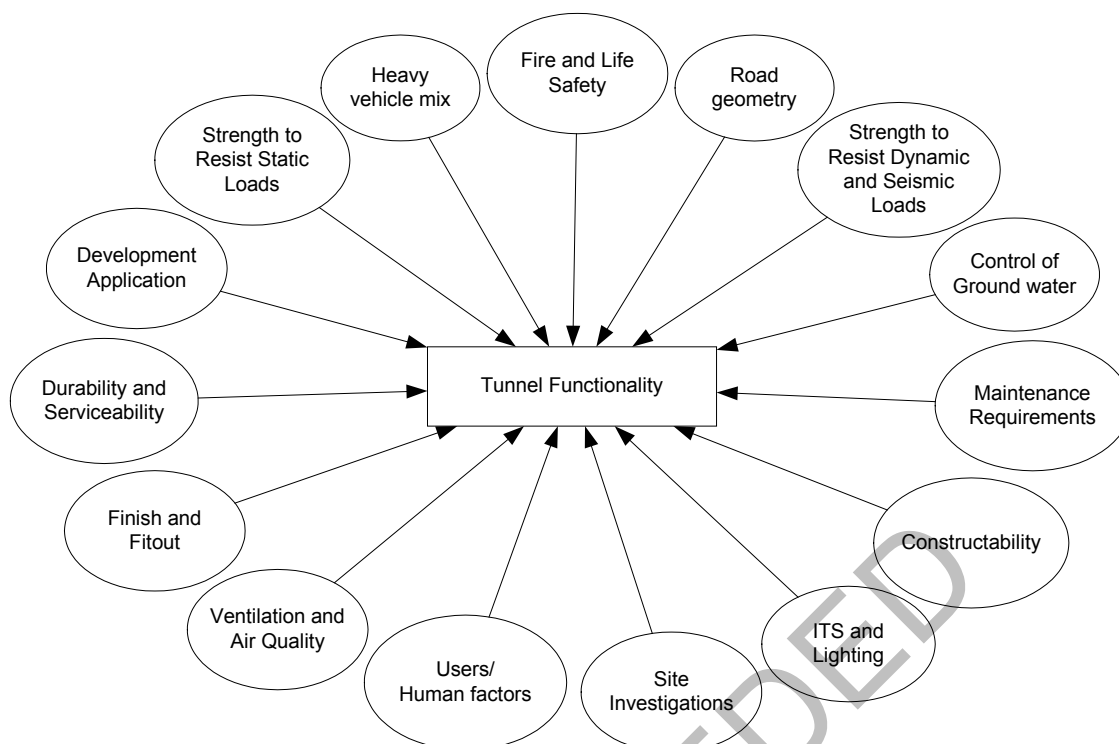
5.2.8 Reviews

All parameters adopted by the designer, following consideration of all the relevant reference material, shall be subject to review and acceptance by the Director (Structures Design, Review and Standards).

5.3 Tunnel functionality

Based on user requirements documented in the design brief or project SWTC, designers shall identify the range of inputs that determine a particular tunnel's functionality.

Figure 5.3 describes a typical range of inputs into tunnel functionality that will inform tunnel design objectives.

Figure 5.3 – Tunnel functionality inputs

5.3.1 Design objectives

Typical objectives for the design of any tunnel include but may not be limited to the following considerations:

- a) Functional – achieving the intended purpose at the required level of service is critical to a successful outcome, whether the tunnel be for transport purposes, telecommunications, power distribution, water supply or other utility services.
- b) Operational – to provide an internal space and environment appropriate to the functions of the tunnel.
- c) Fire safety - consideration of those internal conditions that:
 - avoid fire development
 - enable detection and verification systems to function
 - create appropriate separation between fire / smoke and safe areas
 - prevent such safe areas becoming untenable, and
 - prevent situations that may endanger emergency response personnel.
- d) Structural – ensure a design that:
 - provides support to the surrounding ground for the design life of the tunnel
 - controls the movement of ground water, and
 - prevents tunnel collapse after a fire.

- e) Safety – 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 operational life of the tunnel.
- f) Economic – to provide a tunnel structure that minimises whole-of-life cost, and provides value-for-money (refer Part B, Section 3.4).
- g) 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.
- h) Robustness – a tunnel structure shall not collapse due to the failure of one structural component. Tunnel facilities subject to deterioration through use and age shall be easily accessible and replaceable (for example, fans). Robustness requires that facilities that cannot be inspected, or are difficult to access for maintenance, repair or replacement (for example, permanent anchors and drainage on the earth face), must have a design life equal to or more durable than the design life of the tunnel, and
- i) Flexibility – a tunnel structure shall be designed with allowance for foreseeable future development adjacent to, and above the tunnel as per Section 5.11.3.

Failure of 'one structural component' applies to any structural element including but not limited to, tunnel lining, internal support members or external ground elements required for support of the tunnel structure. Failure may occur from overloading, fatigue, fire, explosion, impact and so on. Failure of a single element must not result in damage to an extent that is disproportionate to the cause or compromise the structural integrity of the tunnel.

The actual ground conditions can vary from the assumed parameters. For any given length of tunnel that has the same assumed ground conditions, a sensitivity analysis can be used to achieve a design that is sufficiently robust to accommodate the variations.

The environmental conditions and air quality issues inside tunnels are generally more adverse compared with surface roads. The air quality can be compromised by a high percentage of trucks using steep graded tunnels. The problem is compounded if there is an accident, vehicle breakdown or traffic congestion inside the tunnel. Therefore, the ventilation design should be sufficiently robust to maintain optimum functionality to meet all demands.

5.4 Geological and geotechnical investigations

An understanding of the geological and geotechnical conditions along a tunnel alignment is essential, to ensure a durable, structurally sufficient tunnel capable of withstanding all imposed loads.

Determining accurate geological conditions and geotechnical properties along a tunnel alignment, and the potential variability of these properties, both vertically and horizontally, may involve a significantly more difficult and widespread investigation than that normally carried out for design of bridges and other associated structures.

It is essential that sufficiently adequate information is obtained from the site investigations so that the best possible information is obtained for the design, and the effort required for this task must not be underestimated.

Site investigation should include, but need not be limited to:

- geological modelling
- geotechnical investigations
- soil parameter determination
- hydrogeological assessment
- groundwater extent, and
- soil aggressiveness testing.

5.5 Design life – tunnels

Further to Part A, Section 1.5.3 of this document, the design life of tunnel infrastructure, and associated attachments, components and related equipment shall be as follows:

a) Permanent structural components	100 years
b) Inaccessible drainage components	100 years
c) Accessible drainage that is replaceable	50 years
d) Supports for Jet fan/major overhead equipment	100 years
e) All permanent structural fittings/anchors	100 years
f) Ventilation buildings directly over exhaust shafts and subject to high carbon dioxide concentrations	100 years
g) Ancillary above ground buildings not directly associated with exhaust ventilation	50 years
h) Temporary structural components for support	5 years
i) Fans	25 years
j) Tunnel lights, sensors	4 years
k) Luminaries housing and supports	25 years
l) Cabling	20 years
m) ITS hardware	15 years unless otherwise specified
n) ITS software	5 years
o) Other electrics	15 years
p) Pumps	10 years
q) Non-structural Wall panels, doors and architectural components	25 years
r) Asphalt surfacing (if provided)	20 years
s) Non-load bearing Masonry walls	50 years
t) Load bearing Masonry walls	100 years

5.6 Durability

Durability of the tunnel structure and its associated infrastructure shall be determined by the design detail of their elements. The following criteria shall be adopted:

- a) Refer to Part B, Section 3.12 for general requirements concerning concrete and steelwork durability.
- b) For elements of a tunnel with a design life of more than 50 years, as required in Section 5.5 of this document, the minimum exposure classification for cover to reinforcement shall be B2 in accordance with AS 5100.5. Permanent components with a design life of 50 years or less shall be designed for minimum exposure classification A2 to AS 3600.
- c) Structural design for control of cracking shall be carried out considering the exposure classification requirements of AS 5100.5 Clause 2.4.3.
- d) Maximum crack width in permanent concrete and shotcrete shall be 0.2 mm.
- e) Cover to reinforcement in permanent concrete components shall be in accordance to AS 5100.5.
- f) The cover to reinforcement against soil in permanent shotcrete components such as facing slabs of soil nail walls or slope protections shall be increased. This cover increase shall be as per AS/(NZS) 5100 for components with 100 years design life or as per AS 3600 for components of 50 years design life.
- g) Refer Section 5.10.10.2 of this document for limitations in the use of shotcrete and/or unreinforced concrete.
- h) Protective treatment of permanent rock anchors shall be in accordance with BS 8081 *Code of Practice for Grouted Anchors*.
- i) Protective treatment of permanent steel structural members shall be by the provision of a protective coating to achieve the 100 years design life and specified fire rating. Protective coating provided in the form of hot dip galvanising will require additional fire protection.
- j) Permanent mechanical fasteners / anchors are not permitted for heavy overhead facilities (for example, jet fans, smoke duct slabs, and the like). Mechanical fasteners / anchors may be used to support lightweight services such as cable trays and lights.
- k) Chemical / adhesive anchor resin softens at 100°C under fire and suffers from creep under sustain loads. Therefore, the ability of chemical anchors to withstand all conditions, including fire and creep, must be carefully assessed, and have an appropriate design life. Chemical anchors shall not be used as permanent fasteners for overhead facilities unless:
 - i. 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.
 - ii. The resin of the chemical anchors has been tested for fire resistance and creep deflection in accordance with the provisions of the European Organisation for Technical Assessment (EOTA), namely its *European Assessment Document, EAD 330499-00-0601, Bonded fasteners for use in concrete*. The fire resistance requirements shall be specified on the project drawings. EOTA tested displacement under sustained load projected to 100 years shall not exceed 0.2 mm/(N/mm²) in uncracked concrete at 21 to 40°C temperature range.

This displacement is extrapolated to 100 years according to EAD 330499-00-0601, Clause 2.2.2.6), and

- iii. Anchor capacities and durability are confirmed suitable under all anticipated conditions.
- l) Minimum reinforcement in all blockwork walls shall be 12 mm, spaced at 200 mm maximum centres horizontally and vertically. For 50 years design life, infill grout for blockwork shall have a minimum strength of 32 MPa and 140 mm minimum block thickness (for A2 exposure classification). For 100 years design life, infill grout for blockwork shall have a minimum strength of 40 MPa and 190 mm minimum block thickness (for B2 exposure classification).
- m) For retaining walls, refer also to Part D, Section 10 of this document.
- n) Continuous flight auger piles are not permitted for tunnels.

5.7 Dislodging of overhead equipment

The designer shall ensure that under in-service conditions nothing can dislodge and become a hazard to the safe operation of the tunnel performance (for example, concrete fragments, fixtures, fittings and so on).

5.8 Hydraulics and drainage

Tunnel portals shall have a flood immunity derived from an appropriate risk assessment. A range of flood immunities for the tunnel portals shall be investigated, up to and including the probable maximum flood event.

For example, both the CLEM7 and Legacy Way Tunnels in Brisbane, have a flood immunity of 1:10,000 AEP, as the implications of flood water entering those tunnels is considerable.

The minimum level of flood protection provided by physical means at the tunnel portals should be:

- For local (short duration) flooding events – 1:2,000 AEP plus an allowance for climate change. Flood immunity must be achieved by passive means only as there is no warning time, mitigation strategies like placing flood barriers are not appropriate.
- For regional (creek / river) flooding events – 1:100 AEP plus an allowance for climate change.
- A 1:100 AEP storm tide including climate change in coastal areas (where applicable) as per the guidelines provided in the department's guideline *Storm Tide – Issues for Design of Road Infrastructure in Coastal Areas* plus 800 mm for climate change induced sea level rise (where applicable), and
- Highest Astronomical Tide (HAT) plus 800 mm freeboard for climate change induced sea level rise (where applicable).

Where the roadway geometry is such that surface water may 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 carried in by vehicles.

Drainage and any pump systems provided in the tunnel shall be designed for the worst of a local drainage storm event including climate change, the requirements of any deluge system, wash down requirements or for firefighting incident management.

As climate change has the potential to alter the prevalence and severity of rainfall extremes, storm surge and floods, it needs to be considered when designing roads and tunnels for the department. For design rainfall events, the relevant increase in rainfall intensity and sea level raise must be determined in accordance with the latest relevant State policies and/or the recommendations in *Australian Rainfall and Runoff* and be approved by the department prior to commencement of any project.

A freeboard (typically 300 mm) should be considered for rainfall generated flooding to allow for uncertainties in the calculations, wave action, and so on.

1. Whilst changes in average rainfall are still relatively uncertain, a number of studies suggest increases in the intensity of the heaviest rainfall events.
2. The 800 mm freeboard associated with Coastal / HAT scenarios is an allowance for sea level rise in coastal areas. This is a projected figure to the year 2100, which aligns with a tunnel design life of 100 years).

Storm tides, HAT and climate change induced sea level rise are only applicable in Coastal Areas.

Key references for the derivation of this sea level rise allowance are:

1. CSIRO (2013). *Sea Level Rise: Understanding the past – Improving projections for the future*, and
2. IPCC (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Chapter 13 – Sea Level Change)*
https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf

5.9 Fire and life safety

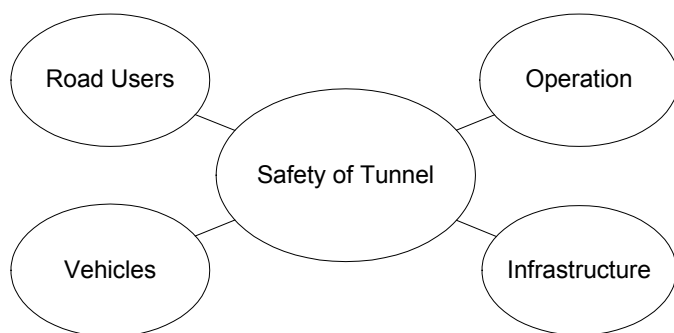
Design for fire and safety shall be in accordance with AS 4825 *Tunnel fire safety*.

The design fires selected shall consider scenarios that ensure adequate risk management for both:

- fire resistance, and
- human safety.

As summarised in Figure 5.9, the tunnel safety shall be ensured by considering a variety of design inputs, including:

- user modalities
- vehicle types
- operational requirements, and
- infrastructure configurations.

Figure 5.9 - Tunnel safety inputs

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, and
- safeguard people from the accumulation of harmful substances in a tunnel.

The design shall ensure there is a low probability of an individual being exposed to any of the following:

- excessive heat flux
- a harmful concentration of CO (carbon monoxide)
- a harmful concentration of HCN (hydrogen cyanide)
- a harmful level of irritants, and
- low visibility.

The designer shall set quantitative limits for all these effects, and the limits shall be based on the most appropriate national and/or international standards.

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
- limits to structural damage in the direct area of the fire, to support emergency response services operation, and

- 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.

The tunnel shall provide emergency 'cross passages' or other emergency exit passages with a spacing not exceeding 120 m with fire safety doors allowing direct emergency exit.

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, unless otherwise required by the design brief, SWTC or the Director (Structures Design, Review & Standards). There are some situations 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, and
- where failure of the lining would allow inrush of water in significant quantities which could not be practically controlled by pumping.

In situations such as those listed above, 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.

The structural integrity of the tunnel shall remain intact after the fire. Unless otherwise required by the design brief, SWTC or the Director (Structures Design, Review & Standards), 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 also comply with the fire design provisions of AS 3600 *Concrete Structures*. 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° for the specified duration.

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.

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.

5.10 Design particulars

5.10.1 General

All 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 *Austrroads Guide to Road Tunnels – Part 2: Planning, Design and Commissioning*.

5.10.2 Tunnel roofs

When the top surface of a tunnel roof forms part of a road or busway, this section of the tunnel shall be designed to suit 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 with maximum spacing of 2.5 times the pile diameter installed in accordance with MRTS63 *Cast-In-Place Piles* when a pile inspection shield is required. 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 with maximum spacing of 2.5 times the pile diameter installed in accordance with MRTS63 *Cast-In-Place Piles* when no inspection shield is required. The space between the piles shall be connected with a reinforced concrete arching system that has a drainage layer behind it.

5.10.3 Hydraulic head

All tunnels shall be designed for a hydraulic head.

It is not permitted to consider a theoretically drained tunnel, designed without a hydraulic head.

The minimum hydraulic head adopted shall be the higher of:

- the predicted, permanent water table
- 2/3 of the tunnel height, or
- 30 kPa.

Tunnels shall be designed for asymmetric hydraulic heads of water, to ensure that the most unfavourable loading conditions are considered.

5.10.4 Arching

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.

5.10.5 Concrete considerations

Design of concrete shall consider concrete shrinkage and temperature effects.

Any concrete ceiling to separate traffic from air ducts shall be supported on concrete corbels.

Long-term concrete modulus relevant for deflection calculations shall be used.

5.10.6 Structural anchors

Grade 316 stainless steel complies with the requirement that all permanent structural fittings / anchors shall have 100 years minimum design life.

5.10.7 Drainage and waterproofing

The outside of the tunnel lining is to be provided with a drainage layer and waterproof membrane. Where this cannot be installed due to construction technique, for example, Tunnel Boring Machine

(TBM) construction, alternative and equally effective waterproofing measures have to be developed and submitted for departmental approval.

The tunnel shall be designed to ensure that no water leaks from the tunnel or wall, or drips from the tunnel soffit onto the tunnel road surface.

5.10.8 Property acquisitions and resumptions

Any property acquisition and other areas required for easements, including those to mobilise the soil block for ground anchors, soil nails, rock bolts, and so on, shall be determined.

The designer shall produce plans to identify resumption and easement requirements for the tunnel in regard to permissible future development above and beside the tunnel.

5.10.9 Road and bus tunnels

The following additional requirements apply for tunnels carrying vehicle traffic:

- a) For road and bus tunnels, traffic barriers in tunnels shall be a minimum of 1100 mm high, single slope, concrete barriers.
- b) The lateral constraints on tunnel sections require 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. Working width shall be in accordance with the *Austroads Guide to Road Tunnels Part 2. Treatment at tunnel entrances, approaches, merges and diverges* shall be in accordance with *Road Planning and Design Manual* 2nd Edition, Volume 3, Part 6. Also refer Appendix B of this document, Part 2: Design Loads, Section 10.2.
- 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 shall include:
 - protecting the tunnel and other infrastructure from being impacted by vehicles
 - reduced sight distances on curved sections, and
 - reduced lateral clearances.
- e) Special consideration needs to be made to the use of work cushions at entrances / approaches / merges and diverges.

5.10.10 Driven tunnels

5.10.10.1 Segmental lining system

Fibre reinforced precast concrete segmental linings are permitted in tunnels driven by Tunnel Boring Machine (TBM).

5.10.10.2 Two pass lining system

Driven tunnels shall conform as follows:

- a) Design of concrete shall consider shrinkage of concrete, and temperature (ordinal and differential) effects.

- b) Primary and secondary tunnel lining shall be designed for symmetric and asymmetric loads, to ensure that the most unfavourable loading conditions are considered.
- c) Cast insitu reinforced concrete secondary lining is preferred. If cast insitu unreinforced secondary lining is proposed, the designer shall demonstrate that the concrete arch remains in a serviceable state and in compression throughout the life of the tunnel. The designer shall take into account the tunnel geometry, concrete shrinkage and creep, corrosion of canopy tubes and rock bolts and changes to water table as well as future developments. Unloading effect created by the excavation of basements for future development adjacent to, or on top of the tunnel shall also be included in the tunnel design.
- d) Shotcrete, to cover reinforcement bars in tunnel secondary lining, is permitted in situations where there are variations in the tunnel geometry such as transition sections, Y junctions and fan enlargements, subject to meeting the criteria for design life, durability, fire resistance, water tightness and robustness and resistance to accidental damage.
- e) However, there may still be cases, such as junctions, where heavier steel reinforcing bars are required. In those cases, good workmanship shall ensure that the steel is safely encased in dense concrete with a low permeability and cast insitu concrete is required.
- f) Sprayed waterproof membranes are permitted provided the system:
- has an extensive history and proven reputation for satisfactory performance in tunnels with similar groundwater conditions
 - is self-extinguishing / non-flammable
 - has a bond strength in excess of 1.0 MPa, and
 - does not contain any component that will leach out and deleteriously affect the durability of:
 - the waterproofing membrane
 - the geotextile drainage / protective layer, and
 - any plastic or PVC materials such as waterstops.
 - Is applied in accordance with the manufacturer's recommendations.

The following definitions apply to two pass lining system in driven tunnels:

- Primary Lining: when the tunnel is sequentially excavated, ground support in the form of shotcrete, usually with lattice girders and reinforcement is installed as excavation proceed.
- Secondary Lining: after installation of the primary lining, at a later stage, a cast-insitu concrete lining is installed. This is called the secondary lining. Secondary linings shall be designed to carry the full permanent design loads.
- A drainage fabric and/or water proofing membrane is sandwiched in between the primary and the secondary linings.

5.10.11 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 water proofing sheet membrane.
- c) Cover to concrete shall be in accordance with AS 5100.5.
- 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 2.4.3 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.
- f) Contiguous piles shall have a minimum diameter of 600 mm.
- g) A drainage layer shall be provided behind the walls.
- h) All cut and cover tunnels in road reserve or under public space shall have a 100 mm thick reinforced concrete protection slab constructed above the tunnel waterproof membrane.

5.10.12 Parametric study

A parametric study shall be undertaken on the sensitivity of the tunnel design to the adopted design loads and assumptions.

5.11 Design loads

5.11.1 General

In addition to the loads imposed by ground forces surrounding the tunnel, designers shall also consider loads imposed by traffic, development, and any future filling and/or excavation that may take place:

- above tunnels
- on the surface of Tunnel Portal Transition Zones, and
- within easements.

5.11.2 Vehicle live loads

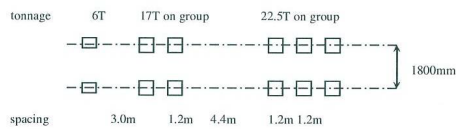
Where applicable, the following road corridor live loads shall to be applied to tunnels:

- a) Road Traffic Loading: SM1600, HLP400, W80 and A160, in accordance with the requirements of Australian Standard AS 5100.2, and the vehicles shown in Figure 5.11.2. Note that the tyre patches for a T44 vehicle are 200 x 200 mm for a single axle, and 400 x 200 mm for a tandem axle, where the 200 mm dimension is in the direction of travel.

Figure 5.11.2 – Design vehicles live loads above tunnels (additional to AS 5100.2)

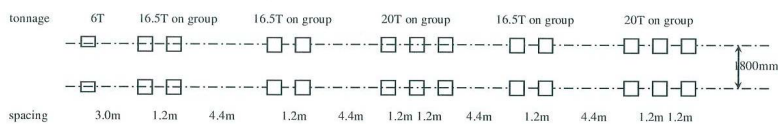
1. A 45.5T Semi Trailer:

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



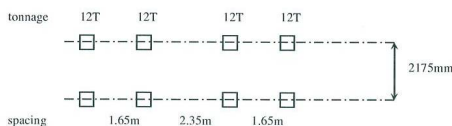
2. A Road Train configuration:

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



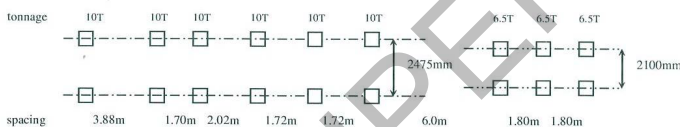
3. A 48T crane configuration (V3)

- Overall width (outside of tyres): 2700mm
- All axles with single tyres of width: 525mm



4. A 79.5T crane configuration (V4)

- Overall width (outside of tyres): 3000mm (front) & 2600 (mm)
- All 10T axles with single tyres of width: 525mm
- All 6.5T axles with dual tyres of width: 500mm



- b) **Crane loading:** it is desirable that crane outrigger loads must not exceed other additional loads listed in Section 5.11.3.5. Crane loads, however, are project specific and shall be nominated by the Designer, who shall specify the maximum allowable outrigger load, outrigger spacing and minimum rigid bearing area.

5.11.3 Loads due to development and surcharge above and/or beside a tunnel**5.11.3.1 Development load**

The maximum future development load permitted on top of the tunnel shall be determined from a consideration of known development approvals, future urban planning, and foreseeable expectations. The load adopted shall be the larger of:

- any loads from already permitted developments above and/or beside the tunnel, for which construction approval has been granted
- any foreseeable loads from future developments above and/or beside the tunnel, which would be permitted under planning regulations in place, or

- c) loading due to permitted development consisting of 50 kPa acting on the surface level in the case of a driven tunnel or a cut and cover tunnel.

5.11.3.2 Surcharge load

A tunnel shall be designed for a uniformly distributed surcharge load of 20 kPa, to allow for any future build-up of the natural and/or finished surface level by embankment fill, to a maximum 1 m equivalent surcharge.

The permitted maximum excavation on top or either side of the tunnel shall be 1 m, unless:

- a) planning approval has already been granted for a development with a greater depth, or
- b) a development already exists with a greater depth.

5.11.3.3 Load combinations

Designers shall allow for a future development load plus the surcharge load.

5.11.3.4 Tunnel integrity

Where additional stress or load can be applied or tolerated, the tunnel designer shall provide a performance specification on what allowable movement is acceptable while still maintaining the integrity of the tunnel.

5.11.3.5 Tunnel structure retaining wall design loads

In addition to the loads imposed by the retained material, retaining walls associated with tunnels shall be designed to resist both:

- a) a fill maximum surcharge of 20 kPa (1.0 m depth), and
- b) a live load of 25 kPa behind retaining walls, to be applied as a uniform surcharge load in accordance with AS 5100.2.

5.12 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 the department's provisions for ITS.

5.13 Review of scheme documents

5.13.1 General

The scheme documents are subject to formal review and acceptance by Transport and Main Roads for safety, durability, future performance, constructability and maintenance in accordance with the design review process described in Part A, Chapter 2 of this document, which requires a phased submission of the design report, drawings and associated documents at 15%, 50%, 85% and final (100%) design stages. The following documents shall be submitted to the department for review:

- Design Report (see Section 5.13.2)
- Fire and Life Safety Report as per Section 5.13.3
- Operations, Inspections and Maintenance Manual (refer Section 5.13.4)
- Incident Management and Recovery Manual (see Section 5.13.5), and

- Level 2 (and Level 3 if required) Tunnel Inspection Report for extensions or alterations to existing tunnels.

All reports and manuals shall be submitted and accepted by Transport and Main Roads in accordance with the design brief, project SWTC, or other contractual arrangement prior to opening the facility to use.

The scheme documentation shall ensure that all required and necessary procedures / trials / simulations / tests / training are to be satisfactorily completed prior to opening the tunnel to traffic.

5.13.2 Design report

In preparing the tunnel design report, the designer shall consider and adopt any relevant requirements specified in Part A, Section 2.4 of this document.

The tunnel design report shall provide details including, but not limited to:

- design references adopted, including date of publications and (any) amendments
- date of referenced Transport and Main Roads *Design Criteria for Bridges and Other Structures*
- 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
- achieving Level of Service (LOS), and
- assumptions, departures, Extended Design Domain (EDD).

The report shall demonstrate compliance with the project Design Brief or SWTC. 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 Director (Structures Design, Review and Standards) for consideration in accordance with the contract. The Design Report shall be certified by the appropriately experienced RPEQ responsible for each component of the design.

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 (D&C) type projects, the Design Report must be accepted by the department prior to construction commencing.

5.13.3 Fire and life safety report

This report shall address the fire engineering and user safety provisions required by the references in Section 5.2, particularly:

- *Austrroads Guide to Road Tunnels*
- *AS 4825 Tunnel Fire Safety*.

Consideration shall also be given to the stipulations of Section 5.9.

The report shall contain a copy of the submission to Queensland Fire and Rescue Service (QFRS), and details of its response.

Minimum requirement is the submission of *Operation, Inspection and Maintenance Manual* to the QFRS.

5.13.4 Operation, inspection and maintenance manual

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 operations, in-service inspections and maintenance of the tunnel.

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

- Operational information for all elements of the tunnel (structural, mechanical, electrical, ITS, fire suppression and so on).
- 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 component / sub-component shall be provided.
- Anticipated Inspection activities. In general, this will be in accordance with the Transport and Main Roads *Structures Inspection Manual*. That manual, however, is principally for bridges, so its provisions will need some modification to suit tunnel related activities.
- Inspection frequency; which will need development to suit tunnel inspection activities.
- Details of inspection access requirements, including any need for confined space access.
- 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 scheduled maintenance will be undertaken, and
- Special maintenance.

The *Operation, Inspection and Maintenance Manual* shall be made available to the QFRS.

5.13.5 Incident management and recovery manual

An *Incident Management and Recovery Manual* shall be prepared and shall include, but not be limited to:

- a) vehicle breakdown
- b) damage-only incident
- c) debris on road
- d) fire
- e) injury incident
- f) spills
- g) load shedding
- h) over-height vehicles
- i) external electrical supply failure
- j) water on pavement
- k) flooding
- l) unauthorised entries
- m) explosion and release of noxious liquid or gas, and
- n) incident management training (including any in-tunnel incident trials / simulations / tests).

5.14 Construction issues

5.14.1 Technical specifications

Design provisions shall ensure that tunnel construction will conform to all relevant Transport and Main Roads Technical Specifications including those pertinent to Transport and Main Roads Intelligent Transport Systems Specifications.

Supplementary Specifications for tunnel concrete and shotcrete shall be in accordance with Transport and Main Roads requirements (refer also Section 5.2.6a)).

Concrete shall conform to the requirements of MRTS70 *Concrete* for alkali silica reactivity assessment.

The specification shall require the preparation of a work method statement for the control of ground water, which shall stipulate that removal of ground water by the Contractor shall not result in damage to any existing development or structure, nor the tunnel.

Designs shall ensure that significant lowering of the natural ground water table shall be avoided where practical. Any anticipated changes in natural groundwater shall be subject to an Environmental Impact Statement (EIS).

The specification shall require the installation of piezometric devices to monitor seasonal fluctuations in ground water between the tunnel and any existing development or structure.

5.14.2 Instrumentation

The design of tunnels shall incorporate the installation of 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.

5.14.3 Design validation

The specification shall stipulate that design assumptions must be validated during construction.

The specification shall prescribe the level of testing or other physical assessment required to ensure that any drainage liner is not crushed or otherwise damaged during construction.

5.14.4 Validation of permanent anchors

5.14.4.1 Service life performance

Specified acceptance testing for Service Life Performance shall be as follows:

- i. For the purpose of production testing of permanent bolts installed in the Works, bolts shall be split into lots of 1000 maximum, or less if required otherwise by the designer.
- ii. Ten out of a lot of 1000 bolts, or a similar proportion approved by the designer, shall be randomly selected after installation for production testing for acceptance of service life performance.
- iii. The following properties of the corrosion protection system shall be inspected, photographed and measured where appropriate. The bolt shall be sectioned to obtain the following data:
 - integrity and thickness of cement grout cover
 - location and spacing of cracks in cement grout, and
 - degree of filling the grout inside and outside the sheath / sleeve.

Overcoring shall be carried out in the following manner. A 150 mm diameter hole shall be cored over the bolt. The core shall be diamond sawn into two half cylinders for inspection. The over cored hole shall be immediately filled with cementitious grout and/or another bolt.

The anchor has failed if the test shows the bolt is not fully encapsulated in grout irrespective whether the defect is observed in the inner or outer grout annulus or if other grout defects are observed such as excessive cracking of the grout which may affect the service life of the bolt or if the sheath has been punctured.

The anchor will be accepted if the test shows the bolt is fully encapsulated in grout and does not show any other defects such as excessive cracking which may affect the service life of the bolt.

- iv. Production tests for service life performance shall be carried out on one percent of the permanent rock bolts installed. The designer will select the bolt which shall be recovered by over coring.
- v. Mandatory testing shall be carried out in all lots however if the criteria of test reductions is met, the minimum for mandatory testing shall be for Lot 1 and 2 as in Lot 'X' and Lot 'Y'. Lot 'X' and 'Y' will be selected by the designer during construction.

Acceptance criteria for Service Life Performance are:

- i. Production test series for service life performance shall be conducted on 10 out of 1000 bolts per lot. The lot shall be accepted if not more than one bolt out of ten recovered by over coring shows defects.
- ii. The lot shall be rejected if more than one fails out of ten. Subsequently another 10 bolts shall be tested in the lot as directed by the designer until the failure rate within the lot drops below or is equal to 10%.

Acceptance criteria for reduction of production testing for Service Life Performance are:

- i. Testing by overcoring into other lots shall continue until the cumulative average number of grout defects becomes less than 3%. Testing may then be terminated until mandatory testing commences again at Lot 'X' and 'Y'.
- ii. The following tables illustrate three examples for acceptance testing in regard to service life performance with the main focus on the acceptance criteria within a lot and the accumulated average criteria for a reduction of production testing.

Table 5.14.4.1(a) – Acceptance testing for service life performance – Example 1

Lot No:	Test	Failure	Accumulated average of grout defects in %	Comment
1	10	0	0	Lot 1 accepted
2	10	0	0	Lot 2 accepted

Testing will be terminated until mandatory testing continues in Lot 'X' and Lot 'Y'.

Table 5.14.4.1(b) – Acceptance testing for service life performance – Example 2

Lot No:	Test	Failure	Accumulated average of grout defects in %	Comment
1	10	0	0	Lot 1 accepted
2	10	1	5	Lot 2 accepted
3	10	0	3.4	Lot 3 accepted
4	10	0	2.5	Lot 4 accepted

Testing will be terminated once accumulated average drops below 3% until mandatory testing will continue in Lot 'X' and Lot 'Y'.

Table 5.14.4.1(c) – Acceptance testing for service life performance – Example 3

Lot No:	Test	Failure	Accumulated average of grout defects in %	Comment
1	10	1	10	Lot 1 accepted
2	10	2	15	Lot 2 rejected
2	10	1	13.4	Lot 2 rejected
2	10	0	10	Lot 2 accepted

Testing will be terminated in each lot once the acceptance criterion in a lot falls below or is equal to 10%. Testing will continue across into other lots until accumulated average falls below 3% however mandatory testing will continue in Lot 'X' and Lot 'Y'.

10% of all rock anchors shall be proof tested to the serviceability load.

The design and construction shall allow for extra rock anchors in excess of the design number for long-term durability monitoring / testing at the rate of 2 per 1000 or part thereof.

5.15 Post construction considerations

5.15.1 'As Constructed' drawings and construction handover report

The design documentation shall ensure that 'As Constructed' documents comply with *MRTS50 Specific Quality System Requirements* and the *Drafting Design Presentation Standards Manual*, and are produced in accordance with Part A, Section 2.9.

5.15.2 Level 2 (and Level 3) inspection of tunnel

A Level 2 (and Level 3 if required) inspection shall be carried out by a Transport and Main Roads certified / qualified inspector prior to opening of the facility to use in accordance with the department's *Structures Inspection Manual* and the results provided to the department for entering into Transport and Main Roads Bridge Information System.

SUPERSEDED

Part D: Other Structures

6 Public transport stations and ancillary structures

6.1 Scope

6.1.1 In scope

The scope of this chapter includes:

- a) busway stations
- b) light rail stations, and
- c) any structures ancillary to the provision of bus or light rail public transport, where ancillary structure is meant to include any structure required to augment or support public transport functions.

6.1.2 Not in scope

This chapter does not cover railway stations, nor ancillary structures thereto, on railway networks operated by Queensland Rail, or any other rail authority.

6.1.3 Application

This chapter is intended to complement the *Public Transport Infrastructure Manual* (PTIM) maintained by TransLink.

Where a transport station is incorporated within the confines of structures covered in chapters elsewhere in this document, for example within a tunnel or on / under a bridge, the provisions of those relevant chapters shall apply.

6.2 Design references, standards and reviews

6.2.1 General

This chapter should be read in association with Part A to this document.

6.3 Design life

6.3.1 General

Refer to Part A, Section 1.5 for general information on design life.

Designers shall specify the design life of any elements with design life less than 100 years.

The *Structures Inspection Manual* shall inform the method of replacement of all sub-elements with design life less than 100 years.

6.3.2 100 year design life

Further to Part A, Section 1.5.3 of this document, the design life of public transport infrastructure, and associated attachments, components and related equipment shall be 100 years for the following elements:

- bridges
- all major infrastructure elements that are above a busway, light rail or above a roadway / rail

- all elevated parts of the infrastructure not integrally connected to the bus / road bridge (major infrastructure element excludes roofing, glazing)
- major retaining walls, which are intrinsic to the stability of any bridge or major infrastructure element with 100 years design life
- public transport station buildings, or similar, of more than one storey.

6.3.3 50 year design life

Further to Part A, Section 1.5.3 of this document, the design life of public transport infrastructure, and associated attachments, components and related equipment shall be 50 years for the following elements:

- public transport station buildings, or similar, of one storey
- slab-on-ground buildings, buildings not constructed over road, rail or other transport infrastructure
- minor retaining walls, paths, walkways or similar
- bus shelters and other elements that are not over road, busway, rail or transport infrastructure, and
- building, architectural and fit-out items sub-elements such as windows, glazing, tiles, fascia.

6.4 Design criteria

6.4.1 General

- a) The structural design criteria for public transport stations and ancillary structures shall be developed by the responsible authority, prepared to suit the requirements of each specific project, for review and acceptance by the Director (Structures Design, Review and Standards).
- b) Busway and light rail stations, associated buildings and associated structures shall comply with *Disability (Access to Premises – Buildings) Standards 2010, Part H2 – Public transport buildings*.

6.5 Foundations

6.5.1 Types not permitted by the department

The following foundation types are not accepted for use in foundations for structures above a busway carriageway or those located above a light railway:

- bored piles (without permanent 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.

Any Proponent, who believes the use of such piles is cost effective and will achieve the strength and durability required, may prepare a written submission for assessment by the Director (Structures

Design Review and Standards). Delays in assessing such submissions, and any consequent costs are entirely the responsibility of the Proponent. The publication *Engineering Innovation within the Department of Transport and Main Roads* outlines the steps involved in the innovation process, which takes time and should ideally be done outside of a Contractual situation, at the concept design stage.

6.6 Materials

6.6.1 Concrete

All concrete shall be in accordance with MRTS70 Concrete.

Special class concrete shall be used for all structural members.

Except as allowed under the provisions of Section 6.6.1(d), special class concrete shall be used for all other concrete facilities associated with public transport infrastructure.

Where permitted by the Director (Structures Design, Review and Standards), normal class concrete may be used for:

- i. slabs-on-ground carrying pedestrian traffic only
- ii. drainage gullies, kerbs and channels
- iii. road furniture and signs
- iv. electrical and ITS
- v. minor retaining walls:
 - not supporting road, bus or light rail traffic, and
 - where the retaining wall is not adjacent to a road or busway.

The minimum exposure classification for determining cover to reinforcement and the concrete mix shall be B2 to AS 5100, except for components with design life of 50 years. Minimum exposure classification for components of 50 years or less shall be A2 to AS 3600.

Refer also to Section 3.8.4 for additional requirements of concrete durability.

6.6.2 Structural steelwork

6.6.2.1 Specification

Structural steel material shall meet the requirements of Part B, Section 4.18 of this document, and MRTS78 *Fabrication of Structural Steelwork*.

6.6.2.2 Column base plate details

The detailing of column footings is 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. This hazard may be overcome by ornamental screens to stop people tripping or placing the column base 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.

6.6.2.3 Corrosion protection for structural steelwork

All structural steelworks shall be hot dip galvanised to AS/NZS 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. Galvanising and paint systems shall be applied in accordance with MRTS88 *Protective Coating for New Work*.

Refer Section 3.12.2.1 of this document 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.

6.6.2.4 Substitute for hot dip galvanising

Where hot dip galvanising is not possible, due to a reason such as limitation of the galvanising bath sizes, a zinc metal paint system in accordance with MRTS88 *Protective Coating for New Work* shall be applied subject to prior acceptance from Director (Structures Design, Review and Standards).

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:

- i. Abrasive blasting on site is difficult and undesirable.
- ii. The closure of some lanes for repainting is not possible on highly trafficked roads. Similar conditions shall apply to other transport corridors, and/or
- iii. 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.

7 Gantries and support structures for signage, lighting and ITS

7.1 Applicability

7.1.1 In scope

These design criteria apply to signage, lighting and tollage support structures, of the type covered by Clause 23 of AS 5100.1, where road signs and lighting shall be interpreted to also include provision for the department's Intelligent Transportation System (ITS).

The criteria apply to any gantries or support structures, including cantilevers, that extend over roadways, including traffic lanes and shoulders, irrespective of sign size. The sign size limitations contained in Clause 23 of AS 5100.1 shall not constrain the application of these criteria.

The maximum span for cantilevered structures shall not be greater than 9.5 m, from centreline of the column to the end of the horizontal arm, without the approval of the Director (Structures Design, Review and Standards).

The department maintains the following standard drawings to provide guidance on the general arrangements for gantries and cantilever structures:

- Standard Drawing 1573 *ITS Gantries: Lane Control / Variable Speed Limit Signs – without maintenance Platform*
- Standard Drawing 1577 *ITS Gantries: Lane Control / Variable Speed Limit Signs – Walk on Gantry*
- Standard Drawing 1581 *ITS Cantilever: Cantilever Structure*

Designers are also referred to the provisions of *MRTS61 Gantries and Support Structures for Road Signs, Tolling Systems and ITS Devices*.

These criteria apply to any traffic light poles with characteristics in excess of the parameters given in *MRTS92 Traffic Signal and Road Lighting Footings*, *MRTS94 Road Lighting* and *MRTS97 Mounting Structures for Roadside Equipment*.

7.1.2 Out of scope

These criteria do not apply to advertising signs. For criteria relating to support structures for roadside advertising signs refer to Chapter 8.

Supports for traffic signs and tolling systems on the side of the road, which are not greater than 7.5 m wide nor 8 m high, nor greater than 40 m² in area, may be designed in accordance with the *Traffic and Road Use Management (TRUM) Manual, Volume 3 Signing and Pavement Marking, Part 5: Design Guide for Roadside Signs*, provided that no part extends over a roadway, including traffic lanes and shoulders.

Cantilevered structures greater than 9.5 m, from centreline of the column to the end of the horizontal arm, are not expressly covered by these criteria, and can only be adopted with the prior approval of the Director (Structures Design, Review and Standards), who may impose additional criteria.

Traffic light poles within the parameters provided in *MRTS92 Traffic Signal and Road Lighting Footings*, *MRTS94 Road Lighting* and *MRTS97 Mounting Structures for Roadside Equipment* shall conform with those documents.

7.2 Purchasing guidelines

Proponents are directed to the department's Technical Note TN174 *Purchasing Guidelines for Transport and Main Roads Major Sign Structures*, for introductory guidance on the procurement of these support structures.

7.3 Sign categories

7.3.1 General

These design criteria apply to the following two categories of support structures for signage, ITS and lighting:

1. on-carriageway support structure, and
2. off-carriageway support structure.

7.3.2 On-carriageway support structure

Any support structure that could collapse and fall onto traffic lanes or onto shoulders shall be considered as an on-carriageway structure. The following structure locations are classified as on-carriageway:

- a) the support structure is within the width of the carriageway and shoulders
- b) the support structure posts are located outside the carriageway / shoulder region, but the structure is over the carriageway or shoulders, and
- c) the sign is attached to an overpass bridge.

7.3.3 Off-carriageway support structure

Support structures that are not categorised as on-carriage may be considered as off-carriageway support structures.

7.4 Design life

The design life for support structures shall be as follows:

- | | |
|---------------------------------------|-----------|
| a) On-carriageway support structures | 100 years |
| b) Off-carriageway support structures | 50 years |

7.5 Aesthetics

Support structures shall be aesthetically compatible with other similar structures in the road network.

7.6 Provision of ITS devices

An Intelligent Transport System (ITS) allows the placement of devices with the intent of effectively managing traffic flows on a state-controlled road. These devices include:

- a) Variable Message Sign (VMS)
- b) Lane Use Management Sign (LUMS)
- c) Variable Speed Limit Sign (VSLS)
- d) Travel Time Sign (TTS), and
- e) Closed Circuit Television (CCTV).

The requirements for selection of appropriate ITS devices, and the support structures necessary to position them, are given in various Transport and Main Roads Manuals and Technical Specifications.

A useful guide to the project design process for the selection of ITS support structures is the department's Technical Note TN123 *Flow Charts for Selection of Gantries for Intelligent Transport Systems (ITS) Devices*.

The general and specific standards and Technical Specifications relevant to ITS are shown in Table 7.6.

Table 7.6 – ITS Specifications

General Technical Specifications and Standards	
MRTS01 <i>Introduction to Technical Specifications</i>	MRS50 <i>Specification (Measurement)</i>
MRS01 <i>Specification (Measurement)</i>	MRTS96 <i>Management and Removal of Asbestos</i>
MRTS02 <i>Provision for Traffic</i>	MRS96 <i>Specification (Measurement)</i>
MRS02 <i>Specification (Measurement)</i>	AS 3000 <i>Australian Wiring Rules</i>
MRTS50 <i>Specific Quality System Requirements</i>	Installation requirements for AS/CA S009 <i>Customer Cabling</i>
ITS Technical Specifications	
MRTS61 <i>Gantries and Support Structures for Road Signs, Tolling Systems and ITS Devices</i>	MRTS226 <i>Telecommunication Field Cabinets</i>
MRTS91 <i>Conduits and Pits</i>	MRTS228 <i>Provision of Electrical Switchboards</i>
MRS91 <i>Conduits and Pits (Measurement)</i>	MRTS232 <i>Provision of Field Processors</i>
MRTS201 <i>General Equipment Requirements</i>	MRTS234 <i>Communications Cables</i>
MRTS202 <i>Provision of Variable Message Signs</i>	MRTS225 <i>Imaging</i>
MRTS206 <i>Provision of Variable Speed Limit and Lane Control Signs</i>	MRTS245 <i>Principal's Telecommunications Network</i>
MRTS210 <i>Provision of Mains Power</i>	MRTS256 <i>Power Cables</i>

7.7 Vertical clearance

The minimum vertical clearance of the structure or sign face (whichever is lower) above the roadway 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 facility, or other areas accessible by vehicles, a minimum of 2700 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 and/or cyclists.

7.8 Protection of sign support structures from vehicle impact

7.8.1 General principles

Portal frame and cantilever style overhead gantry support structures within the clear zone shall be protected, from vehicle impact, by a traffic barrier.

The clear zone shall be as defined in the department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

The traffic barrier shall be designed to suit road environment, traffic volume and mix, and road design speed.

7.8.2 Barrier deflection restrictions

The minimum nearside and offside distance to the edge of the lane and the barrier shall comply with:

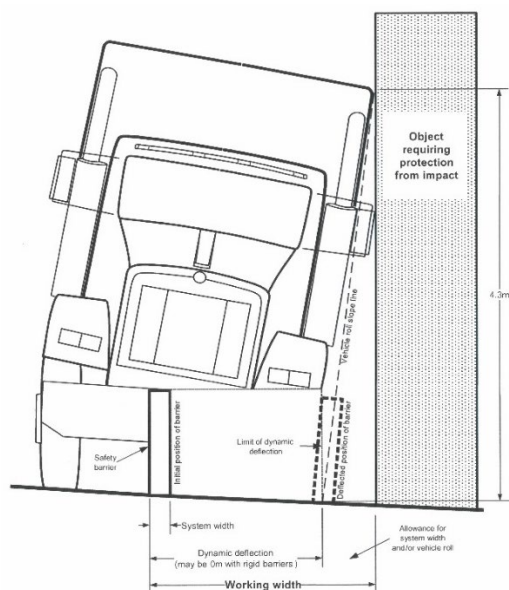
- a) AS/NZS 3845 *Road Safety Barrier Systems and Devices, Part 1: Road Safety Barrier Systems*, and
- b) the department's *Planning and Design Manual, Edition 2, Volume 3 Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

The barrier shall have sufficient clearance to the support structure to allow for barrier dynamic deflection and provide access for maintenance. It should be noted that all road safety barriers have a range of deflection values.

7.8.3 Working width restrictions

In general, gantries and support structures shall be located behind a road safety barrier, at a distance greater than the estimated working width requirement (refer Section 7.8.4).

To ensure that the gantry is not subjected to vehicle impact loads that cause its collapse, the estimate of working width shall take into account both the dynamic deflection of the barrier and an assessment of body roll of a high vehicle striking the barrier (refer to Figure 7.8.3), and accord with the department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

Figure 7.8.3 – Working width

Where, in exceptional cases, a support structure cannot be located outside the working width, special conditions apply (refer Section 7.8.4).

7.8.4 Traffic barrier design criteria

7.8.4.1 Traffic barrier categories

When designing traffic barriers for support structures, there are two design categories, namely:

- normal road safety barrier - where the gantry support is outside the working width, and
- special road safety barrier - where the gantry support is inside the working width.

7.8.4.2 Normal road safety barrier requirements

The following conditions apply when the sign support structure is located outside the working width.

- Where cantilever or gantry mounted signs are to be installed on-carriageway, the following is required to shield and protect 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 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. In such cases refer to the department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*, for guidance on analysis and risk assessment of road safety barriers, and

- v. 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 department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.
- b) Once the type of barrier required is determined, the geometrical layout of the barrier, including the 'length of need' of the barrier, shall be designed in accordance with the department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

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.

- c) 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 within the median may be preferable.

7.8.4.3 Special road safety barrier

7.8.4.3.1 Sign support structure located within the working width

Where a special road safety barrier design is required, the design is considered outside the scope of standard Transport and Main Roads' road safety barrier designs and the *Road Planning and Design Manual, 2nd Edition*. In such instances, the road safety barriers shall be designed in accordance with the 'Special Performance' criteria outlined in AS 5100.1 – Table 14.4 and Clause 14.5.6 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 1800 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, for 'Special performance level barriers', the ultimate transverse outward load is 750 kN (for a straight horizontal alignment, design speed 110 km/h), and 1200 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 1200 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 the department's *Road Planning and Design Manual, Edition 2, Volume 3: Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

The road safety barriers shall be constructed concurrently with the gantry or support structure so that once it is erected, the permanent road safety barriers are in place to protect the gantry / support structure from vehicle impact.

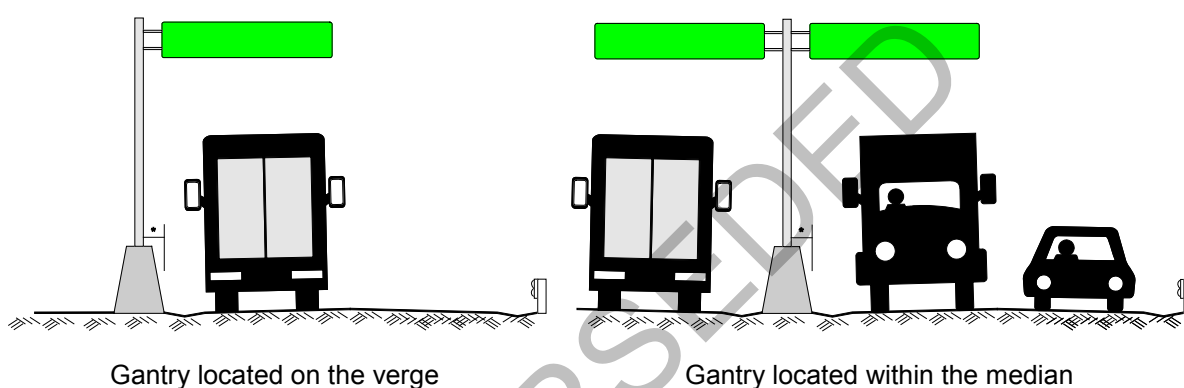
7.8.4.3.2 Sign support is incorporated within road safety barrier

Every attempt shall be made to avoid situations where support structures are within both:

- i. road safety barrier itself, and
- ii. working width as defined in Section 7.8.2.

As examples, consider the roadside cantilever and the 'butterfly' cantilever gantries within median barriers as shown in the Figure 7.8.4.3.2.

Figure 7.8.4.3.2 – Gantry supports designs incorporated within road safety barriers and within the working width



These situations can only be utilised with the approval of the Director (Structures Design, Review and Standards).

7.9 Structural design considerations

7.9.1 General

The principle design considerations for gantries and support structures are:

- wind loads
- load combinations
- maintenance loads (if applicable)
- deflections
- fatigue, and
- vibration.

7.9.2 Wind loading

Wind load shall be calculated in accordance with AS/NZS 1170.2 with wind perpendicular and at 45° to the sign face.

a) Ultimate strength:

Ultimate strength structural design shall be to AS 5100.2.

ARI for ultimate limit state wind speed shall be 2000 years.

b) Serviceability:

ARI for serviceability limit state wind speed shall be 20 years.

The following design parameters, at least, shall be nominated in the design report, and shown on the design drawings:

- wind region
- terrain category
- design wind speeds, and
- drag force coefficients.

Ideally, the regional gust wind speed and the site multipliers adopted in the design process should also be nominated.

7.9.3 Load combinations

Load factors and load combinations shall be in accordance with AS(/NZS) 5100.

7.9.4 Fatigue

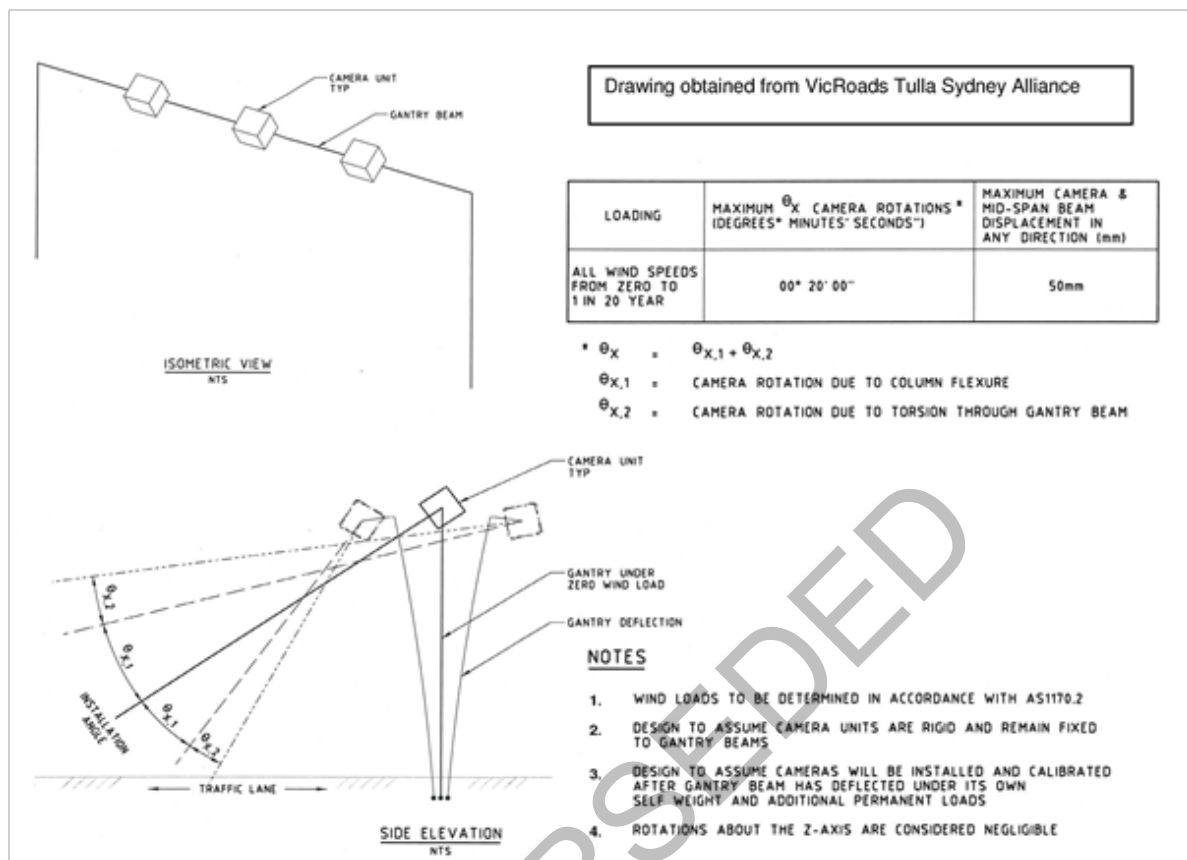
Design for fatigue shall be in accordance with the latest revision of the *AASHTO LRFD Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*.

7.9.5 Serviceability deflection

Deflection calculations shall consider appropriate combinations of self-weight, service live loads and serviceability wind loads.

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 (refer Figure 7.9.5).

Figure 7.9.5 – Camera deflection criteria (deflection criteria are subject to specific camera requirements)



The deflection calculations for all structures shall include the long-term creep deflection resulting from the foundation movement.

Deflection criteria for portal structures are provided in Tables 7.9.5(a).

Table 7.9.5(a) – Deflection criteria for portal structures

Load case	Deflection	
	Vertical	Horizontal
Self-weight (Permanent loads)	Refer Clause 24.3.2 of AS 5100.2	-
Live Load	Span / 250	-
Serviceability Wind	-	Span / 250
Serviceability Wind - camera	Refer to Figure 7.9.5	

Deflection criteria for cantilever structures are provided in Table 7.9.5(b).

Table 7.9.5(b) – Deflection criteria for cantilever structures

Load case	Deflection ¹	
	Vertical	Horizontal
Self-weight (Permanent loads)	Refer Clause 24.3.3(b) of AS 5100.2	-
Live Load	Arm Span / 125	-
Serviceability Wind	Refer Clause 24.3.3(c) of AS 5100.2	

Note 1: Maximum span for cantilevered gantries shall not be greater than 9.5 m, from centreline of the column to the end of the horizontal arm.

Cantilever structures shall be designed to include the profile adjustment presets required by Clause 24.3.3(a) of AS 5100.2.

7.9.6 Vibrations

Vibration limits shall be in accordance with AS/(NZS) 5100 and the manufacturer's requirements for each particular ITS device.

7.9.7 Durability considerations

7.9.7.1 Steelwork and corrosion protection

The minimum protection of all steel shall be hot-dip galvanising to AS/NZS 4680 including all internal surfaces of circular and hollow section 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, and
- Double dipping shall be allowed.

7.9.7.2 Concrete durability

The minimum exposure classification for determining cover to reinforcement and the concrete mix for structures of design life 100 years shall be B2 to AS 5100.5. The exposure classification for structures of design life 50 years or less shall be minimum A2 to AS 3600.

Also refer to Section 3.12.3 in Part B of this document for additional requirements of concrete durability.

7.9.8 Foundations

7.9.8.1 Foundation investigation, design and documentation

Foundation design, including methodology, geotechnical investigations, design documentations and reporting, shall be carried out in accordance with the department's *Geotechnical Design Standard - Minimum Requirements*.

Foundation design for structures shall be based on specific foundation investigations at the sign location to a minimum depth of one full height of the structure, unless otherwise directed by the RPEQ (Geotechnical) Engineer in charge of the investigation.

An experienced RPEQ Geotechnical Engineer, who is Transport and Main Roads 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 Section 7.9.5.

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 present on the site.

The set of detailed design drawings for a gantry or other support structure shall be so arranged that the geotechnical features of the site and the foundation details are contained on discrete drawings, in such a manner that the Geotechnical Engineer is able to provide the relevant RPEQ certification for the foundations, separate to those other details provided for the remainder of the gantry or support structure.

7.9.8.2 Preferred foundation types

The following foundation types are preferred for gantries and support structures:

- a) Cast-In-Place piles to technical specification MRTS63 *Cast-In-Place Piles* or MRTS63A *Piles for Ancillary Structures* as applicable.
- b) MRTS63A *Piles for Ancillary Structures* 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 *Cast-In-Place Piles*.
- c) Prestressed concrete driven piles to MRTS65 *Precast Prestressed Concrete Piles*, and
- d) Spread footings.

Any other foundation types require prior approval from the department's Director (Structures Design, Review and Standards) prior to start of design.

7.9.8.3 Foundation types not permitted for gantries and support structures

The following foundation types are not generally accepted for use in foundations for structures 'on carriageway' with 100 years design life, or those located above a railway:

- steel screw piles
- Continuous Flight Auger (CFA) piles
- precast reinforced concrete piles
- steel piles (except for Western Queensland, refer Section 4.1.6)

- precast concrete piles manufactured by spinning or rolling
- piles constructed with bentonite or polymer slurry, and
- bored piles without permanent steel or concrete liners.

Any Proponent, who believes the use of such piles is cost effective and will achieve the strength and durability required, may prepare a written submission for assessment by the department's Director (Structures Design, Review and Standards). Delays in assessing such submissions, and any consequent costs are entirely the responsibility of the Proponent. The department's publication *Engineering Innovation within the Department of Transport and Main Roads* outlines the steps involved in the innovation process, which takes time and should ideally be done outside of a Contractual situation, at the concept design stage.

7.9.8.4 Column bases

The foundations shall be designed so that any base plate is installed as close to ground level as practicable, while providing for drainage around the column base.

Column base plates shall always remain clear of avoidable moisture ingress, and be designed to avoid debris collection, including the effects of landscaping activities.

Column bases must be accessible for inspection and enable ease of maintenance.

The design length of the support columns shall take into consideration any variations in the levels of the foundations.

Ideally foundations shall be installed below ground level with the top surface of the pile cap or footing at the same level as the surrounding ground surface level with appropriate falls and detailing to ensure surface drainage falls away from structural baseplates.

Where, in highly visible areas, it is appropriate to bury the footing, column baseplates shall be installed above ground on a bearing plinth with suitable provision for drainage.

7.10 Support structures attached to bridges

7.10.1 General

The following additional criteria apply to the structural design and fabrication of sign structures mounted on Transport and Main Roads bridges:

- a) 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.
- b) The 'working width' is defined in the department's, *Road Planning and Design Manual 2nd Edition, Volume 3*.
- c) To allow 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 and dropping objects onto the motorway below. This is a 'Safety in Design' requirement.
- d) The design shall prevent access by vandals to the sign structure and tamper proof fastenings and connections shall be used.

- e) The sign structure shall not restrict access for maintenance and repairs to the traffic barrier. Drilling or coring into prestressed concrete is NOT permitted. Signs shall be attached with stainless steel or hot dip galvanized bolts, appropriate to the corrosivity environment at the sign.
- f) 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.
- g) The impact load on the barrier shall be assessed using the Road Barrier Performance Level Selection Method in Clause 14 of AS 5100.1. 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 Appendix A, in this document, Matters for Resolution in AS(/NZS) 5100, for the procedure and requirements to determine the barrier performance level.

For comparison, the barrier impact load in the various superseded Bridge Design Codes is as follows:

- i. NAASRA 1976 45 kN (working transverse outward load)
- ii. Austroads 1992 90 kN (ultimate transverse outward load) for $h < 850$ mm
- iii. AS 5100.2 (2004):
 - Low performance 125 kN (ultimate transverse outward load)
 - Regular performance 250 kN (ultimate transverse outward load).

These can be compared with AS 5100.2 (2017)

- Low performance 150 kN (ultimate transverse outward load)
 - Regular performance 300 kN (ultimate transverse outward load).
- h) 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 50% of low performance, that is 75 kN minimum impact load.
 - i) For bridges designed in accordance with AS 5100-2004, the full impact load stipulated by that code for the 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. Designers shall determine the appropriate barrier performance level in accordance with the AS 5100.1-2004, Appendix B.
 - j) For bridges designed in accordance with AS(/NZS) 5100-2017, the full impact load stipulated by that code for the 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. Designers shall determine the appropriate barrier performance level in accordance with the AS 5100.1-2017, Appendix A.
 - k) 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 (Structures Review and Standards).

- l) 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.

7.10.2 Support structures 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.

7.10.3 Support structures 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, the regular level steel traffic barrier detailed in Standard Drawing 2200 will deflect 100 mm when impacted.

7.11 Maintenance access

7.11.1 General

All support structures for signs, lighting and ITS shall make adequate provision for maintenance access, particularly where access over heavily trafficked roads is required.

The department has published Standard Drawings 1577 and 1581 for new gantry and cantilever structures with provisions for maintenance access.

Unless otherwise specified, maintenance platform provisions shall be designed and installed in accordance with:

- *AS 1657 Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
- *AS/NZS 1891 Industrial Fall-arrest systems and devices – series*
- *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.

Guidance in this section has been developed in consultation with the department's WHS Advisor, and is intended to specify general requirements for both new structures, and for retro-fitting existing VMS structures that do not currently comply with AS 1657.

Fall arrester systems have been standardised for consistency of equipment requirements across the department and to minimise variations as required by RoadTek.

7.11.2 Access to the structure site

The design must incorporate an access strategy, indicating where maintenance staff can park a vehicle and a pathway that will allow them to 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 should not require traffic control measures, and/or lane closures, unless there is no other alternative.

Provision shall be made for impact protection of maintenance personnel from errant vehicles.

7.11.3 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 this equipment and structural components without disrupting traffic.

Where a maintenance platform is required, the maintenance platform shall comply with AS 1657 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 loading by a 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.

The serviceability deflection under any live load shall not exceed the limits stated in Section 7.9.5.

All designs for walkways and platforms shall have provisions for permanent plates to be 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.

The floor of the maintenance platform shall be a grated floor to comply with AS 1657

Clause 3.2.3 Flooring materials and Clause 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 prevent 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.

The platform shall be free of sharp corners and projections that can cause injury.

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 guard railing 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.

7.11.4 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 in current legislation. The access shall be secured and ensure unauthorised persons cannot enter the structure.

For new structures, the requirement of intermediate landing and ladder cage shall be in accordance with Table 7.11.4(a) below and AS 1657.

Table 7.11.4(a) – 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	<ul style="list-style-type: none"> • Ladder cage • For existing structures, if ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.4.7: Note 2

Structure type	Fall distance	Fall protection provisions	AS 1657 reference clauses
	> 6.0 m	<ul style="list-style-type: none"> Ladder cage, and Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal. For existing structures, if ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.3.6, 7.4.7 and Table G1 (rung type ladder – twin stiles) Clause 7.4.6 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	<ul style="list-style-type: none"> Ladder cage For existing structures, if ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.4.7: Note 2
	> 6.0 m	<ul style="list-style-type: none"> Ladder cage, and -Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal. 	Clause 7.3.6, 7.4.7 and Table G1 (rung type ladder – twin stiles) Clause 7.4.6 Clause 7.3.6: Note 2
		<ul style="list-style-type: none"> 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). A harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.4.6 Clause 7.3.6: Note 3

When intermediate landing with multiple ladders are used, the ladder arrangement shall be in accordance with AS 1657.

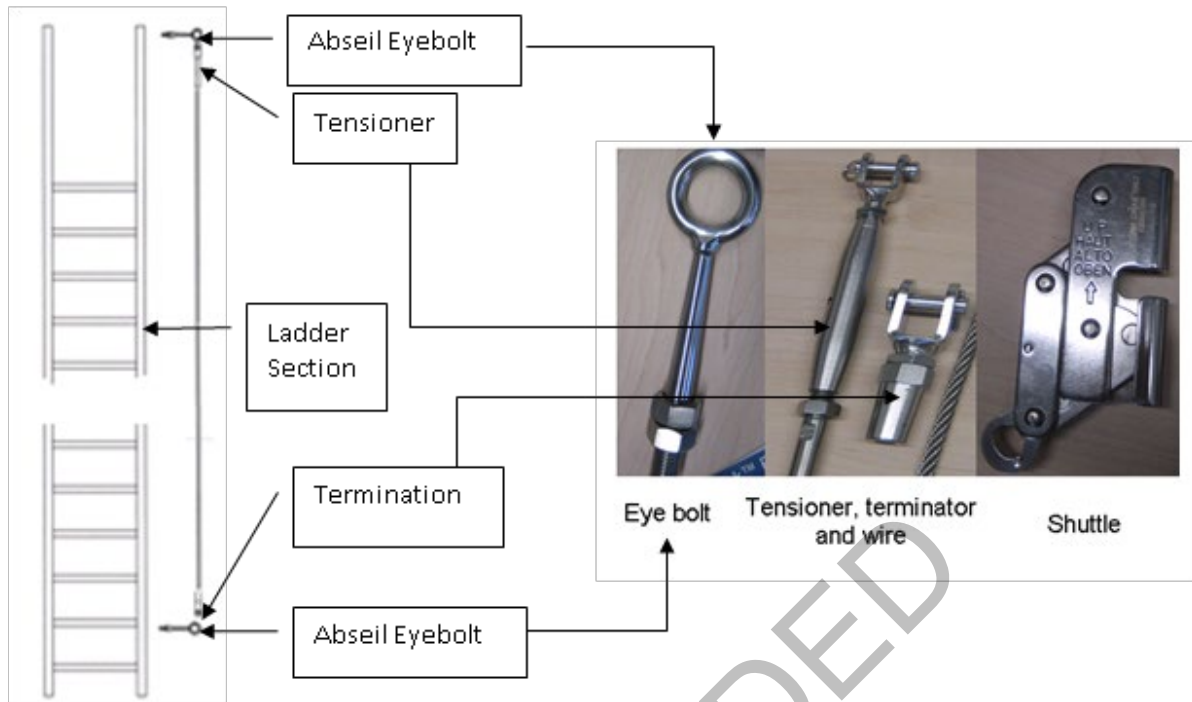
Fall arrester harness systems shall comply with AS/NZS 1891. The harness system shall be capable of arresting falls within a short drop of not greater than 600 mm. The designer shall be responsible for nominating the type of harness and providing attachment points in the structure. The approved fall arrester system shall have Certification and Approval to AS/NZS 1891 (Series): *Industrial fall – arrest systems and devices – harnesses and ancillary equipment*.

Table 7.11.4(b) and Figure 7.11.4 show the details of the fall arrester system manufactured by SafetyLink Pty Ltd which is acceptable to Transport and Main Roads.

Table 7.11.4(b) – Details of the fall arrester system

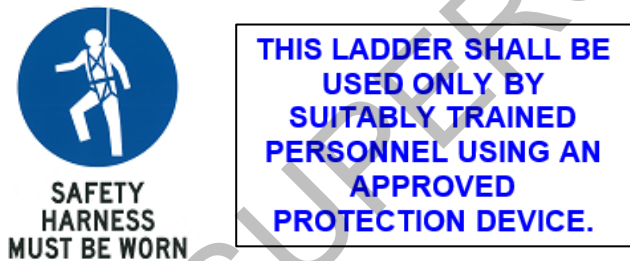
Part Nos.	Product list
Ladder001:10	Vertical Static Line Shuttle with Karabiner (not required for each site, required for those climbing the gantry)
Eyebolt002	Abseil eyebolt (2 Nos.)
Stat.Tensr002	Swage less Tensioner (1 No)
Stat.Term002	Swage less Termination (1 No)
Stat.Cable001	Stainless Steel Cable (typically 9 m length to suite specific gantry)

Figure 7.11.4 – Parts of the fall arrester system



The following additional requirements shall also be met:

1. At the bottom of the ladder, the following sign and the wording shall be attached.



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 from 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 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 Compliance Certificate certified by an appropriately experienced RPEQ stating that the structure complies with:
 - AS 1657 *Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
 - AS/NZS 1891 (series) *Industrial fall-arrest systems and devices – Harnesses and ancillary equipment*
 - *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 Queensland.

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

7.12 Wiring

7.12.1 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 Technical Specification MRTS91 *Conduits and Pits*.

7.12.2 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.

7.13 Fixings

7.13.1 Anchor bolt / rod details

On the basis of NCHRP reports and learnings from interstate sign failures, the following must be observed:

- a) Connections using Class 4.6 bolts are less likely to be controlled by fatigue requirements than those which use Class 8.8. Either grade may be used, however, provided that the design satisfies both ultimate strength and fatigue life requirements. Class 8.8 bolts shall conform to

Transport and Main Roads Technical Specification MRTS78 *Fabrication of Structural Steelwork*.

- 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:
 - i. purpose made half height nuts
 - ii. made from softer steel than the ordinary nut, and
 - iii. located between the ordinary nut and the base plate.
- e) For Class 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 class 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.

7.13.2 Base plate

Base plates shall be at least as thick as the diameter of the anchor bolts/rods in assembly they are attached to.

7.13.3 Bolts, nuts and washers

Steel bolts, nuts and washers shall be in accordance with MRTS78 *Fabrication of Structural Steelwork*.

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.

7.14 Structural steelwork

Structural steel material shall meet the requirements of Section 4.16

7.15 Drawings and design report

All gantries and support structures for signs, lighting, tolling and ITS are subject to the design and review process described in Part A: Section 2 of this document.

The design submission shall include the Design Report and the drawings for construction. Drawings shall comply with the department's *Drafting and Design Presentation Standard Manual, Volume 3, Structural Drafting Standard*. All engineering drawings shall be certified by an appropriately experienced 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 include the following:

- i. Foundation layout, positions and reduced levels shall be shown on the drawings, arranged in accordance with Section 7.9.8.1 e).
- ii. All design loads for the structure are to be shown on the structure specific 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.
- iii. The erection sequence shall include all requirements for tightening of hold-down bolts prior to grouting and prior to attachment of outreach arms.
- iv. 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.
- v. Use of upper and lower templates for hold down bolts is recommended to ensure a good fit with holes in the base plate.
- vi. Bending of hold down bolts and use of enlarged bolt holes are not permitted without design details.
- vii. Impact protection from errant vehicles (refer Section 7.8).
- viii. 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.
- ix. All welds are to be detailed on the drawings and weld symbols shall be in accordance with AS 1101.

Adequate notes for the construction of support structures shall be shown on the drawings. Notes shall be consistent with those in the department's *Drafting and Design Presentation Standard Manual, Volume 3, Structural Drafting Standard*. The notes shall address the following additional issues:

- prior to concreting, excavated foundations shall be inspected by the Geotechnical Assessor, and
- only those welds shown on the drawings are permitted. No weld is to be omitted or added without the specific approval of the Administrator.

Designs shall be submitted in accordance with the Design report phases nominated in Section 2.4.2 of this document, namely:

- 15% - preliminary design
- 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 Director (Structures Design, Review and Standards).

Fabrication shall not begin until final drawings have been submitted to the department and accepted. Fabrication shall not begin until all hold points and witness points in MRTS78 *Fabrication of Structural Steelwork* are released by Transport and Main Roads.

7.16 Fabrication of structural steelwork and aluminium components

The design documents shall include provisions that will ensure the following requirements are achieved:

- a) Fabrication of structural steelwork and aluminium shall be to:
 - MRTS78 *Fabrication of Structural Steelwork*
 - MRTS78A *Fabrication of Structural Stainless Steelwork*, and
 - MRTS79 *Fabrication of Aluminium Components*.
- b) All hollow sections shall be joined using full penetration butt welds. Fillet welds are not acceptable for this application as they encourage crevice corrosion resulting in premature failure.
- c) All structural steelwork and all aluminium work shall be inspected by an appropriately experienced 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.
- d) 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, and
 - Inspection Report outlining the non-destructive testing carried out in accordance with the specification.

7.17 Installation of structure

The design documentation for any gantry or support structure shall ensure that installation shall be in accordance with Transport and Main Roads Technical Specifications.

Transport and Main Roads does not permit the use of levelling nuts to support the structure.

Acceptable installation options are canvassed in the department's Technical Note 68 *VMS Gantry Installation Procedure*. 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. For example, an acceptable procedure is as follows:

- stand the column section and level the column by placing a minimum of four steel wedges under each base plate
- mix the non-shrink mortar to a consistency suitable for placement by trowel
- pack the mortar and ensure that the mortar extends over the full area of the base plate
- wait for the mortar to set sufficiently to support the weight of the structure
- remove the steel wedges
- tension the bolts, and
- repair the mortar where the wedges were located.

All materials and bolts shall conform to the requirements of Transport and Main Roads Technical Specification MRTS78 *Fabrication of Structural Steelwork*.

7.18 Inspection

The design documentation for gantries and support structures shall make provision for the following requirement.

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 the department's Support Advice Note No. 112 *Large Traffic Management Signs - Inventory Creation & Inspection*. The inspection category and inspection frequency shall be as specified in the LTMS Advice Note.

8 Roadside advertising signs

8.1 Introduction

The design of roadside advertising signs shall be developed in accordance with the following Department of Transport and Main Roads' documents:

- i. Engineering Policy EP162 *Policy for the Management of Roadside Advertising*
- ii. *Roadside Advertising Manual*.

8.2 Sign licensee

The Sign Licensee is the person or company who has made a Road Corridor Permit Application and has approval to construct a roadside advertising sign, subject to the provision of a satisfactory RPEQ certified detailed design.

8.3 Scope

These design criteria apply to those requirements, in the *Roadside Advertising Manual*, for roadside advertising sign structures to be certified by an RPEQ.

Prior to the start of structural design, the Sign Licensee and the Transport and Main Roads Director (Structures Design, Review and Standards) shall agree on the members that are to be designed as 'Structural members' and those that can be considered 'Non-structural members'.

'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.

The following sign elements are out of scope:

- 'Non-structural members', being members that do not contribute to the structural integrity of the structure, nor provide a linkage in the load path. Typically, these are members that support any electronic devices and components, flashings for the "sign box" cladding, water proofing and so on.
- Advertising sign face.

8.4 Sign categories

8.4.1 General

These design criteria apply for two categories of roadside advertising sign.

8.4.2 On-carriageway advertising signs

Any sign structure that could collapse and fall onto traffic lanes or onto shoulders shall be considered as an on-carriageway advertising sign.

The following structure locations are classified as on-carriageway:

- i. the sign structure is within the width of the carriageway and shoulders, or
- ii. the sign post is located outside the carriageway / shoulder region, but the sign face is over the carriageway or shoulders as shown in Figure 8.4.3(a)
- iii. the sign is attached to an overpass bridge.

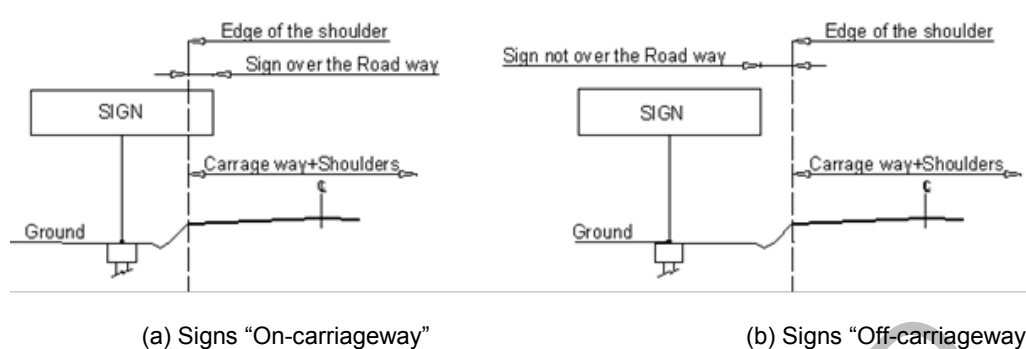
See Section 8.6 for design criteria related to on-carriageway advertising sign structures.

8.4.3 Off-carriageway advertising signs

All sign structures that are not categorised as on-carriage shall be considered as off-carriageway advertising signs. A typical off-carriageway sign is shown in Figure 8.4.3(b).

Refer to Section 8.7 in relation to design criteria for off-carriageway advertising sign structures.

Figure 8.4.3 – Advertising sign structure locations



8.5 Aesthetics

Roadside advertising sign support structures shall be aesthetically compatible with other similar structures in the road network.

8.6 Design criteria for on-carriageway advertising signs

8.6.1 General

These criteria shall be applied for advertising sign locations defined in Section 8.4.2.

Refer to Section 8.7 for design criteria for off-carriageway advertising sign structures as defined in Section 8.4.3.

8.6.2 Vertical clearance

The minimum vertical clearance of the structure or sign face (whichever is lower) above the roadway (carrage way plus shoulders) shall be 6600 mm (6500 mm plus 100 mm for future overlays) after allowing for vertical deflection due to permanent loads.

When a sign face is not over the road carrage ways, road shoulder, parking, or other areas accessible by vehicles, a minimum of 2700 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 and cyclists.

When the sign structure is attached to an existing overpass bridge, the vertical clearance to any component of the sign structure shall not be less than the vertical clearance of the existing bridge plus 50 mm.

8.6.3 Advertising signs attached to bridges

8.6.3.1 General considerations

The following criteria apply to the structural design and fabrication of roadside advertising signs mounted on bridges controlled by the department:

- a) 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.

Transport and Main Roads *Road Planning and Design Manual*, Edition 2, Volume 3: *Supplement to Austroads Guide to Road Design*, Part 6: *Roadside Design Safety and Barriers*. Refer also Section 7.8.3 of this document.

- b) These signs require Transport and Main Roads Level 2 structural inspections.
- c) 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.
- d) The design shall prevent access by vandals to the sign structure and tamper proof fastenings and connections shall be used.
- e) A structure with vertical balustrades or other suitable screens 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 12.5 of AS 5100.2.
- f) The sign structure shall not restrict access for maintenance and repairs to the traffic barrier.
- g) Drilling or coring into prestressed concrete members is NOT permitted. Signs shall be attached with stainless steel or hot dip galvanized bolts.

8.6.3.2 Advertising 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.

8.6.3.3 Advertising 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 performance level double steel traffic barrier detailed in Standard Drawing 2200 will deflect 100 mm approximately when impacted.

8.6.3.4 Working with asbestos in existing bridges

The Licensee shall investigate whether any permanent asbestos items have been used in the bridge prior to preparing the concept design proposal for attaching a sign structure to a bridge. Refer Section 3.6.6 for procedure to be followed for identification and working with asbestos.

If the presence of asbestos is identified in the existing bridge the financial ramifications of attaching the sign structure shall be identified, as the cost of working safely with asbestos can be high.

In the presence of asbestos, approval from Director (Structures Design, Review and Standards) shall be obtained prior to commencing the concept design.

8.6.4 Materials

8.6.4.1 General

Concrete shall be to MRTS70 *Concrete* and steel reinforcement to MRTS71 *Reinforcing Steel*.

Structural steel shall be to standards specified in Section 8.6.4.2.

Other materials, shall not be used without the prior approval of the Transport and Main Roads Director (Structures Design, Review and Standards). If permitted, the approval letter will contain details of the appropriate standards and/or design codes.

8.6.4.2 Structural steel

Structural steel material shall meet the following requirements:

- a) All cold formed structural steel hollow sections to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel.
- b) 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 *Cast-In-Place Piles*. Rolled plates shall be manufactured in accordance with MRTS63 *Cast-In-Place Piles* 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.
- c) All hot rolled steel plates shall be to AS/NZS 3678.
- d) All structural steel hot rolled sections shall be to AS/NZS 3679.1.
- e) Structural steel welded sections shall be to AS/NZS 3679.2.
- f) 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.
- g) 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.
- h) Spirally wound fabricated circular hollow sections are not permitted.

8.6.4.3 Bolts, nuts and washers and safety cables

Steel bolts, nuts and washers shall be in accordance with MRTS78 *Fabrication of Structural Steelwork*.

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, although not to structural members.

8.6.5 Structural design

8.6.5.1 Design life

The design life for advertising sign structures shall be 40 years, unless the advertising sign is attached to a bridge in which case structures and all fasteners attached to the bridge shall have a 100 year design life.

8.6.5.2 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.

8.6.5.3 Wind loading

Wind load shall be calculated in accordance with AS 1170.2 with wind perpendicular and at 45 degrees to the sign face. Drag force coefficient C_d shall be in accordance with AS 1170.2.

ARI for ultimate limit state wind speed shall be 2000 years. ARI for serviceability limit state wind speed shall be 20 years.

8.6.5.4 Design for ultimate strength

Ultimate strength structural design shall be to AS/(NZS) 5100.

8.6.5.5 Structural design criteria for fatigue

Design for fatigue shall be in AASHTO LRFD *Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, 1st Edition, 2017 revision: Section 11, *Fatigue Design*.

8.6.5.6 Attachment to prestressed concrete members

Drilling and coring into prestressed concrete members is not permitted.

8.6.5.7 Load combinations

Load factors and load combinations for structural design shall be to AS/(NZS) 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 5100.1. 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 Appendix A 'Matters for Resolution to AS/(NZS) 5100' for the procedures and requirements to determine the barrier performance level.

For comparison, the barrier impact load in the various superseded *Bridge Design Codes* is as follows:

- i. NAASRA 1976 45 kN (working transverse outward load)
- ii. Austroads 1992 90 kN (ultimate transverse outward load) for $h < 850$ mm
- iii. AS 5100.2 - 2004:
 - Low performance 125 kN (ultimate transverse outward load)
 - Regular performance 250 kN (ultimate transverse outward load).

These can be compared with AS 5100.2 – 2017:

- Low performance 150 kN (ultimate transverse outward load)
- Regular performance 300 kN (ultimate transverse outward load).

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 50% of low performance, that is 75 kN minimum impact load.

For bridges designed in accordance with AS 5100 - 2004, the full impact load stipulated by that code for the 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 – 2004, Appendix B.

For bridges designed in accordance with AS/(NZS) 5100 - 2017, the full impact load stipulated by that code for the 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 – 2017, Appendix A.

Bridges designed prior to 1976 are considered as special cases and the appropriate barrier impact load shall be discussed with the Transport and Main Roads Director (Structures Review and Standards).

The sign structure Designer shall check the structural adequacy of the bridge structure. The following additional load combinations for ultimate design shall be considered:

- i. 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.
- ii. 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.
- iii. 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.

8.6.5.8 Serviceability deflection

The self-weight, live loads and serviceability wind loads shall be taken into account for deflection calculations. 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 Tables 8.6.5.8(a) and 8.6.5.8(b) respectively.

Table 8.6.5.8(a) – Deflection criteria for portal structures

Load case	Deflection	
	Vertical	Horizontal
Self-weight (permanent loads)	No sag or downwards deviation from the horizontal	-
Live Load	Span/250	-
Serviceability Wind	-	Span/300

Table 8.4.5.8(b) – Deflection criteria for cantilever structures

Load case	Deflection *	
	Vertical	Horizontal
Self-weight (Permanent loads)	No sag or downwards deviation from the horizontal	-
Live Load	Arm Span/125	-
Serviceability Wind	Combined horizontal deflection – 200 mm max. at free end of arm (including post and arm horizontal deflection and post torsional deflection)	

* Maximum span for cantilevered sign gantries shall not be greater than 9.5 m, from centreline of the column to the end of the horizontal arm.

8.6.5.9 Vibration

Vibration limits shall be in accordance with AS/(NZS) 5100 and the Sign Licensee's requirements for each particular device and screen.

8.6.5.10 Foundation design

8.6.5.10.1 General

Foundation design for advertising 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 appropriately experienced RPEQ (Geotechnical) Engineer. The RPEQ certified Geotechnical 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 Section 8.6.5.8.

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.

The set of detailed design drawings for a roadside advertising sign shall be so arranged that the geotechnical features of the site and the foundation details are contained on discrete drawings, in such a manner that the Geotechnical Engineer is able to provide the relevant RPEQ certification for the foundations, separate to those other details provided for the remainder of the gantry or support structure.

8.6.5.10.2 Acceptable foundation types

The following foundation types are acceptable for use in supporting on-carriageway signs:

- a) Cast-In-Place piles to MRTS63 *Cast-In-Place Piles* or MRTS63A *Piles for Ancillary Structures* as applicable.

- b) MRTS63A *Piles for Ancillary Structures* 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 *Cast-In-Place Piles*.
- c) Prestressed concrete driven piles to MRTS65 *Precast Prestressed Concrete Piles*, and
- d) Spread footings.

Any other foundation types shall be agreed with Transport and Main Roads (Structures) prior to commencing design.

8.6.5.10.3 Unsuitable foundation types

The following foundation types are not accepted for use in foundations for on carriageway advertising structures or those located above a railway:

- i. steel screw piles
- ii. Continuous Flight Auger (CFA) piles
- iii. precast reinforced concrete piles
- iv. steel piles (except for Western Queensland, refer Clause 4.1.6)
- v. precast concrete piles manufactured by spinning or rolling
- vi. piles constructed with bentonite or polymer slurry, and
- vii. bored piles without permanent steel or concrete liners.

Any Proponent, who believes the use of such piles is cost effective and will achieve the strength and durability required, may prepare a written submission for assessment by the Transport and Main Roads Director (Structures Review and Standards). Delays in assessing such submissions, and any consequent costs are entirely the responsibility of the Proponent. The department's publication *Engineering Innovation within the Department of Transport and Main Roads* outlines the steps involved in the innovation process, which takes time and should ideally be done outside of a Contractual situation, at the concept design stage.

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.

8.6.5.11 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 MRTS78 *Fabrication of Structural Steelwork*.
- 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.

8.6.5.12 Base plate thickness

The base plate shall be at least as thick as the anchor bolt diameter.

8.6.6 Corrosion protection and durability

The minimum protection of all steelwork shall be either painted, to meet departmental technical standards, or hot-dip galvanised to AS/NZS 4680 including all internal surfaces of hollow section 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, and
- Double dipping shall be allowed.

8.6.7 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 Section 3.12.3.1 for additional requirements of concrete durability.

8.6.8 Maintenance platform

Unless specifically nominated otherwise by the department, 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 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 Clauses 3.2.3 Flooring materials and Clause 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 4.4 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, and
- No gaps greater than 50 mm (with or without a mesh) between ends of the guard railing 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 – Harnesses and ancillary equipment*
- *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.

8.6.9 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 secured 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 8.6.9(a).

Table 8.6.9(a) – 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	<ul style="list-style-type: none"> – Ladder cage – For existing structures, If ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.4.7: Note 2
	> 6.0 m	<ul style="list-style-type: none"> – Ladder cage, and – Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal. – For existing structures, If ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 series shall be provided. 	Clause 7.3.6, 7.4.6, 7.4.7 and Table G1 (rung type ladder – twin stiles) Clause 7.4.6 Clause 7.3.6: Note 2
Ladder is fixed other than four post gantry columns. e.g. Single post structure	Up to 6.0 m	<ul style="list-style-type: none"> – Ladder cage – For existing structures, If ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.4.7: Note 2
	> 6.0 m	<ul style="list-style-type: none"> – Ladder cage, and – Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal. – For existing structures, If ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 (series) shall be provided. 	Clause 7.3.6, 7.4.6, 7.4.7 and Table G1 (rung type ladder – twin stiles) Clause 7.4.6 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). A harness based fall-arrest system to AS/NZS 1891 series shall be provided.	Clause 7.3.6: Note 3

When intermediate landing with multiple ladders are used, the ladder arrangement shall be in accordance with AS 1657.

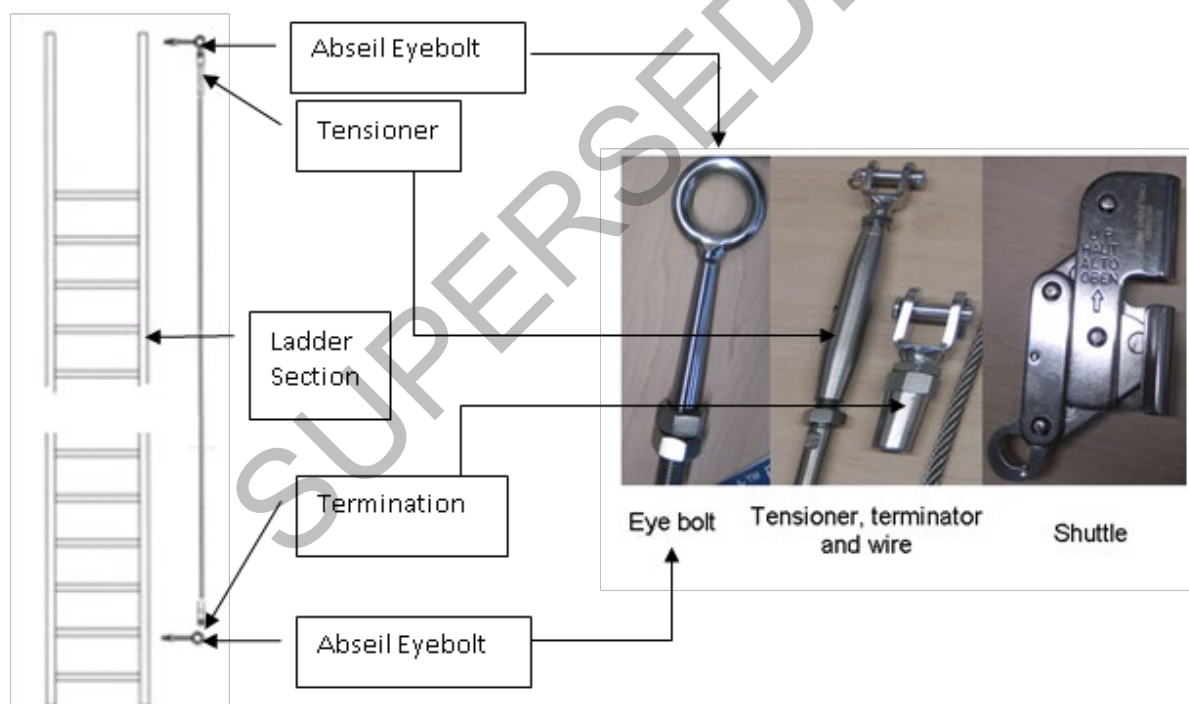
Fall arrester harness systems shall comply with AS/NZS 1891. The harness system shall be capable of arresting falls within a short drop of not greater than 600 mm. The Designer shall be responsible for nominating the type of harness and providing attachment points in the structure. The approved fall arrester system shall have Certification and Approval to AS/NZS 1891 (series).

Table 8.6.9(b) and Figure 8.6.9 show the details of the fall arrester system manufactured by SafetyLink Pty Ltd which is acceptable to Transport and Main Roads.

Table 8.6.9(b) – 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 8.6.9 – 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 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 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.
5. Following erection a competent person (as defined in the *Workplace 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 Compliance Certificate certified by an appropriate experienced RPEQ 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.

8.6.10 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 Technical Specification MRTS91 *Conduits and Pits*.

8.6.11 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.

8.6.12 Protection of structures from vehicle impact

Section 7.8 of this document details the requirements for the protection of on-carriageway advertising sign support structures from vehicle impact.

8.6.13 Transport and Main Roads review of drawings and scheme documents

This section documents the approval process for on-carriageway signs and supporting structures.

The drawings, specifications, design report, safety in design report and geotechnical report shall be submitted to Transport and Main Roads by the Sign Licensee in accordance with Part A, Chapter 2 of this document. These documents are to be reviewed by Transport and Main Roads for safety, durability, future performance, constructability and maintenance. Drawings and 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 (refer Section 2.4.2). Drawings shall comply with the *Drafting and Design Presentation Standards, Volume 3, Structural Drafting Standard*.

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 Director (Structures Design Review and Standards). The final decision acceptable to Deputy Chief Engineer (Structures) 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 Fabrication of Structural Steelwork are released by Transport and Main Roads.

For information regarding technical advice for acceptance of advertising signs refer to:

Director (Structures Design, Review and Standards)
Department of Transport and Main Roads
Structures Division
GPO Box 1412
Brisbane Qld 4001

8.6.14 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.

Design shall be by a RPEQ or supervised by an experienced RPEQ structural engineer.

Design shall be checked by a RPEQ structural engineer. The engineer who undertakes the check shall be different to the Designer and shall do independent calculations.

All Engineering Drawings shall be arranged as required by Section 8.6.5.10.1 and certified by an appropriately experienced RPEQ. 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:

- maximum horizontal and vertical serviceability deflections of the structure
- installation procedure for the structure, including erection procedure of the structure, and
- 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:

- Sign structure location including its position 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.
- 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.
- Material standards, design standards and relevant Transport and Main Roads Technical Specifications shall be referred in the drawing notes.
- The erection sequence shall include all requirements for tightening of hold-down bolts prior to grouting and prior to attachment of outreach arms.
- 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.
- 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.
- Impact protection from errant vehicles.
- 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.
- All welds are to be detailed on the drawings and weld symbols shall be in accordance with AS 1101.3.
- All access holes for cables and wires shall be fabricated without sharp edges to prevent damage to insulation when the cables are drawn.
- No additional holes are permitted to be drilled that are not shown on the RPEQ certified drawings without approval from the Structural Designer.
- Adequate vent holes for galvanising process shall be detailed in the drawings.

- Only those welds shown on the drawings are permitted. No weld is to be omitted or added without the specific approval from the Designer.

8.6.15 Design certification

Design Certification is required for each sign structure.

All Engineering Drawings shall be arranged as required by Section 8.6.5.10.1 to allow ease of certification.

A geotechnical design report, certified by an experienced RPEQ Geotechnical Assessor, shall be included in the Final Design Report for each sign structure.

A structural design report, certified by an experienced RPEQ Structural Engineer, shall be included in the Final Design Report for each sign structure.

8.6.16 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 Transport and Main Roads.

8.6.17 Fabrication of structural steelwork 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 appropriately experienced 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.

All hollow sections shall be joined using full penetration butt welds. Fillet welds are not acceptable for this application as they encourage crevice corrosion resulting in premature failure.

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.

8.6.18 Installation of the structure

8.6.18.1 General

The design documentation shall ensure that:

- a) Sign installation shall be undertaken by a Contractor 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.
- b) Installation shall be in accordance with Transport and Main Roads Technical Specifications.

8.6.18.2 Hold and Witness Point

The design documentation shall include provisions that ensure:

- a) The Administrator is responsible for RPEQ certification for releasing Witness Points and Hold Points referred to in the relevant Transport and Main Roads Technical Specifications. This certification shall include the following construction activities:
 - i. 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 project 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 Specifications.
 - Prior to concreting, excavated foundations shall be inspected by the experienced 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 *Environmental Management* and MRTS04 *General Earthworks*.
 - ii. Cast-in place piles
 - Cast-in place piles shall be in accordance with MRTS63 *Cast-In-Place Piles* or MRTS63A *Piles for Ancillary Structures* as applicable and all Hold Points in MRTS63 *Cast-In-Place Piles* and MRTS63A *Piles for Ancillary Structures* shall be released and certified by the Administrator.
 - iii. Precast prestressed concrete piles
 - Precast prestressed concrete piles shall be in accordance with MRTS65 *Precast Prestressed Concrete Piles*. All Hold Points and Witness Points in MRTS65 *Precast Prestressed Concrete Piles* and Hold Point (approval to place concrete in first

member) of MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units* shall be released and certified by the Administrator.

iv. Dynamic testing of piles

- Dynamic testing of piles shall be in accordance with MRTS68 *Dynamic Testing of Piles*. All Hold Points and Witness Points in MRTS68 *Dynamic Testing of Piles* shall be released and certified by the Administrator.

v. Concreting

- Concreting shall be in accordance with MRTS70 *Concrete*. All Hold Points and Witness Points of MRTS70 *Concrete* shall be released and certified by the Administrator.

vi. Steel reinforcing

- Fabrication and placing of steel reinforcement shall be in accordance with MRTS71 *Reinforcing Steel*. All Hold Points and Witness Points in MRTS71 *Reinforcing Steel* shall be released and certified by the Administrator.

vii. Structural steelwork

- Fabrication of structural steelwork shall be in accordance with MRTS78 *Fabrication of Structural Steelwork*. All Hold Points and Witness Points in MRTS78 *Fabrication of Structural Steelwork* shall be released and certified by the Administrator.

viii. Aluminium works

- Fabrication of aluminium components shall be in accordance with MRTS79 *Fabrication of Aluminium Components*. All Hold Points in MRTS79 *Fabrication of Aluminium Components* shall be released and certified by the Administrator.

8.6.18.3 Erection

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:

- stand the column section and level the column by placing a minimum of four steel wedges under each base plate
- mix the non-shrink mortar to a trowelable consistency
- pack the mortar and ensure that the mortar extends over the full area of the base plate
- wait for the mortar to set sufficiently to support the weight of the structure
- remove the steel wedges
- tension the bolts, and
- repair the mortar where the wedges were located.

Bolts with T/B or T/F classification shall be tensioned in accordance with MRTS78 *Fabrication of Structural Steelwork*.

All materials and bolts shall conform to the requirements of Transport and Main Roads Technical Specification MRTS78 *Fabrication of Structural Steelwork*.

8.6.19 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 the department's *Structures Inspection Manual*.

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.

8.7 Design criteria for off-carriageway advertising signs

These criteria shall be applied for sign locations stated in Section 8.4.3.

8.7.1 Vertical clearance

A minimum vertical clearance of 2700 mm above the ground level to the underside of the sign face or any structural component shall be maintained to prevent collision with pedestrians and cyclists.

8.7.2 Materials

Concrete shall be to AS 3600.

Steel reinforcement shall be to AS/NZS 4671 and ACRS (Australian Certification Authority for Reinforcing Steel) certified.

Structural steel shall be to standards specified in Clause 8.7.2.1.

Other materials, not contained in this document, 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.

8.7.2.1 Structural steel

Structural steel material shall meet the following requirements:

- a) All cold formed structural steel hollow sections to AS/NZS 1163 Grade XXXL0 where XXX is the grade of the steel.
- b) 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.
- c) All hot rolled steel plates shall be to AS/NZS 3678.
- d) All structural steel hot rolled sections shall be to AS/NZS 3679.1.

- e) Structural steel welded sections shall be to AS/NZS 3679.2.
- f) Minimum steel thickness for structural steel sections shall be 3.0 mm.
- g) 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, and
- h) Spirally wound fabricated circular hollow sections are not permitted.

8.7.2.2 Bolts, nuts and washers

Standard bolts, nuts and washers shall confirm to following standards:

- a) 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.
- b) 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.
- c) Flat washers - to AS 1237.
- d) High Strength Bolts, Nuts and Washers shall confirm to AS/NZS 1252. Bolt diameter, thread form and pitch shall be to ISO coarse pitch series to AS 1275 to 8g tolerances.
- e) 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.
- f) Self-tapping screws are permitted to fasten cladding only.

8.7.3 Structural design

8.7.3.1 Design life

The design life shall be 40 years.

8.7.3.2 Live load

The design live loads shall be as for the on-carriageway advertising signs stated in Section 8.6.5.2.

8.7.3.3 Wind loading

Wind load shall be calculated in accordance with AS 1170.2 with wind perpendicular and at 45 degrees to the sign face. Drag force coefficient C_d shall be in accordance with AS 1170.2.

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.

ARI for serviceability limit state wind speed shall be 20 years.

8.7.3.4 Ultimate strength

Ultimate strength for concrete design shall be to AS 3600 and steel designs to AS 4100.

8.7.3.5 Structural design criteria for fatigue

Design for fatigue shall be in accordance with AASHTO LRFD *Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, 1st Edition, 2017 revision: Section 11, *Fatigue Design*.

8.7.3.6 Load combinations

Load combinations for structural design shall be to AS/NZS 1170.0.

8.7.3.7 Foundation design

Sign structure shall be designed with a suitable foundation based on specific foundation investigation reported by an experienced RPEQ Geotechnical Engineer. Transport and Main Roads will not restrict the foundation types providing they satisfy following Australian Standards as appropriate:

- i. AS 5100 *Bridge design - Foundation and soil support structures*, and
- ii. 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 Earthworks* to specify the treatment of Acid Sulphate Soils if this is present on the Site.

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.

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.

The set of detailed design drawings shall be so arranged that the geotechnical features of the site and the foundation details are contained on discrete drawings, in such a manner that the Geotechnical Engineer is able to provide the relevant RPEQ certification for the foundations separate to those other details provided for the remainder of the gantry or support structure.

8.7.3.8 Anchor bolt details

Anchor bolt design and installation shall be certified by appropriately experienced RPEQ.

8.7.4 Corrosion protection and durability

A suitable paint system to meet the department's specified durability requirements of the support structure, or it shall be hot-dip galvanized.

8.7.5 Maintenance platform

The requirements of the maintenance platform are as specified by the sign owner and shall comply with following standards and guidelines:

- AS 1657 *Fixed platforms, walkways, stairways and ladders – Design, construction and installation*
- *Principals of Good Work Design* by Safe Work Australia (SWA)
- *Guidance on The Principles of Safe Design for Work* (May 2006) by Australian Safety and Compensation Council (archived by SWA)
- *Safe Work Australia Codes of Practice*, and
- WHS legislations.

Refer to Section 8.6.5.2 for design live loads.

8.7.6 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.

8.7.7 Protection of structures from vehicle impact

If the post is within the clear zone, the protection of off-carriageway advertising sign support structures from vehicle impact shall be in accordance with Section 7.8 of this document.

8.7.8 Construction specifications

The Designer shall prepare construction specifications for the sign structure.

The minimum specification for construction shall be the relevant Australian Standards, except where the department's Technical Specifications have been nominated in this document.

8.7.9 Transport and Main Roads design acceptance

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 this section of department's design criteria for *Roadside Advertising Manual*, Transport and Main Roads Technical Specifications and Guidelines, and *Workplace Health and Safety Act* and Regulations.

The Designer shall declare any proposed departures from these during the design stage and request Transport and Main Roads to consider and accept the departures. Transport and Main Roads Director (Structures Review and Standards) will provide a written response to this request. Any departure can only be adopted if accepted 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 this section of *Roadside Advertising Manual*, Transport and Main Roads Technical 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.

8.7.10 Design certification

Design certification is required for each sign structure.

The set of detailed design drawings shall be arranged in accordance with Section 8.7.3.7(e) for ease of certification.

A geotechnical design report, certified by an appropriately experienced RPEQ Geotechnical Assessor, shall be included in the Final Design Report for each sign structure.

A structural design report, certified by an appropriately experienced RPEQ Structural Engineer, shall be included in the Final Design Report for each sign structure.

8.7.11 Fabrication of structural steelwork

Sign fabrication shall be undertaken by a Contractor 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.

All hollow sections shall be joined using full penetration butt welds. Fillet welds are not acceptable for this application as they encourage crevice corrosion resulting in premature failure.

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 costs for the 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 signed off by the Inspector in accordance with AS/NZS 1554.

8.7.12 Construction supervision

Construction cannot be commenced until the design is certified by an appropriately experienced RPEQ.

Construction and installation shall be in accordance with the construction specifications and relevant Australian standards.

Sign installation shall be undertaken by a Contractor 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 certified by an appropriately experienced RPEQ.

Structure location shall be set out on the Site by an experienced surveyor. The Administrator shall witness the set out structure location and sign off prior to commencing excavation or driving piles.

All concrete used in the work shall be subject to sampling and testing to provisions of AS 1012. The Administrator is responsible to certify whether slump 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 concreting for cast-in-place piles shall not start until an RPEQ Geotechnical Assessor has inspected and certify the socket and pile base.

8.7.13 Inspection

Sign owner shall arrange the routine Level 2 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.

8.8 Provisions of fall protection to existing roadside advertising signs

For retrofitting existing signs, if a fall protection system is required, it shall conform to Table 8.8 of this document and AS 1657.

Table 8.8 – Details of the fall protections (Retrofitting)

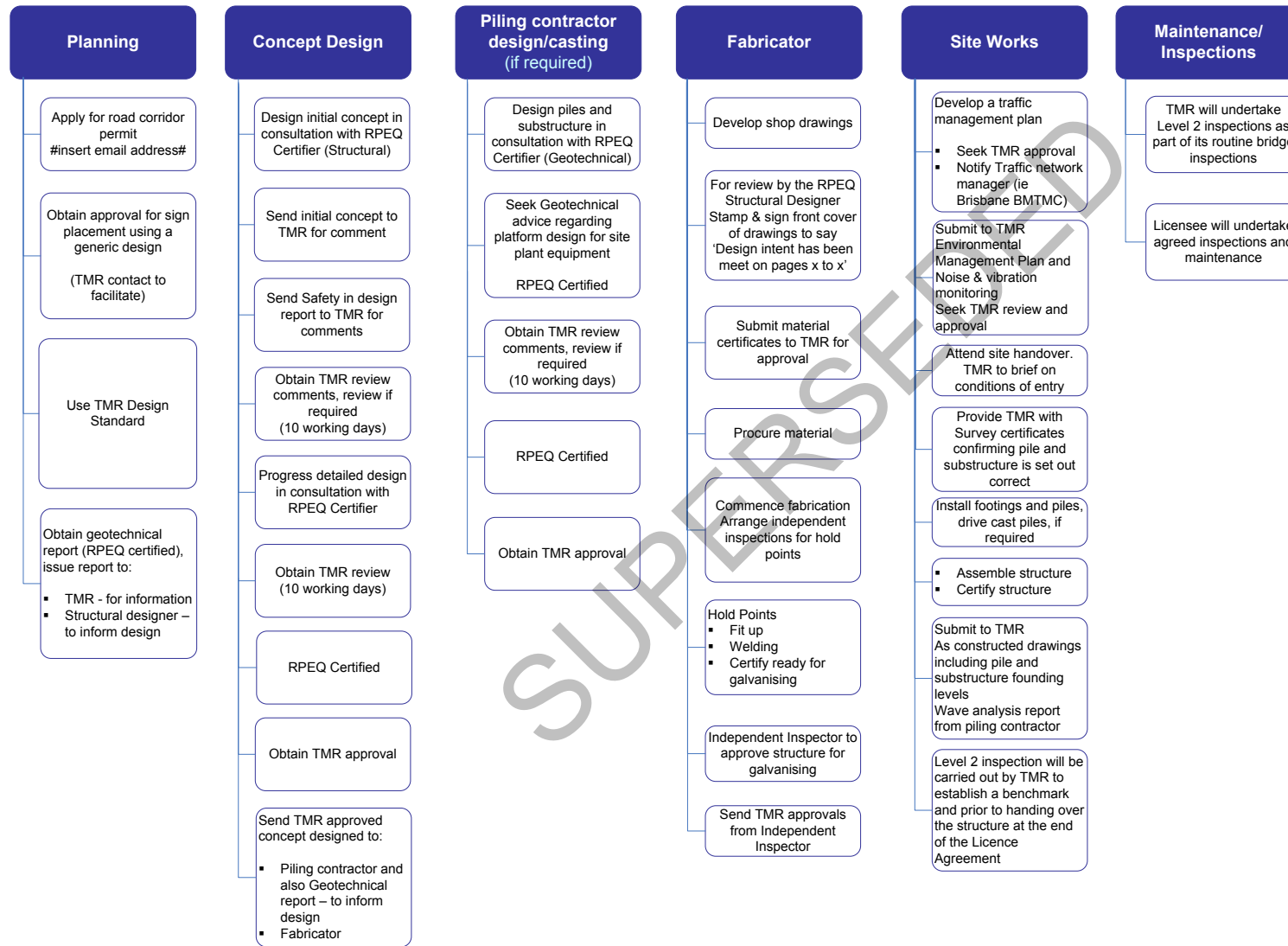
Structure type	Fall distance	Fall protection provisions	AS 1657 reference clauses
Ladder is within four post gantry column	Up to 6.0 m	<ul style="list-style-type: none"> – Ladder cage, or – If retrofitting of ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 series shall be provided. 	Clause 7.4.7: Note 2
	> 6.0 m	<ul style="list-style-type: none"> – Ladder cage, and – Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal or – If retrofitting of ladder cage and/or intermediate landing is not possible, a harness based fall-arrest system to AS/NZS 1891 series shall be provided. 	Clause 7.3.6, 7.4.6, 7.4.7 and Table G1 (rung type ladder – twin stiles)
Ladder is fixed other than four post gantry columns. e.g. Single post VMS structure	Up to 6.0 m	<ul style="list-style-type: none"> – Ladder cage, or – If retrofitting of ladder cage is not possible, a harness based fall-arrest system to AS/NZS 1891 series shall be provided. 	Clause 7.4.7: Note 2
	> 6.0 m	<ul style="list-style-type: none"> – Ladder cage, and – Intermediate landing at maximum of 4.5 m height. Vertical height between landings in multiple flight ladders should be equal or – If installation of ladder cage and/or intermediate landing is not possible, a harness based fall-arrest system to AS/NZS 1891 series shall be provided. 	Clause 7.3.6, 7.4.6, 7.4.7 and Table G1 (rung type ladder – twin stiles)
		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 7.4.6 Clause 7.3.6: Note 3

When intermediate landing with multiple ladders are used, the ladder arrangement shall be in accordance with AS 1657.

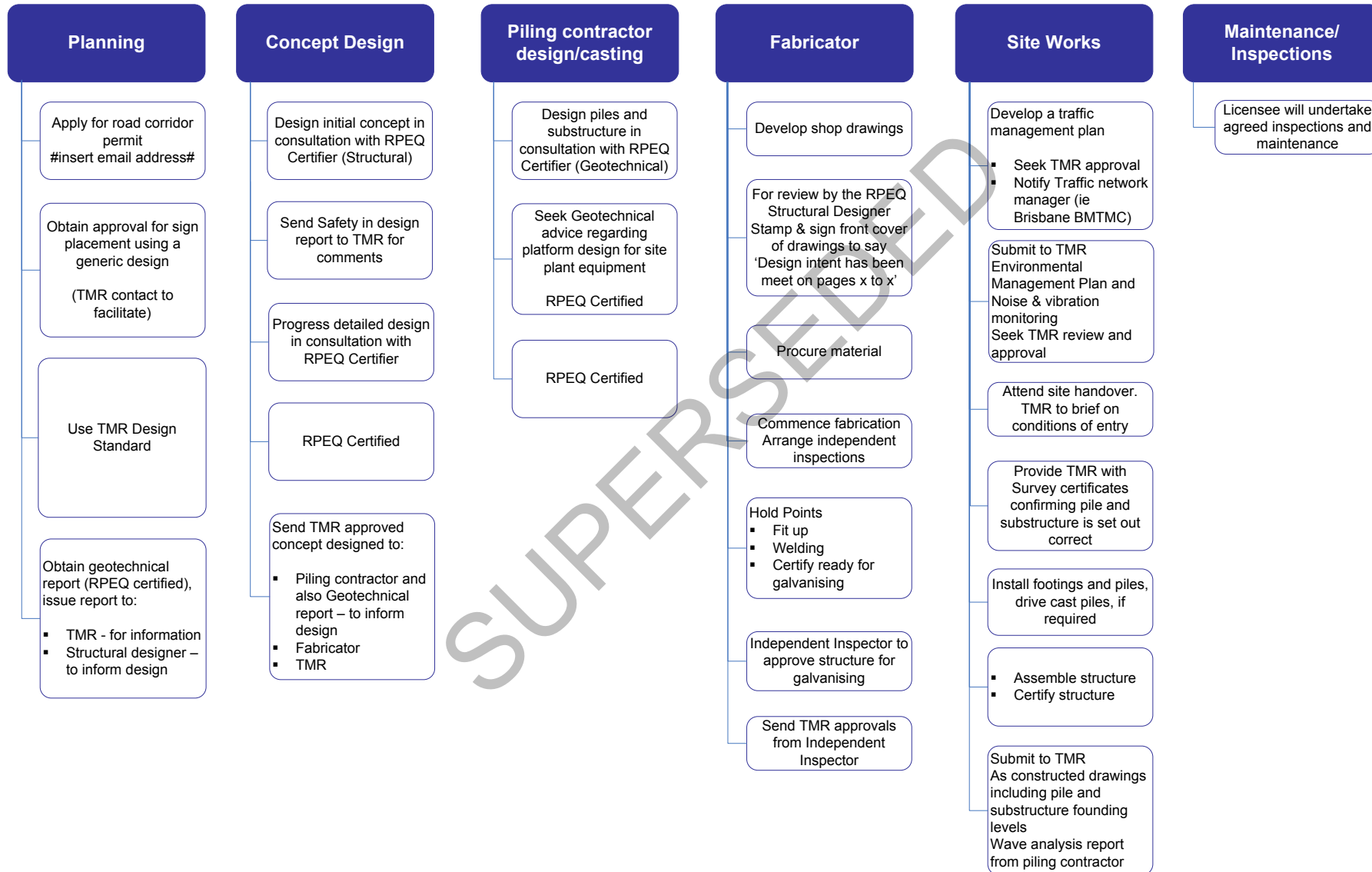
The additional requirements listed in Section 8.6.9 shall also be met.

8.9 Approval flow charts

Design requirements for Advertising Devices – on carriageway



Design requirements for Advertising Devices – off carriageway



9 Buried concrete arches

9.1 Scope

These design criteria are applicable for buried concrete arch structures crossing over waterways, gullies, valleys, roadways and railways.

9.2 Design life and serviceability

Design life of arch structures shall be 100 years with minimum future maintenance. The roof of all arches below ground shall be waterproofed throughout the extrados of the whole roof.

9.3 Design documentation

In accordance with Part A, Chapter 2 of this document, the arch designer (arch manufacturer's designer) shall provide the following:

- a) Comprehensive project specific documentation, including but not necessarily limited to:
 - detailed construction drawings
 - work method statement meeting design intent
 - recess and nibs required
 - backfill material
 - compaction layers
 - compaction equipment, and
 - reactions at arch footings.
- b) The designer of the arch foundation and earthworks is responsible for the inclusion of arch design assumptions provided by the arch designer, including the sequencing of spandrel and wing wall construction, into the design documents for the construction of arch foundation, and provide RPEQ certification of the foundation design by an appropriately experienced engineer.
- c) The arch designer shall provide RPEQ certification of the arch design by an appropriately experienced engineer.
- d) The arch designer shall provide a letter signed by an appropriate RPEQ, stating that the design intent has been incorporated by the designer of the arch foundations, and that associated earthworks has met the design assumptions of their arch design.
- e) The design documentation shall include provisions that ensure the contractor will prepare a detailed work method statement (WMS) conforming the design intent of the arch and arch foundations. This documentation shall ensure the detailed WMS shall be reviewed by the arch designer and arch foundation designer; and both designers shall provide RPEQ certification prior to commencement of the arch installation.

All of the above documents including structural design calculations, detailed construction drawings, detailed work method statements (WMS) certified by an appropriately experienced RPEQ shall be submitted to the Department of Transport and Main Roads Director (Structures Design, Review and Standards) at the concept design stage and subsequent detailed design stages 50%, 85% and 100% for Transport and Main Roads' review and acceptance. All RPEQ certification shall be provided to the department's Director (Structures Design, Review and Standards) at the 100% detailed design stage.

9.4 Design acceptance process

If a concrete arch culvert or bridge is part of the original design for a roadworks project, prior to tender, the design shall be submitted to the department for review and acceptance.

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 departmental review and acceptance at the earliest possible date to avoid construction delays. A minimum of four working weeks is required for the department's review.

If all the required design data is not supplied initially, the Contractor or Manufacturer is responsible for consequent delays.

Construction shall not commence before the Departmental Representative has accepted the design, based on input from the Director (Structures Design, Review and Standards).

The design submission shall include construction method statement including erection sequence. The erection sequence, including requirements of tightening and grouting of hold-down bolts (if any), shall be clearly shown on the structure specific drawings. The precast elements shall be erected in accordance with the specified sequence.

9.5 Design requirements

Buried arch structures shall be designed using soil structure interaction methodology.

Stability of an arch during construction shall be addressed at the design stage. Arch design shall consider all construction stage loading and sequence of erection to ensure the stability of arch components at all stages of construction. Additional requirements for arch stability at construction stages shall be included in the drawings and the design reports. All temporary and permanent supports required during construction shall be designed and RPEQ certified by the permanent works designer.

Expected deflections at arch crown and bases (if any) at each construction stages shall be stated on the drawings.

Arch components can be damaged during transportation and handling. The Designer shall provide a method of transportation and handling of the arch components. Lift anchors shall be designed in accordance with MRTS72 *Manufacture of Precast Concrete Elements*. Lifting anchor details, anchor products and lifting diagram shall be shown in the drawings.

Geotechnical requirements in arch foundation design including design methodology, geotechnical investigations, design documentations and so on, shall be in accordance with the the department's *Geotechnical Design Standards - Minimum Requirements* document. In addition, the following requirements shall also be met:

1. Geotechnical assessment on site during construction shall be undertaken and certified by an appropriately experienced RPEQ (Geotechnical Engineer).
2. 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 the estimates of bearing capacity and long-term foundation settlement.

The arch foundation shall be designed for vertical and lateral loads to support the arch during all phases of construction as well as in service. Good foundation information is very important for arch performance. Accordingly, an accurate representation of founding conditions at the site of each arch shall be incorporated into the design drawings.

3. 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.
4. The arch foundation design and the arch structure design shall be certified separately by appropriately experienced RPEQ Designers.
5. Structural design shall be in accordance with AS(/NZS) 5100.
6. Design traffic loads shall be SM1600 and HLP400 in accordance with AS 5100.2.
7. All the load cases and load combinations shall be submitted for acceptance for both the construction and the final fill load cases.
8. 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.
9. 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, when compared to the effect on a softer 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.
10. The design shall model the individual layer, incremental backfilling and compaction. Delivery and placement sequence of backfill is vitally important and any 'non-standard' approach to method of backfill delivery and placement shall be indicated on drawings. Otherwise standard backfill delivery and placement sequence would be assumed by the designer.
11. 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, and
 - reference shall be made to Section 9.6.

12. The ground reactions at the base of the arch for both the construction and the final load cases shall be submitted.
13. 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).
14. 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 the Department of Transport and Main Roads Director (Hydraulics & Flooding) for review and acceptance.
15. Piles shall conform to Technical Specifications MRTS63 *Cast-In-Place Piles*, MRTS65 *Precast Prestressed Concrete Piles* and MRTS68 *Dynamic Testing of Piles* as applicable.
16. The design documentation shall ensure that at three monthly intervals during the first nine months of traffic loading, at a minimum of three locations but at a spacing not exceeding 20 metres along the arch, settlement and deflections of the arch structure at the footings, $2/3$ height on both sides, and the crown shall be monitored during construction. Reports for every interval shall be provided to Department of 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.

Survey data shall be obtained on arch behaviour during backfill phase and in the 'As Constructed' condition. Otherwise it is always difficult to ascertain or understand if any recorded movement has occurred pre or post construction behaviour without base survey data.
17. 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.
18. In high risk situations, as assessed by the Director (Structures Design, Review and Standards), the spandrel headwalls and wing walls shall be constructed of insitu reinforced concrete, not precast components. For example, the portion of the arch components that can be reached by flood water shall be of insitu reinforced concrete. The extent of insitu reinforced concrete shall extend from the foundation up to a minimum of one metre above the 2000 year ARI flood height.
19. Minimum vertical clearance and minimum carriageway width shall be as specified in Section 3.5, Part B of this document. The minimum vertical clearance shall extend over the shoulder of the road below the arch. The designer shall provide the Department of 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.
20. For mine haul road carrying mine vehicles, the following shall apply:
 - 'Over height' portal gantries and sensors are required at all approaches. 'Maximum height' signs are required at approaches and on the arch structure.

- Overhead gantries that project across trafficked lanes shall be protected from vehicle impact. The dimensions and foundation of the barriers shall be designed appropriately for the size of the impact vehicle, and
- Traffic barriers on the arch shall be designed for the performance level in accordance with AS 5100.1, with sufficient edge distance from the edge of the road batter. The department's *Road Planning and Design Manual* (2nd Edition) and Guidelines shall be used for barriers not located on the arch.

21. The concept design for the arch shall be reviewed and accepted by Department of Transport and Main Roads' Director (Structures Design, Review and Standards) before proceeding to detailed design (refer Section 9.4).

22. The requirements for design review by the Department of Transport and Main Roads Structures is the same as for bridges (refer Section 2.2). The arch foundation designer and arch designer shall provide their RPEQ certified design reports to the Department of Transport and Main Roads Structures for review and acceptance.

9.6 Other requirements

The department's *Drafting and Design Presentation Standards Manual*, Volume 3, *Structural Drafting Standards* shall be complied with.

9.7 Concrete durability

Reference shall be made to Section 3.12.3 for concrete durability requirements.

Minimum exposure classification for cover of concrete shall be B2 in accordance with AS 5100.5. Higher exposure classifications shall be determined on a project specific basis.

Concrete strengths, minimum cover and curing conditions shall be detailed in the drawings.

9.8 Development adjacent to arches

Other additional loads imposed on the arch to cater for future changes shall be:

- a) additional uniformly distributed working loads of up to 50 kPa acting at ground level
- b) natural surface level build-up of up to 1 m with fill equivalent to a uniformly distributed load of 20 kPa
- c) any loads from proposed developments above (such as residential, commercial or industrial, etc.), and
- d) the allowable maximum difference in level from one side of the arch to the other. A minimum of 0.5 m difference is required.

9.9 Arch manufacturing criteria

The design documents shall include provisions to ensure that construction will be in accordance with the department's Technical Specifications (refer Part A, Section 1.4.3.5), in particular:

- i. MRTS70 *Concrete*
- ii. MRTS71 *Reinforcing Steel*, and
- iii. MRTS72 *Manufacture of Precast Concrete Elements*.

10 Retaining structures

10.1 Scope

Typical retaining structure types are:

- a) Reinforced Soil Structure (RSS) retaining walls
- b) Embedded retaining walls
- c) Reinforced concrete cantilever retaining walls
- d) Soil nail retaining walls
- e) Gabion retaining walls
- f) Boulder retaining walls, and
- g) Reinforced masonry walls.

10.2 Design requirements for retaining walls

Geotechnical requirements for design including design methodology, geotechnical investigations, design documentations and so on, shall be in accordance with the department's *Geotechnical Design Standards - Minimum Requirements*. In addition, requirements stated in this document shall also be met.

10.3 Design life of retaining structures

The design life of retaining structures shall be 100 years.

10.4 Design certification

10.4.1 General

A Design Certification is required for each retaining structure, in accordance with Section 2.1.6 in Part A. Refer also to the department's *Geotechnical Design Standards - Minimum Requirements* for design certifications for geotechnical designs.

10.4.2 Structural design

Structural designs for retaining structures shall be designed by an appropriately experienced RPEQ.

All structural designs of retaining structures shall be design-checked by, or supervised by, an appropriately experienced RPEQ. The Engineer who undertakes the check shall be different to the Designer.

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.

Draw-down effects must be catered for.

Minimum thickness of the shotcrete facing slabs for soil nail retaining walls shall be 165 mm. The minimum thickness is for B2 exposure classification with the cover to reinforcement in accordance with AS 5100.5 and cover increased by 30 mm against soil. Minimum concrete for shotcrete shall be 40 MPa.

10.4.3 Design certification – additional requirements for construction contractors

On projects where the instruction 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 must submit to the departmental representative and the verifier a report certified by the Contractor's appropriately experienced 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.

10.5 Quality assurance for design and construction

The design and documentation of RSS retaining walls shall ensure that:

- a) Prior to any RSS 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 of Reinforced Soil Structures (RSS), regular testing must be undertaken in accordance with MRTS06 *Reinforced Soil Structures*. 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.

10.6 Design principles for retaining walls

10.6.1 Aesthetics

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.

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.

10.6.2 Flood loading

All retaining walls subject to flooding must be designed for the appropriate forces for a 2000 ARI (0.05% AEP) event.

10.6.3 Tiered walls

An upper stepped wall shall be permitted only if the toe of the upper wall is outside the 45° 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.

10.6.4 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.

10.7 Retaining wall drainage

Drainage shall conform to MRTS03 *Drainage, Retaining Structures and Protective Treatments*.

10.8 Design calculations

Where a construction contractor is responsible for the design and construction of a retaining wall the following shall apply:

- a) Prior to the construction of any retaining structure, the contractor must supply to the Administrator all calculations associated with that retaining structure.
- b) In addition to the requirements in Section 10.9, for RSS walls the contractor must supply to the Administrator all calculations associated with that retaining structure, together with the duly completed design checklist in MRTS06 *Reinforced Soil Structures* Appendix which shall be a Hold Point in the project plan.

10.9 Additional requirements for Reinforced Soil Structure (RSS) retaining walls

10.9.1 General

Design of RSS walls must be undertaken in accordance with MRTS06 *Reinforced Soil Structures*. 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.

RSS retaining walls are not permitted where the water level will be at or above RSS foundation level for any flood event up to 100 year ARI.

Where RSS walls are used as the front face of the bridge abutment, the requirements stated in Section 4.5.2 shall also be met.

RSS retaining structures are not designed to resist road / train traffic impact and the provisions of 10.9.2, 10.9.3 and 10.9.4 shall apply.

10.9.2 Impact protection from road traffic

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 or shall be provided with sufficient redundancy so that the bridge that it supports shall not collapse in the event of a collision.

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(/NZS) 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 department's *Road Planning and Design Manual* (2nd Edition) 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.

If the RSS wall is located outside the 10 m clear zone, no additional protection from impact is required.

10.9.3 Impact protection from rail traffic

The minimum requirement is a concrete crash wall designed in accordance with AS(/NZS) 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 *Civil-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.

10.9.4 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 Structure Design Report (refer Part A, Section 2.4).

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 spill throughs 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 spill throughs need to be discussed with Transport and Main Roads Director (Structures Design, Review and Standards) 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.

10.10 Additional requirements for piles in retaining walls

10.10.1 Cast-in place piles for high moment, low axial load applications

Piles for high moment, low axial load applications shall conform to the following:

- i. The minimum diameter for piles is 600 mm.
- ii. Piles for high moment, low axial load applications shall be designed to conform to MRTS63A *Piles for Ancillary Structures*.
- iii. The design intention is that the piles are cast in the dry.
- iv. Liners shall be used to limit water ingress and to prevent collapse of wall or foundation materials. Acceptance from Transport and Main Roads Director (Structures Design, Review and Standards) shall be obtained prior to use of temporary liners.
- v. Temporary liners are not permitted in situations with high water table and/or collapsible soils.
- vi. Bentonite or polymer slurry shall not be used.

10.10.2 Contiguous piled walls

Contiguous piled walls shall conform to the following:

- i. The minimum diameter for piles is 600 mm.

- ii. Foundations for high moment, low axial load applications shall be designed to conform to MRTS63A *Piles for Ancillary Structures*.
- iii. The design intention is that the piles are cast in the dry.
- iv. Liners shall be used to limit water ingress and to prevent collapse of wall or foundation materials. Acceptance from Transport and Main Roads Director (Structures Design, Review and Standards) shall be obtained prior to use of temporary liners.
- v. Temporary liners are not permitted in situations with high water table and/or collapsible soils.
- vi. Bentonite or polymer slurry shall not be used.
- vii. Maximum crack width in permanent shotcrete shall be 0.2 mm.
- viii. Shotcrete infill between piles shall be a minimum 165 mm thick, and shall have minimum reinforcement of SL81 mesh. This minimum thickness is for B2 exposure classification with 40 MPa concrete and reinforcement cover in accordance with AS 5100 increased by 30 mm on the soil side.
- ix. Testing of production shotcrete for compressive strength, density, relative density and permeability, including test frequency shall comply with Annexure B82/L of Roads and Maritime Services (RMS) QA Specification B82 *Shotcrete Work*.
- x. Steel Fibre Reinforced Shotcrete shall only be used where accepted in advance by the Director (Structures Design, Review and Standards). Its toughness shall comply with Clause 3.9 of RMS QA Specification B82, and test frequency shall comply with Annexure B82/L of RMS QA Specification B82.

10.11 Additional requirements for block masonry retaining walls

Block masonry retaining walls shall be designed in accordance with AS 3700. In addition the following requirements shall also be met:

- i. minimum reinforcement size for block walls shall be 12 mm spaced at 200 mm maximum centres horizontally and vertically
- ii. minimum reinforcing steel shall comply with Clause 8.4.5 of AS 3700
- iii. all voids shall be infilled with grout with a minimum strength of 40 MPa
- iv. the minimum block thickness shall be 190 mm with reinforcing steel centrally located
- v. in reinforced masonry walls, the masonry thickness shall not contribute to the reinforcement cover, and
- vi. any retaining wall shall have a reinforced concrete base that is integral with the masonry wall.

11 Design of Fibre Reinforced Polymer (FRP) composite girders

11.1 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 departmental bridges:

- i. Category A: FRP composite girders to be used as superstructure in a new bridge.
- ii. Category B: FRP composite girders that replace timber girders in a timber bridge renewal program.

11.2 Design requirements

Sections 11.3 to 11.7 refer to the general requirements for the design of all FRP composite girders.

FRP composite girders to be used as superstructure in a new bridge (Category A) shall be subject to additional requirements as stated in Section 11.9.

FRP composite girders that replace timber girders in a timber bridge (Category B) shall be designed in accordance with the additional requirements contained in Section 11.10.

Except where otherwise specified, design of FRP girders shall be according to the *Eurocomp Design Code*, as defined in Table 1.4.5, Chapter 1, Part A.

11.3 Symbols and notations

The symbols and notations used in this section are listed in Table 11.3.

Table 11.3 – Symbols and notations

Symbol and Notations	Description	Section Reference
E	Modulus of Elasticity of the Girder (MPa)	11.10.1
EI	Flexural Stiffness of the Girder	11.10.1
I	Second Moment of Area (mm ⁴)	11.10.1
k	Additional reduction factor	11.9.4
K _{test}	Reduction factor used in the absence of sufficient test samples	11.10.1
R _u	Ultimate Strength	11.9.4
S*	Design Action Effects (required strength due to factored loads)	11.9.4
α	Dynamic Load Allowance	11.9.2
γ _g	Load factor for dead loads	11.9.2
ε	Uni Axial Strain	11.8.1
σ	Uni Axial Stress	11.8.1
φ	Strength Reduction Factor	11.9.4

11.4 Provision for innovation

This section provides for innovation in FRP composite girder design. Adopting innovation allows the capture of benefits from rapid changes and evolutions in the FRP composite field.

For this section, the term 'innovation' applies to new:

- i. fibre materials
- ii. resins
- iii. manufacturing processes of fibre composites
- iv. coatings
- v. development in the fibre composite field, and
- vi. a complete girder.

Above innovative products shall be assessed against this section and comply with the structural performance matrix in Table 11.3. 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 within the Department of Transport and Main Roads*, referenced in Table 1.4.5.

Submissions regarding innovation are made to the Director (Structures Design, Review and Standards).

Table 11.3 – 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 <ul style="list-style-type: none"> • Bending Capacity • Shear Capacity • Deflection <ul style="list-style-type: none"> – Short Term – Long Term • Damage Tolerance • Impact Resistance • Fatigue Resistance 	Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i>		
2. Structural Stability <ul style="list-style-type: none"> • Lateral Torsional Rigidity • Robustness • Overturning • Uplift / Sliding 	Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i>		

Score: 1 = Unsuitable, 3 = Satisfactory, 5 = Excellent			
Structural Performance	Standards to be complied	Score	Remark
3. Adaptability of Fibre Composite using established bridge construction techniques <ul style="list-style-type: none"> • Girder <ul style="list-style-type: none"> – Holding Down bolt fixing • Deck <ul style="list-style-type: none"> – Fixing / connections • Bridge Barrier • Bearing Requirement 	<u>Existing Timber Bridges:</u> <ul style="list-style-type: none"> • Transport and Main Roads <i>Timber Bridge Maintenance Manual</i> and <i>Timber Bridge Standard Drawings</i> • Standard Drawings 2280 and 2281 • Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i> <u>New Bridges:</u> Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i>		
4. Constructability <ul style="list-style-type: none"> • Fitting into an existing timber bridge with different substructures: <ul style="list-style-type: none"> – Timber Headstock and Abutments – Concrete Headstock and Abutments – Easy to drill – Easy to cut – Easy to handle 	<ul style="list-style-type: none"> • Transport and Main Roads <i>Timber Bridge Maintenance Manual</i> • Standard Drawings 2280 and 2281 • MRTS60 Installation of Fibre Reinforced Polymer (FRP) Composite Girders 		
5. Durability <ul style="list-style-type: none"> • 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 • Effect of Moisture • Effect of extreme temperatures and thermal cycles • Fire resistance • Wearing resistance • Insect resistance 	Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i>		
6. Ductility	Chapter 11 of <i>Design Criteria for Bridges and Other Structures</i>		
7. Inspection <ul style="list-style-type: none"> • Easy to inspect critical defects 	Manufacturer's guideline		

Score: 1 = Unsuitable, 3 = Satisfactory, 5 = Excellent			
Structural Performance	Standards to be complied	Score	Remark
8. Value for Money <ul style="list-style-type: none"> • Short Term Cost: (Material/fabrication/construction) • Long Term Cost: (maintenance/demolition/disposal) • Life Cycle Cost: <ul style="list-style-type: none"> – initial cost – maintenance cost – operating cost – replacement and refurbishment cost – retirement and disposal costs 			

11.5 Maximum operating temperature

The maximum operating temperature for structural members, components and system designed shall not exceed $T_g - 22^\circ\text{C}$. 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 .

11.6 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).

11.7 Material properties

11.7.1 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:

- assembly of only FRP sections by means of suitable adhesives
- assembly of FRP sections, FRP panels and steel in a hybrid section
- assembly of FRP section, steel, concrete, lightweight core into a hybrid, and
- by means of a vacuum assisted resin infusion process.

11.7.2 Reinforcement

11.7.2.1 Fibres

Only the following glass fibre types are permitted in FRP composite girders:

- a) E-glass
- b) ECR-glass, and
- c) S-glass.

Minimum properties of fibre before processing shall be as specified in Table 11.7.2.1.

E-glass shall not be used in the following applications:

- i. members in salt-rich arid areas
- ii. sea water – tidal or splash zone, and
- iii. soft or running water.

Table 11.7.2.1 – Minimum fibre properties 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 $10^{-6}/^{\circ}\text{C}$	5.0	5.9	2.9

11.7.2.2 Rovings

Use of rovings shall comply with ISO 2797 or equivalent.

11.7.2.3 Mats – continuous filament mats

Use of continuous filament mats shall comply with ISO 2559 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.

11.7.3 Polymer matrices

Selection of polymer matrices shall comply with Section 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.

11.7.3.1 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*:

- a) polyester resins
- b) vinyl ester resins
- c) phenolic resins, and
- d) epoxy resins.

The allowable material properties of resins shall be as shown in Table 11.7.3.1.

Table 11.7.3.1 – 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)	°C	90	90	90	90
Shrinkage (max)	%	5	2.5	5	5

11.7.4 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.

11.7.5 Gel coats

Gel coats shall be considered non-structural. Gel coat shall be appropriate for the structure and to suit the particular environment.

Gel coats are applied to the surface of a composite structure to:

- filter out ultraviolet radiation and improve weathering
- add flame retardancy to provide an increased thermal barrier
- improve erosion
- provide an increased barrier to moisture, and
- provide colour scheme and improve general finish.

11.7.6 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.

11.7.7 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 11.7.7.

Table 11.7.7 – 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

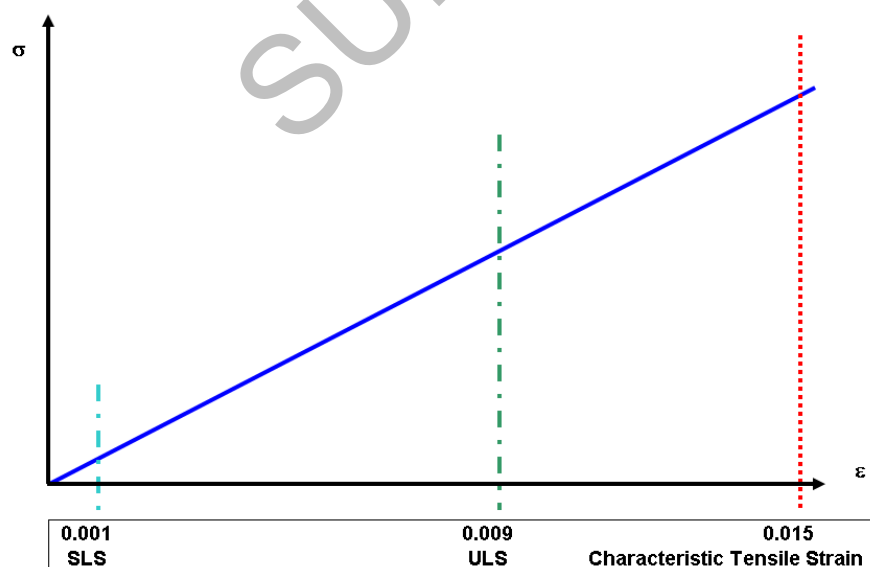
11.8 Design and detailing

11.8.1 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 = 0.6×0.015) as shown in Figure 11.8.1.
- FRP composite structures shall be designed for ultimate limit states according to Clauses 2.3.2 and 4.1 of *Eurocomp Design Code*.

Figure 11.8.1 – ULS and SLS strain limitations



11.8.2 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 11.8.1.

Fibre composite structures shall be designed for SLS according to Clauses 2.3.4 and 4.2 of *Eurocomp Design Code*.

11.8.3 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.

Most FRP composites exhibit limited or no ductile behaviour beyond the linear stress limit. The design shall ensure that a serviceability limit state is reached before its ultimate limit state for the mode of failure being considered. The serviceability limit state to be exhibited may include:

- i. excessive deflection / deformation
- ii. buckling or wrinkling, and/or
- iii. local damage / failure.

11.8.4 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.

11.8.5 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:

- i. independent, and not require lateral stiffeners, and
- ii. torsionally stable in the lateral direction.

11.8.6 Deformability of FRP composite girders

FRP composite girders do not demonstrate ductile behaviour as FRP does not yield like steel. FRP girders shall be designed to exhibit substantial deflection before failure. To ensure a sufficient level of safety between serviceability and ultimate limit states, an adequate level of deformability has to be shown. The deformability factor of FRP composite girders shall be assessed in accordance with the *Canadian Highway Bridge Design Code* (CHBDC) as follows:

$$\text{Deformability Factor} = \Psi_u M_u / \Psi_s M_s$$

where ΨM corresponds to Curvature and Moment capacity at ultimate and serviceability states.

The serviceability strain state corresponds to a maximum compressive strain in the concrete or FRP of 0.001 and tensile strain in FRP of 0.001. The deformability factor shall be greater than 4 for

rectangular sections or 6 for T sections (as per CHBDC). For any other shapes, deformability factor shall be determined by the designer.

11.8.7 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.

11.8.8 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 Section 2 of AS 1530.4.

Fire testing on FRP composite girders shall be carried out if instructed. Testing shall be in accordance with Section 2 and 6 of AS 1530.4. The serviceability limit state load shall be used for fire test in accordance with Section 2 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.

Fire testing is not normally required, but may be specified on certain projects / systems.

11.8.9 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.

11.8.10 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.

11.8.11 End zones design and connections

11.8.11.1 End zone

The Designer shall determine the performance of FRP girders at the supports.

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.

11.8.11.2 Connections

Connections for FRP composite girders shall be designed according to Clause 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 Fabrication of Structural Steelwork*.

11.8.11.3 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.

11.8.11.4 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, and
- prevent tearing of fibre due to bolt movement.

FRP composite girders shall meet the requirements of ULS and SLS, with holes considered.

11.8.11.5 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.

11.9 Additional requirements Category A FRP composite girders for new bridges

This section is applicable only for FRP girders for new bridges. Refer Section 16.10 for additional requirements for FRP girders for timber bridges.

11.9.1 Traffic loads on new bridges

The loading requirements for design of FRP composite girders for new bridges shall comply with AS 5100.2.

11.9.2 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 (γ_g) for dead load of structure shall be 1.2 for ULS and 1.0 for SLS designs.

The dynamic load allowance (α) for traffic loads shall be applied to both ultimate and serviceability limit states.

The design action is equal to $(1+\alpha) \times$ the load factor \times the action under consideration. Dynamic load allowance (α) shall be in accordance with AS 5100.2.

11.9.3 Method of structural analysis and design

Structural analysis and design shall comply with AS(/NZS 5100).

11.9.4 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, and
- the Ultimate Strength (R_u) shall be determined on strain compatibility, internal force equilibrium and controlling mode of failure.

For the Ultimate Limit State, the Design Strength ($=\phi R_u$) shall satisfy the following:

$$\phi R_u \geq \frac{S^*}{k}$$

Where, the strength reduction factor, $\phi = 0.25$ 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.

11.9.5 Deflection

The deflection limits of the bridge shall be in accordance with AS 5100.2.

11.9.6 Design life

The design life for FRP composite girders on new bridges shall be 100 years.

11.9.7 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.

11.9.8 Vibration

FRP composite girders shall be designed for vibration according to Clause 12 of AS 5100.2.

11.10 Additional design requirements for Category B FRP composite girders on existing timber bridges

This section is applicable only for design of FRP composite girders on timber bridges. This section shall not apply to FRP composite girders to be used in new bridges. Refer Section 16.9 for FRP composite girders for 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, and
- working drawings.

FRP composite girders shall satisfy both structural and functional requirements.

11.10.1 Performance criteria

FRP composite girders intended for timber replacement shall comply to the performance criteria shown in Table 11.10.1.

Table 11.10.1 – Performance criteria for existing Transport and Main Roads timber bridges

Criteria	Units	Value
Span	m	9.1
Girder Dimension	Depth (mm)	450
	Width (mm)	350
Target Bending Moment M_{test} $M_{test} \geq M^*/(\phi K_{test})$, where: $M^* = 447$ 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) 1885 (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

11.10.2 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.

11.10.3 Design Life of FRP composite girders on timber bridges

The design life for FRP composite girders on timber bridges shall be 30 years.

12 Drainage structures

12.1 Scope

12.1.1 In scope

This chapter is applicable for drainage structures such as:

- culverts
- culvert headwalls
- drainage pits
- road side kerb inlets, and
- other precast road side drainage elements.

12.1.2 Out of scope

This chapter does not apply to any bridge structures over waterways, however small. The criteria for bridges are covered in Part B of this document.

12.2 Design life for drainage structures

12.2.1 New structures

Minimum design life for new drainage structures shall be as follows:

- | | |
|---|--------------------|
| a) Box culverts including headwalls | - 100 years |
| b) Pipe culverts including headwalls | - 100 years |
| c) Drainage pits, depth less than or equal to 5.0 m | - 50 years |
| d) Drainage pits, depth greater than 5.0 m | - 100 years |
| e) Other drainage structures (Standard Drawings) | - Refer Table 12.2 |

Table 12.2 Other drainage structures - design life

Standard Drawing Number	Detail	Design Life (years)
1033	Kerb and Channel - Kerbs, Channels and Ramped Vehicular Crossings	50
1309	Concrete Gully-Field Inlet Type 1	50
1310	Concrete Gully-Field Inlet Type 2	50
1311	Concrete Gully - Roadway Type Channel Lip in Line	50 Refer Section 12.2c) & d)
1312	Concrete Gully - Roadway Type Kerb in Line	50 Refer Section 12.2c) & d)
1313	Concrete Gully - Precast Lintel Details	50
1321	Concrete Gully - Precast Concrete Side Inlet Gully with Precast Shaft	50 Refer Section 12.2c) & d)
1322	Concrete Gully - Precast Concrete Side Inlet Gully with Cast Insitu Pit	50 Refer Section 12.2c) & d)

Standard Drawing Number	Detail	Design Life (years)
1442	Concrete Gullies - Roadway Type at Concrete Barriers	50 Refer Section 12.2c) & d)
1443	Concrete Gully - Roadway Type Precast Inlet Units on Grade	50
1444	Concrete Gully - Roadway Type Precast Inlet Units in Sag	50
1446	Kerb Ramp - Ramped Kerb Crossing	50
1459	Concrete Gully - Roadway Type Channel Lip in Line Anti-Ponding	50 Refer Section 12.2c) & d)

12.2.2 Residual life

Where an existing culvert or other drainage structure is extended and/or refurbished the minimum nominal residual life of the structure is the difference between the nominal design life and the age of the original structure.

Nominal design life for culverts and other drainage structures are as listed in Section 12.2.1.

Prior to 2004, the nominal design life for culverts was 50 years, and this may require consideration when determining residual life.

12.3 Design requirements

12.3.1 General

Designers shall consider the requirements of all relevant design references including:

- the department's Technical Specification
- Australian Standards, and
- the department's *Road Drainage Manual* (RDM). For example, culvert designers should consult *Chapter 9: Culvert Design* of the RDM for design requirements of all culvert types.

12.3.2 Cast in situ box culverts

Reinforced concrete box culverts, cast in situ, shall be designed to AS/(NZS) 5100 (series): *Bridge design*.

12.3.3 Precast concrete box culverts

Reinforced concrete box culverts, precast, shall be designed shall be in accordance with MRTS24 *Manufacture of Precast Concrete Culverts* and AS 1597 (series): *Precast reinforced concrete box culverts*.

12.3.4 Concrete pipes

Steel reinforced concrete pipes shall be designed in accordance with MRTS25 *Manufacture of Precast Concrete Pipes* and AS/NZS 4058: *Precast concrete pipes (pressure and non-pressure)*.

Fibre reinforced concrete pipe culverts shall be designed in accordance with MRTS26 *Manufacture of Fibre Reinforced Concrete Drainage Pipes* and AS 4139: *Fibre reinforced concrete pipes and fittings*.

Design for installation of pipe culverts shall be in accordance with MRTS03 *Drainage, Retaining Structures and Protective Treatments* and AS/NZS 3725: *Design for installation of buried concrete pipes*.

12.3.5 Corrugated metal culverts

If approved for use, corrugated metal culverts shall be designed to AS/NZS 2041 (set): *Buried corrugated metal structures*.

Refer *Road Drainage Manual* for limitations to adopting metal culverts.

12.3.6 Lifting of drainage structures

The design for lifting of precast concrete components shall be in accordance with MRTS72 *Manufacture of Precast Concrete Elements*.

12.3.7 Accessibility

The design of all drainage structures shall ensure the facilities are readily accessible for cleaning and maintenance purposes.

12.4 Barriers for culverts

Barriers shall be provided to culverts in accordance with the relevant departmental Standard Drawings and *Road Planning and Design Manual*.

12.5 Approach settlement adjacent to large culverts

For large culverts with the height greater than or equal to 6.0 m, the calculated residual settlement on the approaches shall be controlled using selected fill material or ground improvement methods, both specified by the project geotechnical engineer and any residual settlement is accepted by the project pavement design engineer. The short term and long-term settlement control measures shall be submitted to the Director (Geotechnical) for review and acceptance.

12.6 Structural requirements for existing culverts

Refer to the department's *Road Drainage Manual*: Chapter 9: *Culvert Design*.

13 Motor grids

13.1 General

This section is applicable for motor grids.

13.2 Motor grid design requirements

Motor grids shall be designed in accordance with Technical Note 18 *Design Criteria for Motor Grids*.

The department's standard motor grids are shown in Standard drawings 1561, 1562, 1563, 1564 and 1565.

13.3 Design life

Minimum design life for motor grids shall be 50 years.

SUPERSEDED

14 Noise barriers

14.1 Scope

This chapter relates to noise barriers that are either:

- i. attached to a bridge, tunnel or other structure, or
- ii. stand-alone within a corridor controlled by Transport and Main Roads

The provisions herein are intended to clarify the provisions of:

- i. AS(/NZS) 5100, and
- ii. MRTS15 *Noise Fences*.

Subject to the provisions of this chapter, all noise barriers should comply with the requirements of MRTS15 *Noise Fences*.

Unless specified otherwise in this chapter, and notwithstanding the general applicability of MRTS15 *Noise Fences*, the most adverse criteria of either MRTS15 or AS(/NZS) 5100 shall apply for the design of noise barriers attached to bridges, tunnels and other structures.

14.2 Design life

14.2.1 Stand-alone noise barriers

Design life for stand-alone barriers shall accord with the requirements of MRTS15 *Noise Fences*.

14.2.2 Noise barriers on structures

The design life of noise barriers attached to an existing bridge, tunnel or other structure shall match the residual life of the structure, although the minimum design life shall not be less than the requirements of MRTS15 *Noise Fences*.

The design life for noise barriers on new structures shall be the same as the design life of the structure to which it is attached. For example, noise barriers attached to a new bridge shall generally have a design life of 100 years.

14.3 Design Loads

14.3.1 Stand-alone noise barriers

Design loads for stand-alone barriers shall accord with the requirements of MRTS15 *Noise Fences*.

14.3.2 Noise barriers on structures

In general, the design loads for noise barriers attached to a bridge, tunnel or other structure shall be in accordance with AS 5100.2, although the design wind load shall be based on a minimum ARI of not less than 1000 years.

Noise barriers attached to structures shall be subjected to the additional effects of dynamic suction nominated in MRTS15 *Noise Fences*.

14.4 Design documentation

Design drawings for noise barriers shall contain the following information:

- a) A long section indicating the extent of barriers including salient level data, such as ground levels, bridge attachment surface levels, and top of barrier. Particular attention should be

given to the top of barrier profile to ensure that the aesthetic qualities of the barrier are not compromised.

- b) Typical cross sections for all barrier types utilised.
- c) Salient wind load design parameters adopted, including:
 - i. design ARI for both strength and serviceability
 - ii. wind region
 - iii. regional gust wind speed
 - iv. terrain category
 - v. terrain / height multiplier
 - vi. shielding multiplier
 - vii. topographic multiplier
 - viii. nett pressure coefficient
 - ix. net porosity factor (if less than 1), and
 - x. allowance for dynamic suction.
- d) Type of posts.
- e) Type of panels.
- f) Footing details.
- g) Foundation material design characteristics, where applicable for:
 - i. undrained shear strength, and
 - ii. angle of friction.
- h) Connection details for any noise barriers attached directly to a structure.

14.5 Design review and certification

Noise barriers are subject to the design review process described in Part A, Chapter 2.

15 Fauna crossings

All fauna crossings shall be subject to project specific design criteria approved by the Director (Design, Review and Standards).

SUPERSEDED

Part E: Development applications

16 Development applications in the proximity of bridges and other structures

16.1 General

This chapter applies to development applications adjacent to facilities maintained by the department that incorporate bridges and other structures, excluding tunnels.

Development application in the proximity to tunnels are covered in Chapter 17.

Transport and Main Roads is vested with the responsibility to inspect, maintain and operate state-controlled infrastructure. To undertake these duties, the department must make the following provisions:

- a) an allowance for duplication and widening of the road / transport infrastructure, and
- 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.

16.2 Drawings, reports and method statements

The developer shall submit relevant items from the following list in the form of drawings or reports for Transport and Main Roads review.

- a) Both architectural and structural drawings of the proposed new development including, 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, and
 - construction sequence.
- b) Imposed loads on the department's structures, due to construction activities.
- c) The developer shall submit a report explaining the impact of development on Transport and Main Roads infrastructure, if any. The 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, and
 - 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.

16.3 Potholing criteria

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.

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.

16.4 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.

16.5 Construction phases

During the construction phases including excavation, the following issues are to be addressed by the developer:

- a) Dilapidation, vibration, crack growth and soil movement due to the construction activity.
- b) Instability of the excavation walls adjacent to Transport and Main Roads structures.
- c) 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.

- d) Ground water fluctuations next to Transport and Main Roads structures.
- e) Installation of permanent anchors into the department's road reserve for structures on adjacent properties is not permitted.
- f) Transport and Main Roads may permit temporary anchors to be installed in the 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 de-stressing.
- g) Acceptance to install rock anchors that protrude into the department's road reserve or within 2 m of the departmental infrastructure shall be obtained prior to undertaking the works.
- h) Any work adjacent to any Transport and Main Roads infrastructure shall cause no deleterious effect to the departmental infrastructure.

16.6 Additional criteria for development adjacent to bridges

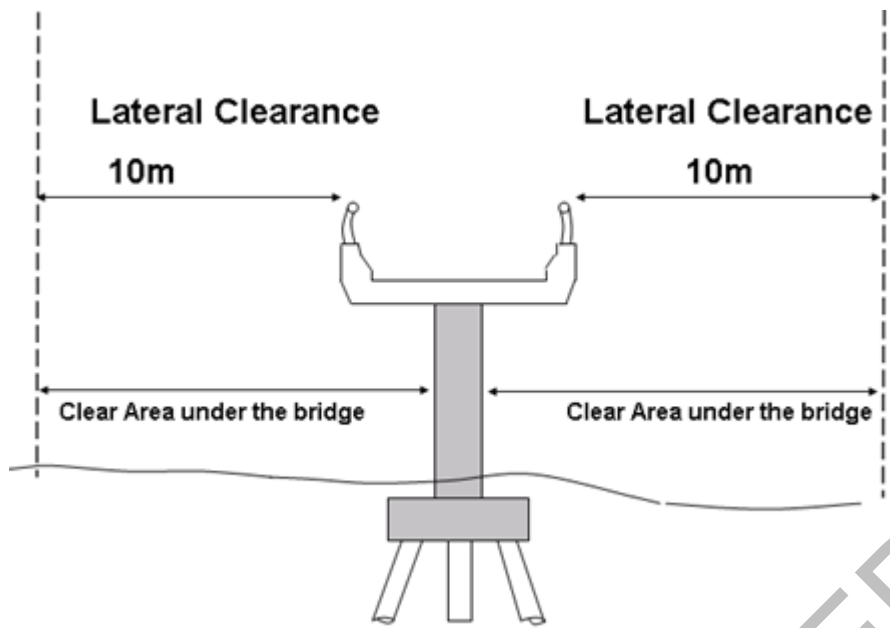
During excavation, explosives shall not be used adjacent to the bridge structures.

No rock blasting shall be permitted during excavation unless the applicant can demonstrate that there is no alternative and approval is obtained from Transport and Main Roads Deputy Chief Engineer (Structures). 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 approval.

The following additional requirements apply to bridges:

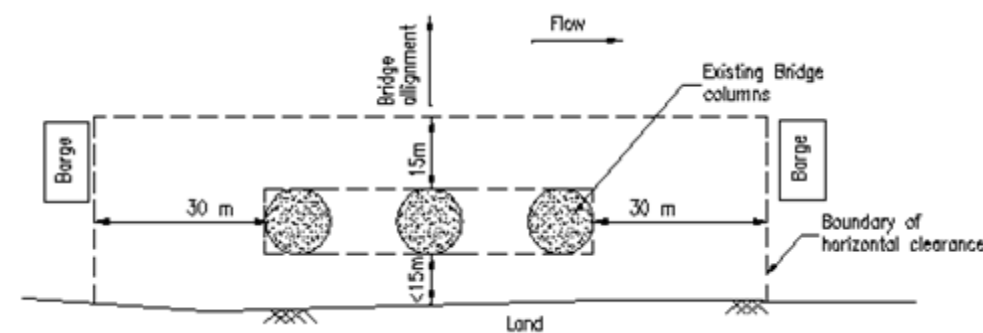
- a) No excavation within 10 m of any part of bridge substructure.
- b) Where the base of the new excavation is below the founding level of the bridge, no excavation shall be within the limit stated in item a) above. Where battered earth retaining design is adopted, the top of the batter shall not encroach 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 Section 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 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 16.6(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 16.6(a) – Lateral clearance to the bridge structures

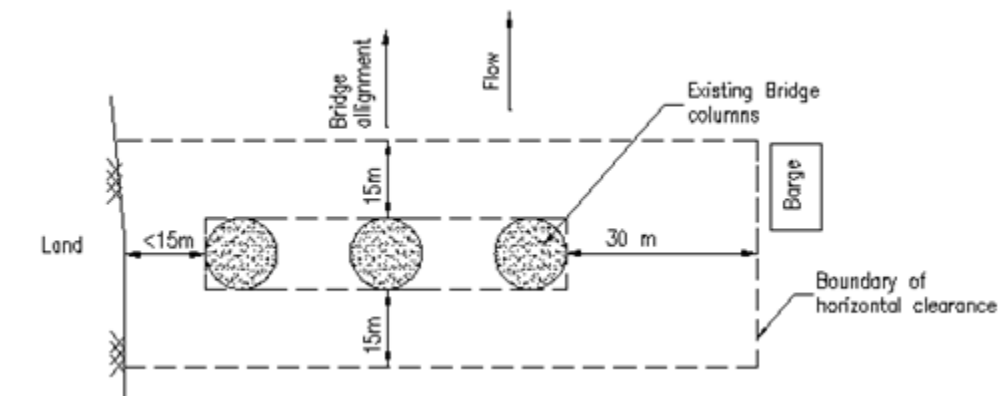


- d) 6.5 m vertical clear height above the highest point of bridge carriageway. Additional provision or buffer in terms of height shall be provided for tunnelling effect, lighting, exhaust fans and signage.
- e) Provision for noise suppression and fire protection shall be provided for tunnel effect around the structure.
- f) Where the bridge columns are located in water and with no land access, horizontal clearance around the bridge columns shall be maintained as shown in Figure 16.6(b) and Figure 16.6(c) as applicable for:
 - construction of temporary work platform
 - barge access associated with rehabilitation works, and
 - underwater inspection of the piles and pile caps.
- g) Within the above horizontal clearance, vertical clearance shall be maintained for possible pile driving for temporary work platforms at every column in the river.

Figure 16.6(b) – Lateral clearance to the bridge columns located closure to river bank

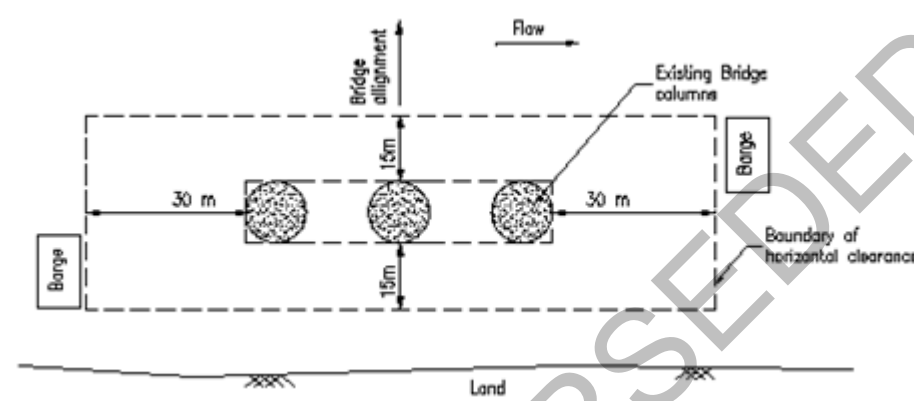


- i. Land is perpendicular to the bridge alignment.

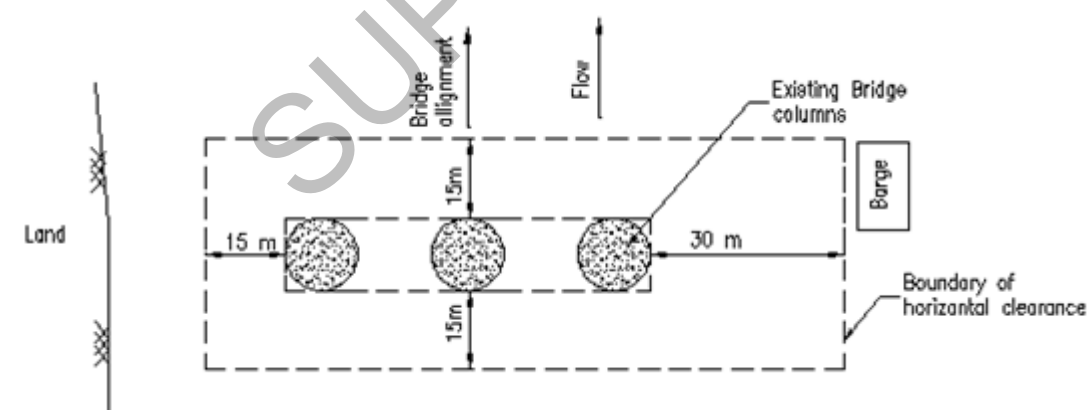


ii. Land is parallel to the bridge alignment.

Figure 16.6(c) – Lateral clearance to the bridge columns located away from river bank



iii. Land is perpendicular to the bridge alignment.



iv. Land is parallel to the bridge alignment.

Additional requirements adjacent to the 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 of 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).

SUPERSEDED

17 Development applications in proximity to tunnels

17.1 General

The purpose of this chapter is to provide guidelines on the type of information the department requires for assessing the impacts of proposed developments in the proximity to tunnels. This document also stipulates the technical requirements for compliance at the design stage of the development.

17.2 State-controlled tunnels in south east Queensland

The tunnels constructed and planned within the state transport network are either cut and cover tunnel or driven (mined) tunnel. State owned busway and road tunnels are listed below in Table 17.2.

Indicative loading and unloading specifications are included in Table 17.2 as a guide for adjacent developments. Detailed loading and unloading specifications are available for each tunnel, and will be made available on request.

The information provided in Table 17.2 is obtained from the As-Constructed tunnel drawings, design manuals or tunnel designers guidelines and may not be reflected in the easement documents associated with the tunnel.

Table 17.2 – State-controlled tunnels ¹ (as at Jan 2016)

Tunnel	Location ²	Construction Types	Loading and unloading specification summary (derived from as-built drawings, design manuals or tunnel designers guideline)
Nundah Bypass	Donkin Street to Boyd Street, Nundah	Cut and cover	Cut and cover loading: No provision for future development loading. Cut and cover unloading: Not permitted.
Northern Busway	Truro Street, Windsor to Norman Ave, Lutwyche	Driven and cut and cover	Driven Loading: 50 kPa at 1 m above the tunnel crown, and up to 1 m of surface fill at 20 kPa. Driven Unloading: Up to 7 m below natural surface to within 5 m of the driven tunnel roof or sides.
	Kedron Busway Station to Somerset Road, Kedron	Driven and cut and cover	Cut and cover loading: 25 kPa with a load factor of 1.5. Cut and cover unloading: No deeper than 1.5 m above the tunnel and no closer than 500 mm of the tunnel roof protection slab or walls.
Inner Northern Busway (Queen Street to RBH)	Queen Street to Upper Roma Street	Cut and cover tunnel	No provision for future development loading.
	Between Wyndham Street, Herston through Victoria Park Golf Course	Cut and cover tunnel	No provision for future development loading.
	Kelvin Grove Station through to Inner City Bypass	Cut and cover tunnel	No provision for future development loading

Tunnel	Location ²	Construction Types	Loading and unloading specification summary (derived from as-built drawings, design manuals or tunnel designers guideline)
South East Busway	Vulture Street Tunnel: between Southbank and Mater Hill Busway Stations	Driven and cut and cover	No provision for future development loading
	Water Street Tunnel: between Mater Hill Busway Station and Allen Street	Cut and cover tunnel	No provision for future development loading
	Buranda Tunnel	Driven tunnel	No provision for future development loading
	O'Keefe Street tunnel	Cut and cover tunnel	No provision for future development loading
	Upper Mt Gravatt Bus station, Northern and Southern Tunnel	Cut and cover tunnel	No provision for future development loading
Boggo Road	From Boggo Road Busway Station under Boggo Road Gaol, Annerley Road through to Dutton Park Place	Driven and cut and cover	<p>Cut and cover tunnel: No provision for future building load.</p> <p>Driven Tunnel: 50 kPa surcharge above tunnel.</p> <p>Driven unloading: <i>on top of the tunnel</i> – 3 m max excavation below surface level, provided 8 m minimum cover above the tunnel.</p> <p>Driven unloading: <i>adjacent to the tunnel</i> – 6 m maximum excavation at:</p> <ul style="list-style-type: none"> • 4 m minimum offset from tunnel external wall provided more than 9 m soil cover present above the tunnel, or • 7 m minimum off set from tunnel external wall provided less than 9 m soil cover present above the tunnel.
Eastern Busway	O'Keefe St under Cleveland Rail line to South East Busway	Cut and cover tunnel	<p>Cut and cover loading: 37 kPa unfactored including existing fill above the tunnel.</p> <p>Cut and cover unloading: no closer than 500 mm of the tunnel roof protection slab or walls.</p>
	O'Keefe St to Logan Road, Woolloongabba	Cut and cover tunnel	<p>Cut and cover loading: 30 kPa, unfactored combined loading of superimposed dead load (including soil surcharge) and live load. Load factor applied is 1.5.</p> <p>Cut and cover unloading: no closer than 500 mm of the tunnel roof protection slab or walls.</p>

Tunnel	Location ²	Construction Types	Loading and unloading specification summary (derived from as-built drawings, design manuals or tunnel designers guideline)
	Adjacent to Cowley Street		Cut and cover loading: 20 kPa, un-factored combined loading including superimposed dead load, live load and soil surcharge. Load factor applied is 1.5. Cut and cover unloading: no closer than 500 mm of the tunnel roof protection slab or walls.
	Laura St to Lilly Street, Greenslopes		Cut and cover loading: 50 kPa un-factored load plus 1.0 m soil fill (20 kPa). Load factor applied for all of these loads is 1.5. Cut and cover unloading: no closer than 500 mm of the tunnel roof protection slab or walls.
Airport Link ³ (Trans urban)	Federation Street, Windsor through to Sandgate Road, Clayfield. Refer Integrated Development Assessment System (IDAS) Mapping for location	Driven tunnel	Driven Loading: 50 kPa at 1 m above the tunnel crown, and up to 1 m of surface fill (20 kPa). Driven Unloading: Up to 7 m below natural surface to within 7 m of the driven tunnel roof or sides.
		Cut and cover tunnel	Cut and cover loading: 25 kPa with a load factor of 1.5. Cut and cover unloading: varies depending on location.

Notes:

1. *Exclusions:* Clem 7 and Legacy Way tunnels; Transport and Main Roads is not the asset owner of these two tunnels.
2. Refer to IDAS trigger mapping for location
3. Airport Link tunnel will be state-controlled asset at the end of 40 year franchise with Transurban.

17.3 Development approval requirements

The impacts of development on the tunnel will vary depending on whether the development abuts an existing or future tunnel.

17.3.1 Zone of influence for tunnels

17.3.1.1 Driven / bored tunnels

For development involving proposed construction adjacent to a Transport and Main Roads bored tunnel, the lateral zone of influence distance (Z) as shown in Figure 17.3.1.1 from the extreme perimeter of tunnel structure which trigger the need for Transport and Main Roads review shall be the greater of:

- 25 m
- $W/2 + D_t$
- $D_t + D_h$

- $W/2 + D_c$, or
- $2D_c$

Where:

W = Tunnel width

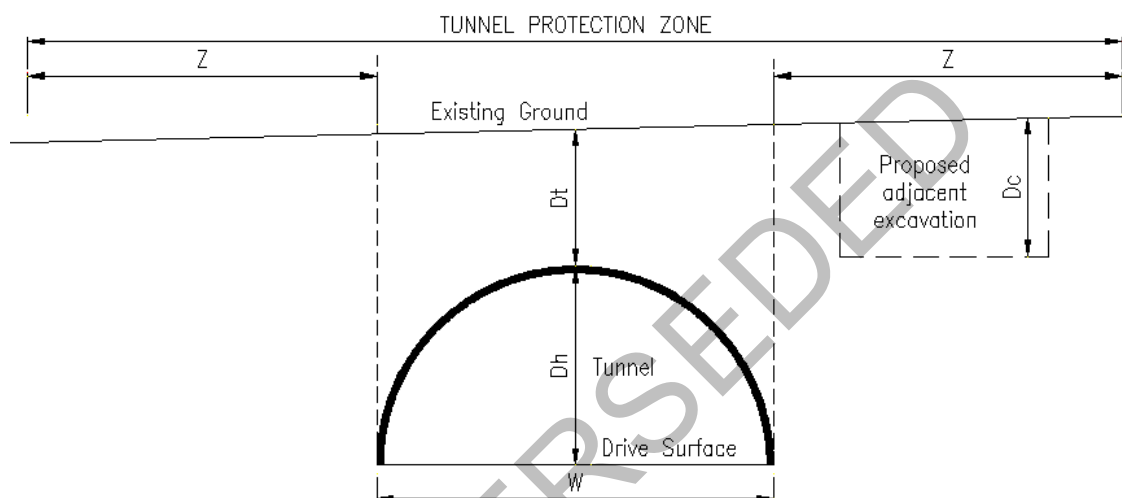
D_h = Tunnel depth

D_t = Depth to tunnel extrados from the ground level

D_c = Depth of excavation for adjacent new development

Tunnel protection zone = $2 \times Z + W$.

Figure 17.3.1.1 - Lateral zone of influence for driven tunnels



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.

17.3.1.2 Cut and cover tunnel

For new developments adjacent to State-controlled cut and cover tunnels, the lateral distance from the tunnel outer face which trigger the need for departmental review shall be the greater of:

- 10 m, or
- lateral offset from the tunnel outer face equal to the depth from the driving surface of the tunnel to the ground level.

17.3.2 Permissible excavation and loading above and beside a tunnel and within the easement area

17.3.2.1 Bored tunnel

No provision for development and/or loading above and adjacent to a tunnel

For tunnels that were not designed to accommodate future development, the following conditions shall apply:

- no excavation/loading permitted on top of the tunnels, and

- excavation adjacent to tunnels is permitted subject to agreement with the department's Deputy Chief Engineer (Structures), and the applicant (Developer) shall carry out tunnel impact studies (Table 17.3.3) to confirm no adverse impact on the integrity of the tunnels.

Provision for development above and adjacent to a tunnel

Excavation / loading above and adjacent to tunnels shall comply with the permissible condition for excavation / loading stipulated by the tunnel designer and/or the department. Excavation / loading shall not extend into the minimum cover above the tunnel roof as specified by the tunnel designer and/or the department.

Provision for development on easement support area

Excavation and development loading on easement area shall comply with the easement support conditions of the relevant tunnel.

17.3.2.2 Cut and Cover tunnel

Above the Tunnel

Excavation shall not extend into the easement boundary above the tunnel roof or into the 0.5 m cover above the tunnel roof, whichever provides the most cover above the tunnel.

Beside the Tunnel and in the Transition Zone from the Surface to the Tunnel Portal

Excavation shall not extend into the easement boundary beside the tunnel or into the 0.5 m side cover from the sides of the tunnel, whichever provides the most side cover beside the tunnel.

From the natural surface level to a depth of no greater than 3.5 m, or if tie back anchorages are present a Transport and Main Roads' review is required.

17.3.3 State-controlled future tunnel assessment requirements

Where a development is proposed adjacent to or above a future tunnel, the development shall be reviewed by the department using the available information for the proposed tunnel design, current at the time of the application. The impacts of development adjacent to a future tunnel will depend on:

- the height and depth of the development
- the proximity of the development to the tunnel
- the type of future tunnel it is adjacent to i.e. cut and cover or driven tunnel, and
- geotechnical considerations.

The departments design specifications for future tunnels are discussed in Chapter 5. Proposed development shall not compromise the future tunnel such as by adverse loading or excavation adjacent to the future tunnel location. In order to determine the impact of the proposed development on the design and constructability of the future tunnel the information indicated in Table 17.3.3 is required for assessment.

The following considerations shall be noted:

- The assessment of development impacts on future tunnels will be undertaken on a case by case basis and will also relate to the planning and design undertaken for the project.
- To demonstrate compliance with any conditions imposed as part of a concurrence agency response, the applicant shall be required to provide RPEQ certified detailed geotechnical

report and RPEQ certified detailed engineering drawings and supporting technical documentation to demonstrate that the design and construction of the future tunnel will not be compromised.

Table 17.3.3- State-controlled future tunnel assessment requirements

Activity	Information Required
RPEQ Certified Structural Engineering Design Drawings	<p>Structural engineering design drawings for the development, including cross sections / elevations and any required supporting technical details, shall be provided which clearly show the following in relation to the future tunnel:</p> <ul style="list-style-type: none"> • The location and setback of the proposed development (including the outermost projections of the closest structural elements such as retaining structures and building foundation structures) from the future tunnel. • The type, spacing, location and depth of building foundation structures (including any proposed structures such as footings, and bored piles / piers and associated columns). • The proposed retention system for the development, including the location, length, depth and angle of insertion of any proposed shoring, rock anchors and/or soil nails. Both the temporary and permanent retention design for the excavation should be detailed. • Demonstrate any proposed shoring, rock anchors and/or soil nails will not compromise the future tunnel both during construction and on-going operation, including any structural or geotechnical impacts, and • Demonstrate that the lateral and vertical loading implications of the proposed development will not compromise the safety and operational integrity of the tunnel. The loading configuration of the proposed development should be provided.
RPEQ Certified Geotechnical Investigation Report	<p>Preliminary geotechnical design information on the following, amongst other relevant considerations, to inform the structural engineering design and construction management of the development:</p> <ul style="list-style-type: none"> • earthworks, including methods for the excavation, the excavation and drilling of rock, the stability of open excavations, and filling / back filling and compaction • permanent and temporary basement retention options, design loads and geotechnical design parameters • suitable options for foundation structures, design loads and geotechnical design parameters • groundwater management • vibration impacts from drilling, boring and excavation, and • advice on effects on the existing state transport infrastructure and relevant construction issues.

17.3.4 State-controlled existing tunnel design assessment requirements

As noted in Table 17.2 each state-controlled tunnel has been designed to a range of specifications to suit transport requirements and localised geological conditions. The assessment of development impacts on tunnels will be undertaken on a case by case basis and will depend on the circumstances of the site and nature of the proposed development. Development proponents are encouraged to contact the Department of Infrastructure, Local Government and Planning to request a pre-lodgement meeting where development may impact on a state-controlled transport tunnel.

Table 17.3.4 details information that may be requested by the department to allow Transport and Main Road's Engineering and Technology Branch to assess the impact of the proposed building design on the existing tunnel.

Table 17.3.4 – State-controlled existing tunnel design assessment requirements

Activity	Information Required
Proximity to State-Controlled Tunnel	<p>Scaled and clearly labelled layout plans, elevations and cross sections shall show the location and minimum setback of all levels of the proposed development (including building foundation and retaining structures) in relation to the tunnel (considering 3D space) and to the volumetric boundary of the existing tunnel. These details shall be accompanied by figures / sketches which detail the as-built details of tunnel infrastructure (including any retaining structures), including relevant dimensions in plan and section view.</p> <p>The minimum distance between tunnel external wall / tunnel crown and the closest structural element of the new development shall be clearly shown.</p>
Geotechnical Studies	<p>RPEQ certified detailed geotechnical investigation report for the structural engineering design and construction management of the development, addressing the following, including other relevant considerations:</p> <ul style="list-style-type: none"> • earthworks, including methods for the excavation, the excavation and drilling of rock, the stability of open excavations, and filling / back filling and compaction • permanent and temporary basement retention options, design loads and geotechnical design parameters • suitable options for foundation structures, design loads and geotechnical design parameters • groundwater management • vibration impacts from drilling, boring and excavation, and • advice on effects on the existing state transport infrastructure and relevant construction issues.
Imposed Load Assessment	<p>The applicant to provide an accurate 'run-down' of the building loads due to new development up to the foundation level and check that the resulting bearing pressure does not exceed the allowable design loads as per the relevant tunnel design criteria. This assessment including appropriate calculation shall be certified by Applicant's RPEQ.</p>
Impact Assessment Report	<p>A RPEQ certified impact assessment report including predicted movements and vibration on the existing tunnel and any associated retaining structures due to the construction activities associated with new development. This assessment is necessary to demonstrate that the proposed retaining system (for an excavation) and the construction methodology are appropriate to keep the tunnel movements within allowable limits.</p> <p>The tunnel impact assessment shall demonstrate no impact on the following:</p> <ul style="list-style-type: none"> • amenity • aesthetics • durability • function • user benefits • safety during operation, and • environment performance.

Activity	Information Required
	The impact assessment must include 3D or 2D Finite Element Modelling at all critical sections. The modelling undertaken shall be based on a detailed geotechnical investigation.
Foundation Details	<ul style="list-style-type: none"> • Building foundation detailed plans / general arrangement drawings • Layout plan showing footing soffit reduced levels • Footing type • Dimensions • Loading configurations and approximate
Adjacent Foundations	Edge / perimeter loading details from adjacent buildings approved post state-controlled tunnel construction.
Building Framing Elements	<ul style="list-style-type: none"> • Details of building columns and lift core • Column and lift core loading
Temporary and Permanent Retention System	Details of retention structures – anchors temporary and permanent.
Construction and Excavation	<p>Construction work method statement shall address:</p> <ul style="list-style-type: none"> • Details of excavations, filling/backfilling / compaction, filling method statement – the applicant must fully detail any excavation or compaction as these will change the applied loads and confirm these do not exceed those specified by the department. • Support details: details of basement excavation support (if relevant), including any temporary support requirements and the potential loading of these support elements on the existing tunnel: <ul style="list-style-type: none"> • retention / temporary support / anchor arrangements • loading on retention elements such as anchors • exclusion zones • total duration of temporary retention system until permanent strutting is constructed (e.g. basement floors) for retention system • machinery used – construction loading shall be considered, the use of storage materials, the use of heavy vehicles must be considered • vibration issues – proposed piling system shall be assessed to determine if the impact on the tunnel is acceptable; generally bored piling systems are preferred as driven piles could induce significant stresses and vibration that might affect the tunnel structure or function, and • assessment of any construction related vibration.

17.3.5 Building load calculations

Building load calculations of proposed developments shall include a floor by floor summary. Slab thickness, dead and live load values shall be determined in accordance with AS 1170.1 and shown in summary. An example of a summary of a building load calculation is shown on Table 17.3.5.

Table 17.3.5 – Building load calculation

Level	Slab Thickness (mm)	Slab dead load allowance (kPa)	Live load allowance (kPa)	Total (kPa)
Basement	250	6.0	3.0	9.0
Ground	100	2.4	2.5	4.9
Level 1	200	4.8	2.3	7.1
Level 2	200	4.8	2.3	7.1
Level 3	200	4.8	2.3	7.1
Level 4	200	4.8	2.3	7.1
TOTAL		27.6	14.7	42.3

Existing building(s) adjacent to proposed development and existing tunnel might have used some of the allowable loading on tunnel. Therefore, the applicant is required to determine the combined building loads of both proposed development and adjacent building(s) and confirm these combined load are not exceeding the allowable loading on tunnel.

17.4 Pre-construction, construction and post construction compliance requirements

17.4.1 General

The department is responsible for safeguarding the tunnel infrastructure and to ensure that the proposed new development has no adverse impacts 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 large or small construction activities adjacent to a tunnel.

The design documentation shall contain sufficient provisions to ensure that all construction activities ensure the following requirements are met:

- a) Prior to commencing work, the development proponent shall have a prestart meeting with the department to discuss the construction methods and program, tunnel monitoring - 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.
- b) Any damage to the tunnels caused by the development shall be rectified by the developer at his own cost.
- c) The department may impose some of, or all, the following activities to the proposed development:
 - potholing to confirm tunnel depth
 - demolition risk assessment and method statement
 - foundation survey depth confirmation
 - dilapidation survey: pre and post construction, and
 - monitoring: crack, movements / tilts (tunnel and retaining walls), ground movement substrate movement (inclinometers), vibration and ground water.

17.4.2 Potholing

Where a development is proposed in close proximity above a tunnel (within three metres) the department may require potholing to confirm the actual location of the tunnel roof protection slab. A sketch plan of the proposed potholing positions and potholing machinery to be used (including vehicle loads) shall be forwarded to the department for review and approval prior to the commencement of potholing works. Potholing positions shall be confirmed on site by a registered surveyor and a sketch plan of the tunnel depths shall be forwarded to the department after completion of the potholing works.

17.4.3 Demolition - risk assessment and method statement

Prior to commencement of any demolition activity, the contractor shall undertake a Demolition Risk Assessment of the potential damages to departmental structures and tunnels. Temporary measures shall be provided to prevent damages to departmental assets during demolition.

The department may request for a Demolition Method Statement upon the outcome of department's review of the demolition risk assessment. This statement shall include proposed monitoring locations for displacements, existing cracks and any other measurable impacts to departmental structures during demolition.

If demolition is deemed high risk to departmental assets, the department may request controlled demolition procedures to be overseen by departmental compliance officers.

17.4.4 Foundation excavation survey

Where a development is constructed within three metres above / adjacent to a Transport and Main Roads tunnel, the department may request a Foundation Survey Sketch Plan to be prepared. A Foundation Survey Sketch Plan shall be prepared at the completion of footing excavation and prior to foundation concrete pour. The sketch plan shall be prepared by a registered surveyor and shall compare the design excavation levels to the As Constructed excavation levels. Where the foundation includes piled walls, the surveyor shall provide confirmation the As Constructed pile depths.

If the As Constructed levels are within 100 mm – 200 mm of the design excavation levels, the department will issue an approval to proceed. If excavation exceeds permitted tolerances the developer shall undertake satisfactory compliance activities and reissues a Foundation Survey Sketch Plan showing compliant excavation levels.

17.4.5 Tunnel dilapidation survey

No demolition, excavation or construction shall commence prior to department's acceptance of the dilapidation survey. A dilapidation survey is required for all types of tunnels and all types of development with or without basement.

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 appropriately experienced RPEQ engineer shall carry out the dilapidation survey, which is carried out with the consent and in the presence of a departmental representative. A copy of the dilapidation survey shall be given to the departmental representative not less than five 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.

17.4.5.1 Driven tunnel survey duration

Transport and Main Roads requires inspection of the tunnel lining (the secondary layer) on a monthly basis and compare with the initial dilapidation survey during the excavation stage of the basement bulk excavation and thereafter dilapidation surveys are required at the following stages:

- end of bulk earth work basement excavation
- completion of basement work – 'close off' of basement ground level slab, and
- end of the construction work.

Early termination of dilapidation survey is at the discretion of the Director (Structures Review and Standards) in the event of no change in tunnel behaviour.

17.4.5.2 Cut and cover survey duration

The department will confirm the duration and number of dilapidation surveys required based on the pre- construction dilapidation survey report, a minimum of two dilapidation surveys will be requested. The first, is to be undertaken prior to any construction / demolition works (pre-construction) and the second at completion of the construction works (that is, post construction).

17.4.5.3 Dilapidation survey costs

The developer is responsible for the dilapidation survey costs. These costs vary depending on the features of the tunnel, development and the condition of the tunnel. Table 17.4.5.3 details some of the usual associated costs. This is not a complete list.

Table 17.4.5.3 – Potential tunnel dilapidation survey costs ¹

Tunnel type	Access approval authority	Preferred timing for tunnel survey	Developer's incurred costs
Busways	TransLink Busway Manager	Negotiate with TransLink authorities	<ul style="list-style-type: none"> • Traffic control costs • Engineering dilapidation survey staff costs • Mobile elevated work platforms hire, other machinery and equipment hire and labour costs • Busway induction costs
Toll Road (e.g. Airport Link)	Toll Road Manager	Negotiate with relevant management authorities and/or franchise operators	<ul style="list-style-type: none"> • Developer and Transport and Main Roads engineering dilapidation survey staff costs • Mobile elevated work platforms hire, other machinery and equipment hire and labour costs • Tunnel induction costs
Road tunnel (Non Toll)	Transport and Main Roads	Negotiate with relevant management authorities	<ul style="list-style-type: none"> • Traffic control costs • Developer and Transport and Main Roads engineering dilapidation survey staff costs • Mobile elevated work platforms hire, other machinery and equipment hire and labour costs • Tunnel induction costs

Note 1 - Indicative only. Additional cost may be required.

17.4.6 Tunnel monitoring requirements

During the demolition / excavation / construction phases, the following issues are to be addressed by the developer:

- dilapidation, vibration, tunnel movements, 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 tunnel, and
- 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.

A monitoring program shall be prepared by the developer in consultation with the department to ensure that the tolerances for vibration, crack, movements / deformation, ground tunnel tolerances are not exceeded. The preparation and running of the monitoring program will be at the expense of the developer.

Monitoring shall be conducted for two weeks prior to commencement of work to establish base level conditions, during construction, and for a minimum of three months after completion of work. Monitoring can be terminated only with the acceptance of the departmental representative, upon demonstrating that the monitoring results confirm that the site conditions have stabilised.

These timeframes are a baseline indication of the department's requirements. Monitoring plans and programs will need to be prepared for each development to respond to local conditions, tunnel type and the position of the development relative to the tunnel.

The monitoring requirements are governed by the position of the development relative to the tunnel. Two scenarios are considered:

- development adjacent to a tunnel, and
- development above a tunnel.

Development adjacent to a tunnel: occurs where **NO** part of the development excavation or building structure is located above the tunnel structure or tunnel volumetric boundary.

Development above a tunnel: occurs where **ANY** part of the development excavation or building structure is located above the tunnel structure or tunnel volumetric boundary.

17.4.6.1 Development adjacent to and above a tunnel

Monitoring requirements for developments adjacent to and above a tunnel is shown in Table 17.4.6.1.

Table 17.4.6.1 – Monitoring requirements for developments adjacent to a tunnel

Type of Monitoring	Cut and Cover Tunnel		Driven Tunnel	
	Without Basement	With Basement	Without Basement	With Basement
Vibration Monitoring	Yes	Yes	Yes	Yes
Crack Monitoring	Based on DS	Based on DS	Based on DS	Based on DS

Type of Monitoring	Cut and Cover Tunnel		Driven Tunnel	
	Without Basement	With Basement	Without Basement	With Basement
Movement / Deformation (Total station monitoring) / Tilt meters at sensitive locations	Yes	Yes	Yes	Yes
Temperature Inside and Outside the tunnel	Yes	Yes	Yes	Yes
Ground Movement/Ground Water				
Inclinometers	N/A	Yes	N/A	Yes
Groundwater Monitoring	Yes ¹	Yes	Yes ¹	Yes

Note¹ The department reserves the right to overwrite these requirements.

In any instance where a development proposes intrusion into the tunnel volumetric boundary or is closer than the department's permitted tolerances, tunnel monitoring requirements are to be assessed on a case by case basis.

17.4.7 Ground water monitoring

The Contractor's work method and system shall be designed to control ground water. Removal of ground water shall not cause damage to the existing tunnel structure. In particular:

- significant lowering of natural ground water table shall be avoided
- the contractor shall install minimum of two piezometric devices to determine the seasonal fluctuations in ground water between the tunnel and the new development
- the developer's engineer requires 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 three months after completion of the basement construction, unless more or less frequent monitoring is deemed acceptable by the department's representative, and
- unusual fluctuations are to be reported immediately to the department's representative.

17.4.8 Tunnel movement monitoring

The developer shall install monitoring (24/7) system using automated total station to capture the movements in tunnel and associated structures including the developer's retention system. This monitoring system shall provide an efficient means to evaluate the trend of movements in a structure. The total station instruments shall have angular, distance measurement and autolock accuracies. The total stations consist of robotic instruments that shall have the ability to search and lock onto series of sensors attached on the structure automatically.

The type of instruments, its location and its proximity to the targets shall be appropriate for the sensitivity required. At critical locations of the structure, in addition to total stations, structural sensors such as tilt meters shall be installed to capture precise movements. Structural sensors shall be installed at critical locations at the same time as prisms are installed for the total stations, prior to commencement of construction of the new development. This ensures enhanced accuracy is already

in place and precise readings available to monitor critical locations should the trigger level is approaching unacceptable values.

The data captured by the automatic monitoring system shall be consistent and stable. The accuracy of the system shall be such that the deviation from the mean reading (which is taken as the actual reading) shall be less than ± 2 mm for 99% confidence level.

The number of prism sensors and its locations are dependent on the type of structures to be measured and the outcome of the tunnel impact studies (refer Table 17.3.4) due to the adjacent development. It is prudent to install prism sensors at the locations where tunnel movement is predicted to be a maximum (by structural analysis) should movement occur during construction of the development. Alternatively, the prism sensor locations can be identified from deformed shape outputs from Finite Element Studies.

The movement shall be measured in the tunnels or associated structures in the transverse, longitudinal and vertical directions.

The automated notification trigger for movements shall be set as follows:

- Automated Notification Trigger = Allowable Movement + Instrument Uncertainty (± 2 mm at 99% confidence).

In the event that the total station readings indicate a trend in movement, additional prism sensors shall be placed at, and near the affected zone, or critical area identified and frequency of monitoring shall be increased. If the trend continues additional structural sensors shall also be installed.

During the progress of the development works, if it becomes apparent from the monitoring results that the ground/or the Developer's retention system exceeds the predicted maximum movement, the Developer shall strengthen the retention system. Revised retention system shall be certified by the Developer's RPEQ.

Trigger levels for tunnel movements and associated structures shall be agreed with the department prior to commencement of construction.

17.4.9 Vibration monitoring

17.4.9.1 General

The developer is required to install vibration monitoring equipment utilising triaxial geophones (4.5 Hz) to capture vibration in the tunnel roof and or walls prior to commencement of any demolition, excavation or construction work. The devices shall be calibrated against a traceable event. The devices shall be installed as per manufacturer's installation guidelines. The output result shall also include waveforms of extreme events.

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 critical events.

- a) Background monitoring and baseline reading shall 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 week baseline reading regime is imposed.
- b) 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 shall be sufficient redundancy built into the system so that losses of discrete elements do not cause loss of the entire monitoring system.

- c) 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 shall record the date, nature of the work and who undertook it. This is useful for error tracing and a change in control procedures.
- d) The location and number will be accepted on a project basis.

17.4.9.2 Trigger and alarm limits - Bored / driven tunnels

A PCPV (Peak Component Particle Velocity) threshold of 1.5 mm/sec is to be set in the logger.

A warning trigger level between 1.5 mm/s to 5 mm/sec is to be set in the logger.

The trigger level to close the tunnel to buses or traffic and immediate ceasing of all excavation is to be set at a PCPV exceeding 5 mm/s.

Responses to trigger levels of bored/driven tunnel lining vibration monitoring shall comply with those listed in Table 17.4.9.2.

Table 17.4.9.2 – Vibration - alarm limits and responses for bored / driven tunnel

Trigger Levels	Tunnel Lining Vibration Monitoring	Responses
Green	PCPV < 1.5 mm/s	No action required.
Orange	1.5 mm/s < PCPV < 5 mm/s	Notify the Developer's Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures.
Red	PCPV > 5 mm/s	Stop all buses or traffic from using tunnel. Place hold on excavation. Notify the Developer's Supervising Engineer and Transport and Main Roads. Resumption of work to be approved by the department.

Any changes to the above trigger based on the background information or at any time during the adjacent development is to be accepted by the Transport and Main Roads, Director (Structures Design, Review and Standards).

Typically 'Vibration Geophone' accuracy is ± 0.1 mm/s.

17.4.9.3 Trigger and alarm limits - Cut and cover tunnels

The following trigger levels shown in Table 17.4.9.3 shall be set for cut and cover tunnels.

Table 17.4.9.3 – Vibration alarm limits and responses for cut and cover tunnels

Trigger Levels	Tunnel Lining Vibration Monitoring	Responses
Green	PCPV < 5 mm/s	No action required.
Orange	5 mm/s < PCPV < 10 mm/s	Notify the Developer's Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures.
Red	PCPV > 10 mm/s	Stop all buses or traffic from using tunnel. Place hold on excavation. Notify the Developer's Supervising Engineer and Transport and Main Roads. Resumption of work to be given by the department.

17.4.9.4 Alert and response plan due to vibration and movements

The developer shall 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 and other construction works.

The 'Alert and Response Plan' shall show the contact chain in case of alarm. Relevant departmental (TransLink Division and Engineering and Technology Branch) representatives shall be the first to be informed.

17.4.10 Crack monitoring device

17.4.10.1 General

The developer is required to install crack monitoring devices in the tunnel 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 selected after the cracks are identified from the dilapidation survey.

17.4.10.2 Trigger and alarm limits for crack

Responses to trigger levels of tunnel lining crack monitoring shall comply with those listed in Table 17.4.10.2.

Table 17.4.10.2 – Tunnel lining cracks, alarm limits and responses

Trigger Levels	Tunnel Lining Crack Width (Crack Monitoring)	Responses
Green	Existing cracks width < 0.5 mm New cracks width < 0.2 mm	No action is required.
Orange	Existing cracks width between 0.5 mm and 1.0 mm New cracks width > 0.2 mm and < 0.5 mm	Notify the Developer's Supervising Engineer and Transport and Main Roads. Review monitoring frequency and construction procedures.
Red	Existing cracks width > 1.0 mm New cracks width > 0.5 mm	Stop all buses and or traffic from using tunnel. Place hold on excavation. Notify the Developer's Supervising Engineer and Transport and Main Roads. Resumption of works to be given by the department.

17.4.10.3 Alert and response plan due to cracking

The **Alert and Response Plan** shall show the contact chain in case of alarm. Relevant departmental (TransLink Division and Engineering and Technology Branch) representatives shall be the first to be informed.

17.4.11 Ground movement adjacent to the tunnel

The development proponent shall undertake the following monitoring of ground adjacent to the tunnel:

- a) Install at least three inclinometers at critical locations between the existing tunnel and the proposed basement to a depth well below the basement excavation level. The decision to increase / decrease the number of inclinometers 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) Inclinometers must be monitored daily during basement excavation and weekly until three months after completion of basement construction. The developer's consultant is required to collect and review all inclinometer data during the excavation stage as well as the basement construction stage. Reports are to be forwarded to the department for review.
- c) Trigger and alarm limits for inclinometer movements are to be agreed prior to commencement of any demolition, excavation or construction work.
- d) The Alert and Response Plan for inclinometer movement shall show the contact chain in case of alarm. The first stakeholders to inform are TransLink and Transport and Main Roads.
- e) Basement construction adjacent to state-controlled tunnels and retaining walls may include temporary and permanent retention systems by the development proponent. Survey monitoring points or inclinometers shall be placed on the development's retention system including the capping beams. The load on struts and/or anchors also to be monitored.
- f) The number of monitoring points required shall be proposed by the developer's RPEQ, reviewed and agreed by the department to ensure sufficient measuring points capture any potential movement on the development's retaining wall. Carry out monitoring twice a day during excavation and once a day when no excavation work is undertaking on site. Daily reports shall be forwarded to the department for review.

17.5 Additional requirements for tunnels

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.

Installation of permanent anchors within the tunnel volumetric boundary area for structures from adjacent properties is not permitted.

Acceptance to install temporary rock anchors that protrude into the tunnel volumetric area or within 2 m of the state-controlled tunnel infrastructure shall be obtained prior to undertaking the works. In addition, it shall be demonstrated that the temporary anchors will not impact upon the tunnel, evidence of which shall be included in Tunnel Impact Assessment report.

Temporary retaining structures such as anchors / shoring may be potentially installed in state-controlled properties, subject to the development proponent adequately demonstrating through RPEQ

certified assessment and drawings that the integrity and safety of the state-controlled transport tunnel will not be compromised. Temporary anchors shall be de-stressed prior to the completion of construction. Certification of the de-stressing by relevant experienced RPEQ shall be submitted to the department within 28 days of the de-stressing operation.

Post tensioned transfer slabs and beams constructed on top or adjacent to tunnels for the development shall be witnessed by departmental representatives during construction to confirm the design post tensioning force had been applied (Witness Point). The developer shall submit RPEQ certified records of the measured post-tensioning forces and hogs to Transport and Main Roads Director (Structures Review and Standards) for review within 14 days of completing post-tensioning. Further construction works over the tunnels shall not be carried out after completing post-tensioning without agreement with the post-tensioning records and hogs from Director (Structures Review and Standards).

Excavation close to tunnel (agreed and allowed by Transport and Main Roads) to be witnessed by the department (Witness Point). Any back filling next to tunnel shall not be carried out (Hold Point), before inspection by the department.

SUPERSEDED

Appendix A: Matters for resolution to AS/(NZS) 5100:2017

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

No.	Issue	Application to project
AS 5100 – Scope and general principles		
1	Requirements for assessment of a bridge due to change in use (see Clause 2).	Project specific approval by Director (Structures Design, Review and Standards) is required. Consider Sections 3.6 – 3.8 of this <i>Design Criteria for Bridges and other Structures</i> .
2	Acceptance of the bridge experience of a Professional Engineer (see Clause 4.6).	Refer to Section 2.1 of this <i>Design Criteria for Bridges and other Structures</i> . All bridges and other structures shall be designed by an experienced structural engineer who is a Registered Professional Engineer of Queensland (RPEQ), or the designers shall be supervised by an experienced structural engineer who is a Registered Professional Engineer of Queensland (RPEQ). Refer also Table 1.3 of this <i>Design Criteria for Bridges and other Structures</i> for a definition of acceptable RPEQ certification.
3	Specification of a rail track as underground rail (see Clause 4.10).	As per AS 5100.1, unless specified otherwise by the relevant rail authority.
4	Approval of the use of alternative design methods and materials (see Clause 7).	Project specific approval by Director (Structures Design, Review and Standards) is required.
5	Specification of a shorter design life for ancillary elements (see Clause 8.2).	Refer Section 1.5 of this <i>Design Criteria for Bridges and other Structures</i> . Otherwise, project specific approval by Director (Structures Design, Review and Standards).
6	Approval of non-linear methods of analysis (see Clause 8.4).	Use of non linear analysis as primary design method is permitted provided methodology has been reviewed and approved by the Director (Structures Design, Review and Standards).
7	Approval to use post-installed fasteners in new construction (see Clause 8.8).	The use of post-installed fasteners in new construction shall be avoided by careful planning. Otherwise, project specific approval by Director (Structures Design, Review and Standards) is required in respect of both design and installation.
8	Specification of special conditions and requirements for design (see Clause 8.9).	Specific requirements as determined by the Director (Structures Design, Review and Standards), or as required by the design brief, or in accordance with a project SWTC.
9	Approval of the process for risk ranking and risk reduction (see Clause 9).	Project specific, with due consideration given to the department's <i>TMR Risk Management Guide</i> . (This is an internal document).

No.	Issue	Application to project
9a)	Relevant policies and risk management approaches for sustainability and climate change (see Clause 10.1)	As per AS 5100.1 and as required in Section 3.11 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Hydraulics and Flooding), or Director (Structures Design, Review and Standards).
10	Specification of bridge waterway requirements (see Clause 11.1).	For hydraulic requirements, project specific approval by the Director (Hydraulics and Flooding) is required in accordance with Section 3.11 of this Design Criteria for Bridges and other Structures, and endorsement by Director (Structures Design, Review and Standards). For navigation requirements the relevant waterway authority shall be consulted.
11	Specification of span and vertical clearances for watercraft (see Clause 11.1).	Project specific approval by Director (Structures Design, Review and Standards), and the Director (Hydraulics and Flooding) is required, based on the requirements of the relevant waterway authority.
12	Specification of alternative ARIs for flood immunity and SLSs (see Clause 11.1 and Table 11.1 (Note 1)).	As per AS 5100 and as required in Section 3.11 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Hydraulics and Flooding), and endorsed by Director (Structures Design, Review and Standards).
13	Specification of soffit level of the bridge relative to the flood immunity level (see Clause 11.1).	As per AS 5100 and required in Section 3.11 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Hydraulics and Flooding), and endorsed by Director (Structures Design, Review and Standards).
14	Specification of the afflux and corresponding ARI (see Clause 11.1).	In accordance with Section 3.11.3 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Hydraulics and Flooding), and endorsed by the Director (Structures Design, Review and Standards).
15	Determination of the environmental requirements (see Clause 12).	Project specific requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
16	Specification of geometric requirements (see Clause 13.1 and 13.2).	As per AS 5100.1 and as required in Section 3.5 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards). Additional geometric requirements for railway bridges shall be as specified by the relevant railway authority.

No.	Issue	Application to project
17	Specification of minimum dimensional clearances for bridges over navigable waterways (see Clause 13.3).	For bridges over navigable waterways, dimensional clearances shall be as specified by the waterway authority and endorsed by the Director (Structures Design, Review and Standards).
18	Specification of road bridge carriageway widths (see Clause 13.4).	Number of lanes and bridge carriageway width shall be in accordance with Section 3.5.2 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
19.	Determination of horizontal clearances to substructure components (see Clause 13.6 and 13.8).	<p>For road bridges over road, refer <i>Road Planning and Design Manual Edition 2: Volume 3, Supplement to Austroads Guide to Road Design, Part6: Roadside Design, Safety and Barriers</i>.</p> <p>Project specific clearances may apply. In such cases refer to the design brief, project SWTC, or as agreed with Director (Structures Design, Review and Standards).</p> <p>For road bridges over railways or waterway, refer relevant authority requirements.</p>
20	Specification of minimum vertical clearance (see Clause 13.7, 13.8 and Table 13.7).	<p>For road bridges over road, refer Section 3.5.4 of this <i>Design Criteria for Bridges and other Structures</i>. Where desirable clearances are not achievable, project specific clearances may apply. In such cases refer design brief, project SWTC, or as agreed with Director (Structures Design, Review and Standards).</p> <p>For road bridges over railways or waterway, refer relevant authority requirements.</p>
21	Superelevation and widening of the deck surface of a bridge on a horizontal curve (see Clause 13.9).	In accordance with Section 3.5.1 of this <i>Design Criteria for Bridges and other Structures</i> , although situations where curve widening occurs on a bridge should be avoided. In such cases refer design brief, project SWTC, or as agreed with Director (Structures Design, Review and Standards).
22	Specification of the clear walkway width on road bridges (see Clause 13.10).	In accordance with Section 3.5.2 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
23	Additional requirements for stairways (see Clause 13.11 and Table 13.11).	In accordance with AS 5100.1, unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
24	Specification of ramp gradient for pedestrian only subways (see Clause 13.12).	Refer AS 1428, or as required by the Director (Structures Design, Review and Standards).

No.	Issue	Application to project
25	Approval of cyclist path width and ramp gradients (see Clause 13.13).	Refer to the department's <i>Road Planning and Design Manual</i> Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6A: <i>Pedestrian and Cyclist Paths</i> . Project specific requirements shall be as specified in the design brief, project SWTC, or as agreed with the Director (Structures Design, Review and Standards).
26	Requirement for traffic barrier where the posted speed is 60 kph or less with a 300 mm min. height non-mountable kerb (see Clause 14.2).	In accordance with Section 4.10.11 of the <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief or project SWTC. Acceptance is subject to approval by the Director (Structures Design, Review and Standards).
27	Approval of a bridge traffic barrier based on performance evaluation of an existing barrier [see Clause 14.4(d)].	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. Acceptance subject to approval by the Director (Structures Design, Review and Standards).
28	Criteria for special performance barriers (see Clause 14.4).	Minimum height 1.8 m. Risk analysis to be undertaken with due consideration of AS 5100.1 and Section 4 of the department's <i>Road Planning and Design Manual</i> Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6: <i>Roadside Design, Safety and Barriers</i> . Project specific requirements shall be as specified in the design brief or project SWTC. Methodology subject to agreement with the Director (Structures Design, Review and Standards).
29	Alternative crash testing standards (see Clause 14.4).	Refer to Section 6 of the department's <i>Road Planning and Design Manual</i> , Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6: <i>Roadside Design, Safety and Barriers</i> . Project specific requirements shall be as specified in the design brief, project SWTC, or as agreed with the Director (Structures Design, Review and Standards).
30	Approval or nomination of traffic barrier performance levels [see Clause 14.5.1, Items (b) and (c)].	<u>New road bridges over railways</u> shall conform to railway requirements (QR documents Civil-SR-007), as modified in the <i>Design Criteria for Bridges and other Structures</i> , and be subject to approval by the Director (Structures Design, Review and Standards). <u>For all other new road bridges</u> , the minimum performance level is 'Regular'. The actual level shall conform to AS/(NZS) 5100, where a higher level is appropriate.

No.	Issue	Application to project
		<p>Safety in design considerations may require a higher performance level than 'Regular'.</p> <p>For design speed equal to or in excess of 80 km/h, bridges with a radius less than 400 m shall have 1500 mm minimum height 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 higher than 1000 mm for steel traffic barrier to prevent overturning on the barrier and loss of side friction on the pavement.</p> <p>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.</p> <p>Design of road approach barriers shall be in accordance with AS/NZS 3845 and the RPDM respectively.</p>
31	Necessity or appropriateness of upgrading of barriers for bridge rehabilitation (see Clause 14.5.1).	<p><u>Retrofit barrier over railways</u> shall conform to both Transport and Main Roads and the rail authority criteria subject to approval by the Director (Structures Design, Review and Standards).</p> <p><u>On widened bridges</u> 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 criteria current at the time. The following considerations shall be applied. Bridges with a repeated crash history of vehicle impacts or vehicles overturning shall be replaced by barriers conforming to AS/(NZS) 5100. Where AS/(NZS) 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 (Structures Review and Standards) for acceptance.</p> <p>Where a 'regular' level barrier or less is required by AS/(NZS) 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 14.5.1. 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 (Structures Design, Review and Standards) for acceptance.</p> <p>Note: Some existing barriers (concrete post with water pipe rails or concrete posts with balustrade) have little strength.</p> <p><u>Replacement of barrier damaged by vehicle impact, flood or due to bridge maintenance.</u></p> <p>Note: Some existing barriers (concrete post with water pipe rails or concrete posts with balustrade) have little strength.</p>

No.	Issue	Application to project
		<p><u>Replacement of barrier damaged by vehicle impact, flood or due to bridge maintenance.</u></p> <ul style="list-style-type: none"> The original barrier on the bridge would have been installed to the criteria current at the time of design. <p>The following action shall be undertaken:</p> <ul style="list-style-type: none"> The barrier should be replaced with a barrier conforming to AS(/NZS) 5100 if the existing deck has sufficient structural capacity to support the design load. Where AS(/NZS) 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 (Structures Design, Review and Standards) for acceptance. Where a 'regular' level barrier or less is required by AS(/NZS) 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 14.5.1. 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 the Director (Structures Design, Review and Standards) for acceptance. <p>Note: Some existing barriers (concrete post with water pipe rails and concrete posts with balustrade) have little strength.</p> <p><u>For timber decks</u>, which do not conform to the above, the matter should be referred to the Director (Structures Design, Review and Standards).</p> <p><u>Upgrading of existing traffic barriers on bridges</u></p> <p>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 existing barriers is uncommon. However, based on a risk assessment or adjacent accidents or near misses, it may be decided to upgrade a barrier.</p> <p>The following actions shall be undertaken:</p> <ul style="list-style-type: none"> The barrier would be replaced with a barrier conforming to AS(/NZS) 5100 if the existing deck has sufficient structural capacity to support the design load. Where AS(/NZS) 5100 would currently require a performance level higher than 'regular', the bridge shall be modified to provide a higher level of protection. <p>If impractical or uneconomic, applications for relaxation shall be submitted to the Director</p>

No.	Issue	Application to project
		<p>(Structures Design, Review and Standards) for acceptance.</p> <ul style="list-style-type: none"> Where a 'regular' level barrier or less is required by AS(/NZS) 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 14.5.1. The minimum strength for replacement rails is 50% of 'low' performance. If impractical or uneconomical, applications for a design relaxation shall be submitted to the Director (Structures Design, Review and Standards) for acceptance.
32	Specification of the provision of special performance barriers (see Clause 14.5.6).	<p>Project specific requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).</p> <p>As per AS 5100.1, and as required in the <i>Design Criteria for Bridges and other Structures</i>, a risk assessment shall be undertaken, the methodology and outcome of which will subject to agreement with, and acceptance by, the Director (Structures Design, Review and Standards).</p> <p>The minimum height shall be 1.5 m.</p>
33	Approval of alternative barrier profiles (see Clause 14.6.1).	<p>Single slope barriers of the type indicated in Figure 14.6.1(B) of AS 5100.1 are normally required, in accordance with Section 6 of the department's <i>Road Planning and Design Manual</i>, Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i>, Part 6: <i>Roadside Design, Safety and Barriers</i>.</p> <p>F-Type barriers as indicated by Figure 14.6.1(A) of AS 5100.1 are not preferred, and will only be accepted for short sections of new barrier connecting to existing F-Type barrier.</p> <p>Project specific requirements shall be as specified in the design brief or project SWTC.</p> <p>All barrier proposals are subject to approval by the department's Director (Structures Design, Review and Standards).</p>
34	Determination of the maximum height of the top of the sloping barrier face (see Clause 14.6.1).	<p>In accordance with AS(/NZS) 5100 and Section 6 of the department's <i>Road Planning and Design Manual</i>, Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i>, Part 6: <i>Roadside Design, Safety and Barriers</i>.</p> <p>Refer also to the department's Standard Drawing 1468.</p> <p>Minimum height shall be 1.1 m.</p> <p>The minimum height of 'Medium' and 'Special' barrier performance levels shall not be less than the minimum effective heights tabulated in AS 5100.2.</p>

No.	Issue	Application to project
35	Approval of alternative barrier post setback [see Clause 14.6.2(c)].	In accordance with AS 5100.1, Clause 14.6.2.
36	Approval of crashworthy traffic barrier or impact attenuation device (see Clause 14.6.4).	In accordance with Section 6 of the department's <i>Road Planning and Design Manual</i> , Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6: <i>Roadside Design, Safety and Barriers</i> .
37	Assessment of risk and determination of the level and form of collision protection (see Clause 15.1).	Generally, in accordance with the department's <i>Road Planning and Design Manual</i> , Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6: <i>Roadside Design, Safety and Barriers</i> , although minimum clear zone requirements apply. For new bridge supports refer to Section 4.10.12 and Appendix B of this <i>Design Criteria for Bridges and other Structures</i> . For existing bridge supports refer to Section 4.10.13 of this <i>Design Criteria for Bridges and other Structures</i> .
38	Determination of the minimum clearance of a pier or column from the roadway beyond which road traffic barrier protection will not be required (see Clause 15.2).	Generally, in accordance with the department's <i>Road Planning and Design Manual</i> , Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i> , Part 6: <i>Roadside Design, Safety and Barriers</i> , although minimum clear zone requirements apply. For new bridge supports refer to Section 4.11.12 and Appendix B of this <i>Design Criteria for Bridges and other Structures</i> . For existing bridge supports refer to Section 4.11.13 of this <i>Design Criteria for Bridges and other Structures</i> .
39	Approval for other than clear span between abutments for structures over rail (see Clause 15.3.2).	New bridges over railways shall conform to railway authority requirements (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>). Widened or refurbished bridges shall conform to both Transport and Main Roads and the rail authority criteria. Formal approval of the railway authority is required. Acceptance is subject to approval by the Director (Structures Design, Review and Standards).
40	Approval of a risk assessment and risk assessment methodology (see Clause 15.3.2).	Risk analysis to be undertaken with due consideration given to: <ul style="list-style-type: none"> • AS 5100.1, and • the railway authority requirements (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>). • Section 4 of the department's <i>Road Planning and Design Manual</i>, Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i>, Part 6: <i>Roadside Design, Safety and Barriers</i>. • Project specific requirements shall be as specified in the design brief or project SWTC.

No.	Issue	Application to project
		Assessment methodology and outcome are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).
41	Approval of the failure mode of frangible piers and the maximum deflection (see Clause 15.3.3).	Subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).
42	Approval to not protect piers using deflection walls (see Clause 15.3.4).	Subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).
43	Requirement to design abutments beyond 20 m from the centre-line of the nearest track for derailment collision protection (see Clause 15.3.5).	In accordance with AS 5100.1 unless required otherwise by either the railway authority or the department's Director (Structures Design, Review and Standards).
44	Approval of risk assessment for abutments located beyond 10 m and within 20 m from the centre-line of the nearest track (see Clause 15.3.5).	<p>Risk analysis to be undertaken with due consideration given to:</p> <ul style="list-style-type: none"> • AS 5100.1, and • railway authority requirements (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>). • Section 4 of the department's <i>Road Planning and Design Manual</i>, Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i>, Part 6: <i>Roadside Design, Safety and Barriers</i>. • Project specific requirements shall be as specified in the design brief or project SWTC. <p>Assessment methodology and outcome are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).</p>
45	Approval of alternative thickness for abutments located within 10 m from the centre-line of the nearest track (see Clause 15.3.5).	AS 5100.1 provisions are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority methodology (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>).
46	Approval not to use deflection walls in the specified locations (see Clause 15.3.6).	AS 5100.1 provisions are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority methodology (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>).
47	Specification of the length of a deflection wall (see Clause 15.3.6).	AS 5100.1 provisions are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority methodology (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>).

No.	Issue	Application to project
48	Determination of the requirements for concrete wall support in rail tunnels (see Clause 15.3.7).	AS 5100.1 provisions are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority criteria.
49	Required level of protection for structures on platforms (see Clause 15.3.7).	AS 5100.1 provisions are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority methodology (for example, QR documents Civil-SR-005, <i>Design of Buildings over or rear Railways</i> , and Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>).
50	Determination of the watercraft to be used for the pier collision forces, pier protection or pier-redundant superstructures (see Clause 15.4).	<p>The Harbour Master or port authority shall recommend the watercraft to be used for collision design purposes on the bridge, after due consideration of all vessels currently operating in the waterway or likely to operate in the waterway for the next 100 years. The Harbour Master or port authority shall nominate the extent of navigable channel required and where adjacent piers may be located, The Harbour Master or port authority shall nominate whether auxiliary structures are preferred.</p> <p>The proposed design watercraft and the pier arrangements shall be reviewed by department's Director (Structures Design, Review and Standards) and amended if necessary prior to acceptance by Transport and Main Roads.</p> <p>Concerning pier-redundant superstructures, Transport and Main Roads does not permit the collapse / removal of a pier) as an allowable design case, notwithstanding the superstructure does not collapse; consequently, paragraph 2 of Clause 15.4 of AS 5100.1 is deleted (refer Appendix B of this <i>Design Criteria for Bridges and other Structures</i>).</p> <p>The method of design for ship impact shall be based on one of the two following methods.</p> <p><u>Energy dissipation separate from bridge</u></p> <p>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 the 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.</p> <p>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.</p>

No.	Issue	Application to project
		<p><u>Impact on pier (or abutment)</u> Transport and Main Roads may in some cases permit the provision of a combined pier / abutment and fender system.</p>
51	Alternative barrier arrangements for the outside edge of a pedestrian or cyclist path (see Clause 16.2.2).	<p>Where cyclists are permitted to use the walkway on a bridge the barrier height from the walkway surface shall generally be 1.4 m, but may be a minimum 1.2 m, provided there are no compounding bicycle risk factors, such as tight curves, steep gradients, head on collision risks, or existential hazards to riders that could result in serious or fatal injury. Notwithstanding the height of the barrier, any safety railing intended to prevent cyclists colliding with the barrier shall be placed such that the rails are set at a height of 1.2 – 1.4 m from the walkway surface, dependant on a consideration of the principal user types and/or user mix on the facility.</p>
52	Requirements for pedestrian protection barriers over electrified rail (see Clause 16.3).	<p>Subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards). Design to consider railway authority technical requirements (for example, QR document Civil-SR-008, <i>Protection Screens</i>).</p>
53	Requirement for protection screens (see Clause 16.4).	<p>In accordance with the following relevant documents maintained by the Department of Transport and Main Roads:</p> <ul style="list-style-type: none"> • Policy – <i>Reduction of Risk from Objects Thrown from Overpass Structures onto Roads and Technical Guidelines for the Treatment of Overhead Structures – Objects thrown or dropped.</i> • Project specific requirements shall be as specified in the design brief or project SWTC. <p>Assessment methodology and outcome are subject to approval by the department's Director (Structures Design, Review and Standards).</p>
54	Minimum height of a protection screen [see Clause 16.4(c)(i)].	<p>3.5 metres, in accordance with Section 5.19 of the department's <i>Technical Guidelines for the Treatment of Overhead Structures – Objects thrown or dropped</i>, unless otherwise approved by the department's Director (Structures Design, Review and Standards).</p>
55	Alternative vertical clearances for a protection screen [see Clause 16.4(c)(iv)].	<p>As per AS 5100.1, although the minimum height of the barrier shall be 3.5 metres, in accordance with Section 5.19 of the department's <i>Technical Guidelines for the Treatment of Overhead Structures – Objects thrown or dropped</i>, unless otherwise approved by the department's Director (Structures Design, Review and Standards).</p>
56	Requirement for noise barriers (see Clause 17).	<p>Project specific requirements shall be as specified in the design brief or project SWTC.</p> <p>Design details are subject to approval by the department's Director (Structures Design, Review and Standards), with due consideration to Technical Specification MRTS15 <i>Noise Fences</i>.</p>

No.	Issue	Application to project
57	Requirements for drainage of road and rail bridges (see Clause 18.1).	For road bridges, as per AS 5100.1 and required in Section 4.9 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards). Rail bridge requirements are subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).
58	Permission for water to run onto the bridge (see Clause 18.1).	As per AS 5100.1 and required in Section 3.11 of this <i>Design Criteria for Bridges and other Structures</i> . Water flowing onto bridges shall be avoided as far as possible, unless project specific requirements are otherwise specified in the design brief, project SWTC, or as approved by the Director (Structures Design, Review and Standards).
59	Waterproofing of rail bridges (see Clause 18.3).	Subject to approval by both the railway authority and the department's Director (Structures Design, Review and Standards).
60	Permission to attach utility services (see Clause 20).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
61	Approval and provisions for method of attachment of utility services [see Clause 20(a)].	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
62	Determination that a bridge shall be designed for the effects of fire (see Clause 22).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
63	Determination of the fire time-temperature curve [see Clause 22(a)].	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
64	Approval of the design life for a sign or light structure (see Clause 23.2).	As required in Section 1.5.2 of this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements are otherwise specified in the design brief, project SWTC, or as approved by the Director (Structures Design, Review and Standards).
AS 5100.2 – Design loads		
1	Approval to vary any of the loads set out in the Standard, provided the provisions of AS 5100.1 are complied with (see Clause 1.2).	As required in this <i>Design Criteria for Bridges and other Structures</i> , unless project specific requirements or as otherwise specified in the design brief, project SWTC, or as approved by the Director (Structures Design, Review and Standards).
2	Design loads and factors for road bridges carrying rail traffic (see Clause 7.4).	The relevant rail authority, as per the AS 5100.2.
3	Load factors for centrifugal and braking loads from heavy load platforms (see Clause 7.10).	As per AS 5100.2, unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).

No.	Issue	Application to project
4	Approval of an analytical procedure for the distribution of road traffic loads through fill (see Clause 7.12).	As approved by the Director (Structures Design, Review and Standards).
5	Design loads for a pedestrian or cyclist bridge that is also used for maintenance, inspection or emergency vehicle access (see Clause 8.1).	Refer Appendix B in this <i>Design Criteria for Bridges and other Structures</i> , regarding the amendments to Clause 8.1(e) of AS 5100.2. Project specific. As approved by the Director (Structures Design, Review and Standards).
6	Design loads for rail bridges carrying cane rail traffic and/or other special applications (see Clause 9.1).	The relevant rail authority, as per AS 5100.2.
7	Approval to use the rational method for braking and traction forces (see Clause 9.7.2 and 9.7.2.3).	The relevant rail authority, as per AS 5100.2.
8	Bridge-specific design parameters to be used in applying the rational method for braking and traction forces (see Clause 9.7.2.3).	The relevant rail authority, as per AS 5100.2.
9	Approval of a risk analysis for road bridges designed with an alternative load path under collision load (see Clause 11.1).	As approved by the Director (Structures Design, Review and Standards).
10	Approval of a risk analysis for bridge supports located between 10 m and 20 m from the centre-line of a rail track (see Clause 11.4.2.4).	<p>New bridges over railways shall conform to railway authority requirements (for example, QR document Civil-SR-012, <i>Collision protection of Supporting Elements adjacent to Railways</i>).</p> <p>Widened or refurbished bridges shall conform to both Transport and Main Roads and the rail authority criteria.</p> <p>Formal approval of the railway authority is required.</p> <p>Acceptance is subject to approval by the Director (Structures Design, Review and Standards).</p>
11	Approval of a dynamic collision analysis (see Clause 11.4.4.2).	Rail bridges over road shall conform to railway authority requirements, as agreed with Director (Structures Design, Review and Standards).
12	Recommendation of the type of vessel, weight of vessel and speed of impact on a bridge for collision from waterway traffic, and approval of the proposed design vessel and speed (see Clause 11.6).	The Harbour Master or port authority shall recommend the type of vessel, weight of vessel and its speed of impact on the bridge. 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 department's Director (Structures Design, Review and Standards) and amended if necessary prior to acceptance by Transport and Main Roads.

13	Approval of the minimum equivalent static impact ship force applicable to piers in navigable waterways (see Clause 11.6).	<p>The minimum Equivalent Static Ship Impact Force applicable to bridges in navigable waterways shall be determined in accordance with the provisions of AS 5100.2, based on the type of vessel recommended by the relevant harbour master or port authority, and subsequently reviewed and accepted by the department's Director (Structures Design, Review and Standards).</p> <p>The Equivalent Static Ship Impact Force energy dissipation model adopted in design shall be described in detail in the design report.</p> <p>Concerning pier-redundant superstructures, Transport and Main Roads does not permit the collapse / removal of a pier) as an allowable design case, notwithstanding the superstructure does not collapse (refer Matter for Resolution No. 50 in AS 5100.1 of this Appendix).</p> <p>As outlined in Matter for Resolution No. 50 in AS 5100.1 of this Appendix), 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.</p> <p>Transport and Main Roads may in some cases permit the provision of a combined pier / abutment and fender system.</p> <p>Piers in the stream shall be designed for an Equivalent Static Ship Impact Force in accordance with the provisions of AS 5100.2.</p> <p>The bridge shall be proportioned and 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.</p> <p>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.</p> <p>Rubbing rails and fenders shall be provided to ensure no direct vessel contact on the pier / abutment.</p> <p>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.</p> <p>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.</p>
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No.	Issue	Application to project
		<p>The fender arrangement shall be acceptable to Transport and Main Roads and the Harbour Master or port authority.</p> <p>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.</p> <p>Protection of the bridge structure during the construction phase shall also be designed.</p>
14	Specification of the ultimate design load, load distribution length and minimum effective height for special barrier performance levels (see Clause 12.2.2 and 12.2.3).	In accordance with Appendix A, AS 5100.2, unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
15	Approval of a load transfer mechanism across a movement joint in a rigid barrier (see Clause 12.4.2).	In accordance with AS 5100.2, unless project specific requirements are otherwise specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
16	Approval of a detailed dynamic analysis (see Clause 13.2.3).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Design, Review and Standards).
17	Approval of a vibration assessment of a rail bridge, when required (see Clause 13.2.3).	Rail bridges over road shall conform to railway authority requirements, as agreed with Director (Structures Design, Review and Standards).
18	Bridge earthquake design category classification (see Clause 15.4.1).	<p>Project specific requirements shall be nominated in the design brief or project SWTC. Where no classification is so specified, a direction shall be sought from the department's Structures Directorate prior to commencing the design.</p> <p><u>BEDC-4</u> will generally only apply in special situations, for structures that are essential to post earthquake recovery, which may include, but need not be limited to:</p> <ul style="list-style-type: none"> • Major stream crossings (for example, Brisbane River, Burdekin River, Burnett River, Fitzroy River). • Bridges with tall piers (> 20 m) on an essential section of main road where there are no alternative detours, or a detour that is acceptable to the Deputy Chief Engineer (Structures). <p><u>BEDC-3</u> will generally be applied to bridges on main roads that are important to the efficient operation of the local community. In this context the definition of 'high volume' and 'high traffic volume' in Clause 15.4.1(b) of AS 5100.2 shall be viewed as relative to the population of the region under consideration and its economic importance to the state.</p> <p><u>BEDC-2</u> will apply to multi-span bridges where the allocation of a BEDC-3 or 4 classification is not considered appropriate.</p> <p><u>BEDC-1</u> will apply for single span bridges where the allocation of a BEDC-2 to 4 is not required.</p>

No.	Issue	Application to project
		Classifications are subject to approval by the department's Director (Structures Design, Review and Standards).
19	Approval of large items for flood impact (see Clause 16.7.3).	The Harbour Master, port authority, local government, or other waterway authority shall recommend the type of large floating items to be considered. The upper bound loads shall consider all items currently existing in the waterway or surroundings, or likely to appear in the waterway for the next 100 years. The velocity of impact shall be the flood velocity, and the design flood will be the one that is assessed to cause the worst effect, due consideration being given to the circumstances under which the objects become floating items. The proposed floating item, and its speed and point of impact, shall be reviewed by department's Director (Structures Design, Review and Standards) and amended if necessary prior to acceptance by Transport and Main Roads.
20	Construction design load criteria for other types of bridge construction (see Table 22.2.2).	The criteria for other types of incrementally launched bridges shall be subject to written agreement by the Director (Structures Design, Review and Standards).
21	Approval of the average recurrence interval for wind load on noise barriers and protection screens (see Clause 25.3.2).	Unless specified otherwise in a project specific design brief or SWTC, stand-alone noise barriers shall be designed in accordance with the provisions of Technical Specification MRTS 15 <i>Noise Fences</i> . All protection screens, and noise barriers attached to bridges or other structures shall comply with Clause 17.2 of AS 5100.2, unless the provisions of Clause 12.5 of AS 5100.2, causes a worse effect. Design details are subject to approval by the department's Director (Structures Design, Review and Standards).
AS 5100.3 – Foundation and soil-supporting structures		
1	Design requirements for foundations for overhead wiring structures (see Clause 1.2).	The design of foundations for electrified rail lines shall conform to the requirements of the relevant railway authority.
2	Detailed method and formulae to be used for the design of geotechnical or structural elements (see Clause 1.2).	Any alternative methods and/or formulae shall be as approved by the department's Director (Structures Design, Review and Standards).
3	Supervision of site investigation (see Clause 1.6).	As per AS 5100.3, where the term geotechnical engineer, as referred to in AS 5100.3, shall be understood to mean a Registered Professional Engineer of Queensland (RPEQ) Geotechnical Engineer.
4	Extent and coverage of preliminary and design investigation (see Clause 1.6).	As per AS 5100, with due consideration given to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .

No.	Issue	Application to project
5	Minimum number of boreholes (see Clause 1.6.2).	As per AS 5100, with due consideration given to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and its technical guideline <i>Geotechnical Borehole Logging</i> .
6	Selection of the geotechnical strength reduction factors (see Clause 2.3.5).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .
7	Testing requirements if design by prototype testing (see Clause 2.6).	As allowed in the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> . Otherwise, project specific requirements shall be as allowed in the design brief or project SWTC. Methodology subject to agreement with the Director (Structures Design, Review and Standards).
8	Requirement for consideration of future development (see Clause 2.8).	As allowed in the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> . Project specific requirements shall be as required in the design brief or project SWTC. Methodology subject to agreement with the Director (Geotechnical Engineering), and endorsed by the Director (Structures Design, Review and Standards), with due regard to the provisions of the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .
9	Other durability criteria (see Clause 4.1).	Unless specified otherwise in a project specific design brief or SWTC, durability criteria shall be in accordance with the provisions of this document.
10	Use of treated and untreated timber (see Clause 4.2).	Timber used in the refurbishment of existing timber bridges, under the jurisdiction of Transport and Main Roads, shall comply with the department's <i>Timber Bridge Maintenance Manual</i> . New timber bridges shall comply with AS 5100.9. In general, timber treated or otherwise is not permitted in new bridge foundations. Project specific exceptions shall be as required in the design brief or project SWTC. Design of timber foundations will be subject to agreement with the Director (Structures Design, Review and Standards), with due regard to the provisions of the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .
11	Requirements for prevention of corrosion of reinforcement (see Clause 4.3).	For electrified rail lines, the relevant rail authority. Otherwise, the appropriate electric power network authority. Expert advice will generally be required, and detailing subject to agreement with the Director (Structures Design, Review and Standards), with due regard to the provisions of the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .

No.	Issue	Application to project
12	Acceptance of rates of corrosion for steel surface (see Clause 4.4).	<p>As per AS 5100, where unprotected steel surfaces are permitted, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i>.</p> <p>Project specific requirements, where special requirements and/or site data is provided, shall be as required in the design brief or project SWTC.</p> <p>Design details for unprotected steel items will be subject to agreement with the Director (Structures Design, Review and Standards).</p>
13	Requirements to minimize corrosion effects on stray currents (see Clause 4.4).	<p>For electrified rail lines, the relevant rail authority.</p> <p>Otherwise, the appropriate electric power network authority.</p> <p>Expert advice will generally be required, and detailing subject to agreement with the Director (Structures Design, Review and Standards), with due regard to the provisions of the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i>.</p>
14	Durability requirements of other materials (see Clause 4.5).	Project specific approval by Director (Structures Design, Review and Standards) is required.
15	Design requirements for durability of materials used in shallow foundations (see Clause 5.3.6).	Project specific approval by Director (Structures Design, Review and Standards) is required.
16	Requirements for structural design and detailing for shallow footings (see Clause 5.4).	Project specific approval by Director (Structures Design, Review and Standards) is required.
17	Requirements for materials and construction for shallow foundations (see Clause 5.5).	Project specific approval by Director (Structures Design, Review and Standards) is required.
18	Bridges essential for post-disaster recovery (see Clause 6.3.2).	<p>Project specific requirements shall be nominated in the design brief or project SWTC. Where no classification is so specified a direction shall be sought from the department's Structures Directorate prior to commencing the design.</p> <p>The term 'essential for post disaster recovery' will be determined by consideration of numerous potential criteria including:</p> <ul style="list-style-type: none"> • whether the bridge traverses a major impediment to transportation, such as major stream crossings (for example, Brisbane River, Burdekin River, Burnett River, Fitzroy River) • the existence of alternative routes • the importance of the bridge in accessing emergency facilities, such as hospitals, communication centres, police stations, fire brigades • bridges on main roads that are important to the efficient operation of the community • bridges on routes that have economic importance to the state.

No.	Issue	Application to project
		Classifications are subject to approval by the department's Director (Structures Design, Review and Standards).
19.	Use of timber piles (see Clause 6.3.2).	<p>Timber used in the refurbishment of existing timber bridges, under the jurisdiction of Transport and Main Roads, shall accord with the department's <i>Timber Bridge Maintenance Manual</i>.</p> <p>In general, timber piles are not permitted in new bridge foundations under the jurisdiction of Transport and Main Roads.</p> <p>Project specific exceptions shall be as required in the design brief or project SWTC.</p> <p>Design of timber foundations will be subject to agreement with the Director (Structures Design, Review and Standards), with due regard to the provisions of the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i>.</p>
20	Requirements for durability of materials used (see Clause 6.3.4).	Project specific approval by Director (Structures Design, Review and Standards) is required.
21	Requirements for structural design and detailing for construction of piles (see Clause 6.4).	<p>Project specific approval by Director (Structures Design, Review and Standards) is required.</p> <p>For scour considerations refer to Section 3.11 of these <i>Design Criteria for Bridges and other Structures</i>.</p>
22	Requirements for materials and construction for piles (see Clause 6.5.1).	Project specific approval by Director (Structures Design, Review and Standards) is required.
23	Requirements for testing of piles (see Clause 6.6).	<p>Testing and certification of piles shall be in accordance with Transport and Main Roads Technical Specifications:</p> <ul style="list-style-type: none"> • MRTS63 <i>Cast-In-Place Piles</i> • MRTS63A <i>Piles for Ancillary Structures</i> • MRTS64 <i>Driven Tubular Steel Piles (with reinforced concrete pile shaft)</i> • MRTS65 <i>Precast Prestressed Concrete Piles</i> • MRTS66 <i>Driven Steel Piles</i> • MRTS68 <i>Dynamic Testing of Piles</i>.
24	Design requirements for durability of anchorages and anchorage components (see Clause 7.3.6).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
25	Requirements for materials and construction for anchorages (see Clause 7.4).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
26	Requirements for method of installation and on-site assessment tests for anchorages (see Clause 7.6.1).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .

No.	Issue	Application to project
27	Proof load test for anchors (see Clause 7.6.2).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
28	Requirements for anchorage suitability tests (see Clause 7.6.3).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
29	Requirements for anchorage acceptance tests (see Clause 7.6.4).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
30	Requirements for the design of retaining walls and abutments (see Clause 8.1).	In accordance with AS 5100, the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and complying with MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> .
31	Acceptance of geotechnical strength reduction factor for retaining walls and abutments (see Clause 8.3.1).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .
32	Design requirements for durability of retaining walls and abutments (see Clause 8.3.5).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and: <ul style="list-style-type: none"> • MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> • MRTS62 <i>Bridge Substructure</i>.
33	Requirements for structural design and detailing for retaining walls and abutments (see Clause 8.4).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and: <ul style="list-style-type: none"> • MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> • MRTS62 <i>Bridge Substructure</i>.
34	Requirements for materials and construction for retaining walls and abutments (see Clause 8.5).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and: <ul style="list-style-type: none"> • MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> • MRTS62 <i>Bridge Substructure</i>.
35	Approval of drainage system for retaining walls and abutments (see Clause 8.6).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and: <ul style="list-style-type: none"> • MRTS03 <i>Drainage, Retaining Structures and Protective Treatments</i> • MRTS62 <i>Bridge Substructure</i>.
36	Requirements for the design of buried structures (see Clause 9.1).	As per AS 5100, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .

No.	Issue	Application to project
37	Design requirements for the durability of materials (see Clause 9.3.3).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and Transport and Main Roads Technical Specifications.
38	Requirements for structural design and detailing for buried structures (see Clause 9.4).	As per AS 5100.3, except where otherwise required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> .
39	Requirements for materials and construction for buried structures (see Clause 9.5).	In accordance with to the provisions required by the department's manual <i>Geotechnical Design Standard - Minimum Requirements</i> , and Transport and Main Roads Technical Specifications.
AS 5100.4 – Bearings and deck joints		
(i)	Approval to exceed the nominated maximum compressive stresses on ASM at the ULS (see Clause 14.2).	Project specific approval by Director (Structures Design, Review and Standards) is required.
(ii)	Reduction factor applicable to the allowable bearing pressure where the bearing temperature may exceed 35°C (see Clause 14.2).	Project specific approval by Director (Structures Design, Review and Standards) is required.
(iii)	Approval to exceed the nominated maximum compressive stresses at the ULS on effective contact area ASM sliding surfaces (see Clause 15.3).	Project specific approval by Director (Structures Design, Review and Standards) is required.
(iv)	The range of velocities at which the axle shall be stepped over the joint for Method 3 (see Clause 20.3.8).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
AS 5100.5 - Concrete		
(i)	Additional acceptance criteria on ductility (see Clause 1.2(d)(v)).	Not permitted.
(ii)	Combinations of supplementary material as constituents within cementitious materials (see Clause 1.4.3.10).	Permitted in accordance with the provisions of: <ul style="list-style-type: none"> • MRTS70 Concrete.
(iii)	Acceptance of the use of alternative materials, methods of design or construction (see Clause 1.9).	Not permitted.
(iv)	Approval of alternative concrete mix for durability (see Clause 4.4.1).	Permitted in accordance with the provisions of: <ul style="list-style-type: none"> • MRTS70 Concrete.
(v)	Approved use of special purpose cement as defined in AS 3972 on its own (see Table 4.4.1; Note 3).	Approved concrete mixes and minimum concrete strengths shall comply with the provisions of: <ul style="list-style-type: none"> • MRTS70 Concrete.
(vi)	Permission to use curing compounds (see Clause 4.4.2.3).	Permitted in accordance with the provisions of: <ul style="list-style-type: none"> • MRTS70 Concrete.

No.	Issue	Application to project
(vii)	Requirements for concrete for Exposure Classification U (see Clause 4.5).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
(viii)	Approval of test method for alkali aggregate reactivity (see Clause 4.10).	Aggregate shall comply with the provisions of: • MRTS70 <i>Concrete</i> .
(ix)	Approval to adopt prescribed requirements for alkali reactive aggregates (see Clause 4.10).	Aggregate shall comply with the provisions of: • MRTS70 <i>Concrete</i> .
(x)	Determination whether a bridge is required to be designed for fire resistance, the type of fire load to be applied, and fire resistance rating as applicable (see Clause 5.1).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
(xi)	Determination that a non-hydrocarbon design fire resistance is required (see Clause 5.3).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
(xii)	Request to supply the CE label and current 'Certificate of Conformity for steel fibres used in SFRC' (see Clause 16.7.1).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
(xiii)	Acceptance of the means adopted for the repair of inactive cracks (see Clause 17.3.2).	As required in Section 3.15 of this <i>Design Criteria for Bridges and other Structures</i> , or as approved by the Director (Structures Design, Review and Standards).
(xiv)	Requirement for project assessment in accordance with AS 1379 (see Clause 17.3.6.1).	The applicable 'project specification' shall be the: • MRTS70 <i>Concrete</i> .
(xv)	Acceptance of hardened concrete liable to rejection (see Clause 17.3.6.1).	Acceptance and rejection of hardened concrete shall comply with the provisions of: • MRTS70 <i>Concrete</i> .
(xvi)	Additional requirements for the sampling and testing, sample size, and frequency of routine testing for bar chairs and spacers (see Clause 17.4.5.2).	In accordance with the provisions of: • MRTS70 <i>Concrete</i> .
(xvii)	Approval of permeability testing for concrete bar chairs and spacers (see Clause 17.4.5.2).	In accordance with the provisions of: • MRTS70 <i>Concrete</i> .
(xviii)	Requirement for certification of testing for the quality and properties of anchorages (see Clause 17.5.1.2).	In accordance with the provisions of: • MRTS89 <i>Post-Tensioned Concrete</i> .
(xix)	Approval for Appendix A to take precedence over AS 5100.7 (see Clause A1).	Project specific. Subject to agreement with Director (Structures Design, Review and Standards).
(xx)	Approval to use the values obtained by non-destructive testing directly to assess some properties of concrete (see Clause A6.3).	Project specific. Generally not permitted. Subject to agreement with Director (Structures Design, Review and Standards).

No.	Issue	Application to project
AS/NZS 5100.6 – Steel and composite construction		
1	Requirements for bridges, members and materials specified in Items (a) to (d) of Clause 1.2, and for new and unusual bridges (see Clause 1.3).	Project specific requirements as agreed with the department's Director (Structures Design, Review and Standards) in accordance with the <i>Design Criteria for Bridges and other Structures</i> .
2	Design requirements for structural elements using non-ferrous metals (see Clause 1.3).	Project specific approval by Director (Structures Design, Review and Standards) is required.
3	Requirements for steels for machined parts and for uses in other than structural member or elements (see Clause 2.2.4).	Project specific approval by Director (Structures Design, Review and Standards) is required.
4	Requirements for structures, members and materials (see Clause 1.2).	Project specific requirements as agreed with the department's Director (Structures Design, Review and Standards) in accordance with the <i>Design Criteria for Bridges and other Structures</i> .
5	Requirements for the fatigue design assessment method (see Clause 13.6).	Project specific approval by Director (Structures Design, Review and Standards) is required.
Part 7 – Bridge Assessment		
1 to 34	Bridge Assessment is outside the scope of these criteria, and is covered by other departmental documentation.	Project specific advice by Director (Structures Management) is required.
Part 8 – Rehabilitation and strengthening of existing bridges		
1	Life expectancy of the particular rehabilitation or strengthening method and materials (see Clause 2.1).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
2	Design live loading including the use of BSALL (see Clauses 2.3.1, 2.3.2 and Paragraph E1, Appendix E).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
3	Procedure to measure distribution of carbonation depths using aqueous phenolphthalein solution (see Clause 3.2.5).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
4	Suitability of a structure for CP system installation (see Clause 3.3).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
5	Depth and extent of concrete removal for repair (see Clause 3.5.3.4.2).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
6	Use of encapsulation paints (see Clause 4.5.2).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).

No.	Issue	Application to project
7	Use of non-metallic materials for bolted anchorages of deck joints [see Clause 8.4.1(i)].	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
8	The need to upgrade or replace traffic barriers (see Clause 9.5).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
9	Design standard and return intervals for the modification of an existing culvert (see Clause 10.2.3).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
10	Pull off test results where mean bond strengths are less than 1.5 MPa (see Paragraph A4.3.4).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
11	Assessment of material performance data and design values for fibre fabric, laminates and adhesive resins (see Paragraph A4.3.5.1, Appendix A).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
12	Alternative design methods for assessment of the capacity of an FRP strengthened beam.	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).
13	Power source for the operation and maintenance of CP systems (see Paragraph B11, Appendix B).	Project specific. Requirements as specified in the design brief, project SWTC, or as required by the Director (Structures Management).

Appendix B: Additional requirements to AS(/NZS) 5100

Note: Part and clause numbers hereunder refer to AS(/NZS) 5100.

Preface	
<p>Add the following paragraph.</p> <p>Any errors or anomalies in AS(/NZS) 5100 shall be discussed with the Deputy Chief Engineer (Structures) for clarification or for amendment to this document.</p>	
Part 1: Scope and general principles	
	<p>Clause 14.5.2 No barrier</p> <p>Replace this clause with the following:</p> <p>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:</p> <ul style="list-style-type: none"> • 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 • No pedestrian / cycle traffic is anticipated • 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, and • where a risk assessment has been undertaken and it has been agreed with the Director (Structures Design, Review and Standards) that barriers are not to be provided.
	<p>Clause 14.6.3 Bridge approaches</p> <p>Paragraph 2 of this clause is deleted and replaced with the following:</p> <p>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:</p> <ul style="list-style-type: none"> • 1 in 10 in the horizontal plane • 1 (V) to 10 (H) in the vertical plane <p>for the barrier components, and a maximum taper of 1 in 20 for kerb discontinuities. Frangible attachments are defined as having a maximum section dimension 90 mm and 5 mm wall thickness for square, rectangular or circular section based on AS/NZS 1163, and shall have a maximum taper of:</p> <ul style="list-style-type: none"> • 1 in 10 in the horizontal plane • 1 (V) to 2 (H) in the vertical plane.
	<p>Clause 15.4 Collision from waterway traffic</p> <p>Paragraph 2 of this clause is deleted.</p>

Part 2 – Design loads																	
	<p>Clause 7.3 Heavy load platform</p> <p>The heavy load platform design load for bridges shall be HLP 400. Any reference to HLP 320 shall be deleted.</p> <p>The lateral placement of the HLP 400 on a one lane ramp shall be positioned to create the worst effect, with due consideration given to the most likely path of the vehicle.</p> <p>In the case of widening of an existing bridge, the <u>existing part</u> of a widened bridge may have been designed for HLP loading less than HLP 400, or no HLP loading. The <u>widening</u> shall be designed for HLP 400 loading if structurally possible. It may also be necessary, if required, to consider a replacement structure to provide HLP 400 loading in each direction on priority mass routes.</p> <p>The location(s) of the HLP 400 considered during design shall be shown on the project drawings.</p>																
	<p>Clause 8.1 Pedestrian and cyclist path loads</p> <p>To Subclause 8.1(e) concerning maintenance, inspection or emergency vehicles add the following paragraphs:</p> <p>Consideration of how inspection and maintenance will be achieved shall be undertaken.</p> <p>If it is proposed that inspection and maintenance will be achieved by vehicle access from the bridge, the design vehicle, including axle loads and dimensions, shall be indicated on the project drawings.</p> <p>If the trafficable width of a bridge, accessible by an inspection or maintenance vehicle, is greater than 3.5 metres, the minimum inspection and maintenance truck loading shall be an M13.5 truck as defined in Figure 8.1(e).</p> <p>Where the trafficable width of a bridge, accessible by an inspection or maintenance vehicle, is between 3.0 and 3.5 metres, the minimum inspection and maintenance truck loading is an M9 truck where the M9 load is 50% of an M18 truck as defined in Figure 8.1(e).</p> <p>Figure 8.1(e) - M Class trucks</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Designation</th> <th>Designation</th> <th>Rear axle load</th> <th>Total mass <i>M</i></th> </tr> </thead> <tbody> <tr> <td>M18</td> <td>36 kN</td> <td>144 kN (Note 1)</td> <td>18 t</td> </tr> <tr> <td>M13.5</td> <td>27 kN</td> <td>108 kN</td> <td>13.5 t</td> </tr> <tr> <td>M8</td> <td>18 kN</td> <td>72 kN</td> <td>8 t</td> </tr> </tbody> </table> <p style="text-align: center;">Length of contact with deck = 100 mm for front wheel = 200 mm for rear wheel</p> <p style="text-align: center;">Load lane width = 3 m</p> <p style="text-align: center;">Kerb</p> <p style="text-align: center;">0.8 1.8 0.8 Except as specified in Paragraph A2.4.8</p>	Designation	Designation	Rear axle load	Total mass <i>M</i>	M18	36 kN	144 kN (Note 1)	18 t	M13.5	27 kN	108 kN	13.5 t	M8	18 kN	72 kN	8 t
Designation	Designation	Rear axle load	Total mass <i>M</i>														
M18	36 kN	144 kN (Note 1)	18 t														
M13.5	27 kN	108 kN	13.5 t														
M8	18 kN	72 kN	8 t														

	<p>Where a bridge is designed for an inspection or maintenance vehicle, the balustrades for the bridge shall be appropriately designed, to ensure sufficient robustness.</p> <p>Where emergency vehicle access is considered necessary to a pedestrian or cyclist bridge, the design vehicle shall be an M9 truck where the M9 load is 50% of an M18 truck as defined in Figure 8.2, unless more definitive data is obtained by consultation with the appropriate ambulance, police and/or fire services.</p> <p>Figure 8.1 – Pedestrian and cyclist path loads</p> <p>The reference to ‘For pedestrian and cyclist paths attached to the road or railway bridge superstructure’ shall be interpreted as follows:</p> <ol style="list-style-type: none"> 1. The ‘walkways attached’ design load curve shall be considered with simultaneous traffic loads, and 2. The ‘independent’ design load curve shall be applied to an attached walkway without no simultaneous traffic load. <p>The load case adopted, for the purposes of Clause 8.1(a), shall be the one that causes the worst effect.</p>
	<p>Clause 11.2 Collision load from road traffic</p> <p>Add the following:</p> <p>This clause is intended to apply for any support element within a road reserve.</p> <p>Reference to <i>Austroads Guide Road Design</i> (Part 3) shall be understood to mean the department’s:</p> <ul style="list-style-type: none"> • <i>Road Planning and Design Manual</i> Edition 2: Volume 3 • <i>Supplement to Austroads Guide to Road Design</i> • Part 6: <i>Roadside Design, Safety and Barriers</i>. <p>(A) Protection of bridge supports within the 10 m clear zone</p> <p>Bridge supports that are within the minimum clear zone (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 80 km/h as a minimum barrier requirement complying with the requirements of Clause 12.2 of AS 5100.2 with appropriate approach treatment. The barriers shall be designed so as to not transmit the barrier design load to the bridge supports. However, the design barrier performance level shall be determined using the barrier selection method in AS/NZS 3845 and the department’s <i>Road Planning and Design Manual</i> Edition 2: Volume 3 <i>Supplement to Austroads Guide to Road Design</i> Part 6: <i>Roadside Design, Safety and Barriers</i>. The design performance level of the barrier may be greater than TL5, depending on the results of the barrier selection method.</p> <p>A rigid reinforced concrete barrier shall be used unless there are drainage considerations that require 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.</p> <p>A rigid barrier is refined 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.</p> <p>Guardrail, W beam, Thrie beam and wire rope barriers are not permitted.</p> <p>The protection barrier shall extend at least 6 m beyond the end of the protected structure in both directions, or longer if required by the risk assessment, and a transition provided to standard road barrier for continuation to the total length. For road safety requirements, the barrier alignment and total length of barrier shall be in accordance with the department’s <i>Road Planning and Design Manual</i> Edition 2: Volume 3, <i>Supplement to Austroads Guide to Road Design</i>, Part 6: <i>Roadside Design, Safety and Barriers</i>.</p>

(B) Protection of bridge supports outside the 10 m clear zone

For the protection of bridge supports, which fall 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.

The selection of barrier type is subject to the results of a risk analysis, taking into account the modification factor for horizontal curve, slopes and so on in *Road Planning and Design Manual* Edition 2: Volume 3, *Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*.

The minimum acceptable barrier is the G9 (modified) Thrie beam.

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

The protection barriers shall extend at least 6 m beyond the end of the protected structure in both directions, or longer if required by the risk assessment, and a transition provided to standard road barrier for continuation to the total length.

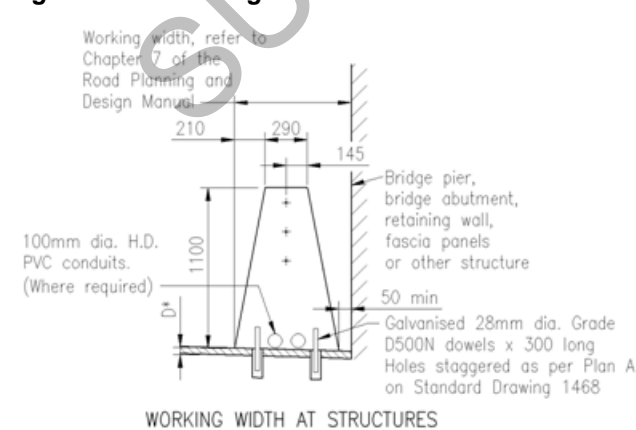
For road safety requirements, the barrier alignment and total length of barrier shall be in accordance with the department's *Road Planning and Design Manual* Edition 2: Volume 3, *Supplement to Austroads Guide to Road Design, Part 6: Roadside Design, Safety and Barriers*.

Working width

The working width behind the barrier front face corresponds to the region where an impacting vehicle may extend during a collision incident. To ensure that bridge supports are not subjected to vehicle impact loads that cause their collapse, the estimate of working width shall take into account both the dynamic deflection of the barrier and an assessment of body roll of a high vehicle striking the barrier (refer to Figure 7.8.3 in this document), and accord with the Transport and Main Roads *Road Planning and Design Manual*, Edition 2, Volume 3: *Supplement to Austroads Guide to Road Design, Part 6: Roadside Design Safety and Barriers*.

The motorway cross section and alignment should be adjusted if necessary to satisfy these 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 11.2 shows the acceptable arrangement of extruded barrier. Extruded barrier and its ground embedment shall be in accordance with the department's Standard Drawing 1468 *Single slope concrete barrier - Extruded median barrier - Barrier, reinforcing and expansion joint details*. The minimum distance detailed is only applicable for rigid barriers.

Figure 11.2 Working width at structures

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.

	<p>Clause 12.5 Pedestrian and cyclist path barrier load</p> <p>The design of pedestrian railing loads without panic loads shall conform to either:</p> <p>a) Clause 12.5, or</p> <p>b) Transport and Main Roads Standard Drawings for steel and aluminium balustrade.</p>
	<p>Clause 24.2 ULS design</p> <p>In (a) and (b) delete Clause 21.1 and insert Clause 23.1.</p>

Part 3 – Foundations and soil supporting structures	
	No requirements

Part 4 – Bearings and deck joints	
	No requirements

Part 5 - Concrete	
	<p>Amendment No. 1 to AS 5100.5:2017/2018-11-12</p> <p>This amendment shall be adopted.</p>
	<p>Additional requirements to AS 5100.5 for prestressed members:</p> <ul style="list-style-type: none"> • maximum compressive stress at transfer: $0.6f_{cp}$ (in accordance with Clause 8.1.6.2), and • maximum compressive stress at all other times: $0.4f'_c$.
	<p>In relation to Clause 1.2(a)(i), the maximum characteristic compressive strength at 28 days (f'_c) shall be 65 MPa, rather than 100 MPa, unless approved otherwise by the Department of Transport and Main Roads.</p>
	<p>Concerning Clause 3.1.8.3</p> <p>Where precast, prestressed concrete elements are steam cured, in accordance with Technical Specifications MRTS70 <i>Concrete</i> and MRTS73 <i>Manufacture of Prestressed Concrete Members and Stressing Units</i>, the age of concrete at the time of loading, for the purposes of determining k_3, to be used in Equation 3.1.8.3, may be taken as seven days.</p>
	<p>Concerning Table 3.3.1</p> <p>All 7 wire ordinary strand used in PSC elements shall comply with the requirements of Section 4.8.1.6 in this document.</p>
	<p>In NOTE 2 for Table 4.3, after ‘... this Standard’ insert ‘, unless approved otherwise by the Department of Transport and Main Roads’.</p>
	<p>Technical Specification MRTS70 <i>Concrete</i>, maintained by the Department of Transport and Main Roads, takes precedence over the following provisions of AS 5100.5:</p> <ul style="list-style-type: none"> • Table 4.4.1(A) • Table 4.4.1(B) • Table 4.4.1(C) • Clause 4.4.2 • Clause 4.10.
	<p>In Clause 4.12, last line (before the NOTE) replace 20°C with 25°C to align with Technical Specification MRTS70 <i>Concrete</i>, maintained by the Department of Transport and Main Roads.</p>

	Concerning Table 4.13.1 , the values of chloride ion content provided shall not be adopted, and instead the provisions of Technical Specification MRTS70 <i>Concrete</i> , maintained by the Department of Transport and Main Roads, shall apply.
	In Table 4.14.3.2 , NOTE 1, the increase in cover, where curing compounds are used, need not be applied.
	In Table 4.14.3.3 , NOTE 1, the increase in cover, where curing compounds are used, need not be applied for PSC products.
	Clause 8.6.2.1 General Delete Clause 8.6.2.1(b) and insert the following: (b) in the case of HLP 400 loading only, the increment in steel stress near the tension face shall be limited to that given in Table 8.6.2.1, as the load increases from its value when the extreme concrete tensile fibre is at zero stress to the SLS load combinations values.
	Clause 10.7.4.1 General requirements In (a) Single bars - After the sentence 'Where ... do not apply' add the following: Columns designed with $N^* < 0.5 \varnothing N_u$ must be provided with the following minimum lateral restraints: <ul style="list-style-type: none"> • at least every sixth longitudinal bar must be restrained in accordance with Clause 10.7.4.2 to 10.7.4.4 of AS 5100.5 and the horizontal distance between laterally restrained bars must not exceed 1000 mm, and • the vertical spacing of lateral restraints must not exceed 600 mm. After (b) and the sentence 'Bundled bars, ... bars', add the following: c) the provisions of Clause 10.7.6 of AS 5100.5 for earthquake resistance take precedence over and may override the above requirements.
	Technical Specification MRTS70 <i>Concrete</i> , maintained by the Department of Transport and Main Roads, takes precedence over the following provisions of AS 5100.5: <ul style="list-style-type: none"> • Clause 17.3.1 • Clause 17.3.6.2 • Clause 17.3.7.1 • Clause 17.3.7.2.
	Clause 17.3.7.2 is accepted, subject to adherence with the additional requirements of Technical Specification MRTS70 <i>Concrete</i> , maintained by the Department of Transport and Main Roads.

Part 6 – Steel and composite construction

No additional requirements.

Part 7 – Bridge assessment

No additional requirements.

Part 8 – Rehabilitation and strengthening of existing bridges

No additional requirements.

Part 9 - Timber

No additional requirements.

SUPERSEDED