Chapter 8 Structures

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8.1 Introduction

1. This chapter outlines the following for structures:
2. design and construction standards;
3. advice about satisfying assessment benchmarks in the planning scheme.
4. This chapter applies to design and construction of the following:
5. bridges;
6. culverts;
7. tunnels;
8. earth retaining structures;
9. elevated structures;
10. water access structures;
11. sea- and river wall structures;
12. fences.
13. The purpose of this chapter is to ensure consistent, best value, whole-of-life design outcomes for these structures and assets, and to achieve the following outcomes:
14. the entire completed structure is safe, flood resistant, aesthetically pleasing, functional and easy to maintain without the need for specialised techniques, plant, skills or equipment not readily available in South East Queensland;
15. the structures are designed and detailed to ensure maintenance costs do not exceed on average 1% of asset value per annum including operational maintenance, and maintenance can be carried out without significant noise, disruption or nuisance to users or adjoining property owners;
16. all structures have an attractive appearance appropriate to their general surroundings and any adjacent structures;
17. retaining walls and wing walls use simple, straight or large radius curved alignments sympathetic to the road alignment and interfaces with adjoining development, pathways, structures and environmental features;
18. retaining walls conform to a consistent modular pattern, with emphasised vertical joints.
19. Common requirements for any structure are:
20. fixings for retaining structures are concealed or integrated as a design feature;
21. unless a feature of the architectural design (for earth retaining structures) all structures are of uniform colour and surface finish, even after repair;
22. colours are chosen from the standard colour palate;
23. anti-graffiti coatings are not used.

8.2 Bridges

8.2.1 Design principles

1. This section outlines the design specifications, guidelines and standards in relation to the design and construction of bridges.
2. The design and construction of bridges aligns with the following principles:
3. structural design is based on proven methods, materials and technology;
4. all structures present smooth, clean lines with minimum structural depth consistent with their spans and method of construction;
5. the design of bridges addresses the slenderness of the structure and considers the effects of the parapets and all other elements of the structure.

8.2.2 Design specifications and guidelines

1. All bridges and associated elements are:
2. designed in compliance with the following:
3. [AS 5100.3 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/details.aspx?ProductID=320873);
4. [AS/NZS 3845:1999 Road safety barrier systems](https://infostore.saiglobal.com);
5. [AS 1428.1-2009 Design for access and mobility - General requirements for access - New building work](http://infostore.saiglobal.com);
6. [Guide to Road Design Practice (Austroads](http://www.austroads.com.au));
7. [Waterway Design. A guide to the Hydraulic Design of Bridges, Culverts and Floodway’s (Austroads, 1994)](http://www.austroads.com.au/);
8. [Chapter 12](Ch12PublicRiversideFacilities.docx) of this planning scheme policy;
9. [Department of Transport and Main Roads](http://www.tmr.qld.gov.au/) specifications (as appropriate).
10. designed by a [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld).
11. Where the above references are silent in relation to specific standards or technical requirements, compliance is with one of the following technical publications:
12. British Standards (BS 5400);
13. American Standards (AASHTO LRFD);
14. European Standards (Euro codes).
15. In addition to [AS 5100](http://infostore.saiglobal.com/store/details.aspx?ProductID=320873), bridges over railways are designed in compliance with all of the following standards:
16. [Queensland Rail — Design of road overbridges](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Guide-to-development-in-a-transport-environment-rail.aspx);
17. [Queensland Rail — Work in or about Queensland Rail Property](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Guide-to-development-in-a-transport-environment-rail.aspx);
18. [Queensland Rail — Requirements for work on or near high voltage overhead line equipment](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Guide-to-development-in-a-transport-environment-rail.aspx) and low voltage services;
19. [Queensland Rail — Standard Drawing 2754 Standard Clearances](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Guide-to-development-in-a-transport-environment-rail.aspx) (unless formally agreed otherwise by both Queensland Rail and Council).

8.2.3 Design life

1. All bridges and associated elements are designed to achieve the minimum design life in [Table 8.2.3.A](#Table8p2p3A) without major maintenance or replacement of elements, whilst remaining safe and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset which it forms a part.
3. A replacement methodology is specified for components that have life shorter than the structure design life.

Table 8.2.3.A— Minimum required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Bridge structures and roadway support structures including underpasses | 100 years |
| Reinforced embankments, retaining walls, including reinforced soil structures | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management and control systems | 100 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Roadway noise barriers and architectural or structural noise attenuation devices | 40 years |
| Signage support structures, roadside barriers and other roadside furniture | 40 years |
| Tolling system structures, gantries and other equipment structures | 40 years |

Note—Widened bridges are assumed to have durability assessment of 100 years for the widened portion only.

8.2.4 Durability

8.2.4.1 Minimum requirement

A bridge and its associated works meet the following minimum requirements for durability.

8.2.4.2 Exposure classification

A bridge is designed to comply with the AS 5100 exposure classification specified in [Table 8.2.4.2.A](#Table8p2p4p2A).

Table 8.2.4.2.A— Minimum required exposure classifications

|  |  |
| --- | --- |
| Structure | Minimum required exposure classification |
| Above ground structures (bridge superstructure, pier column and headstocks, barriers) | B2 |
| Structures cast against ground | B2 |
| Structures in saline water and tidal zones | C |
| Structures in aggressive ground water | C |

8.2.4.3 Concrete durability

1. Minimum concrete strengths and associated nominated concrete covers comply with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com) to suit the required exposure classification.
2. Cover spacers or permanent fixings are incorporated within the concrete covers zone and are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structures design life.

8.2.4.4 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and is of suitable grade to resist corrosion or protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
2. At the end of that maintenance-free life, the coating remains soundly adhered to the metal substrate and suitable for overcoating without removal. The minimum surface preparation complies with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and is of suitable grade to resist corrosion or protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.

8.2.4.5 Structural steel durability – steel girder bridges

1. Steel girder bridges are not used over or immediately adjacent to salt water or where they may be inundated by brackish water in less than a 100 year [ARI](Appendix1IndexGlossary.docx) flood.
2. Where steel girder bridges are used, all steel surfaces are protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and is of suitable grade to resist corrosion or protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
3. Internal areas too small to paint and repaint during maintenance are sealed and filled with either an inert gas or a water-absorbing product, such as Corroless.
4. Bolts are provided with tabs to monitor internal condition for all sealed sections.
5. Coating systems are capable of being repainted by brush.
6. A trial test panel is undertaken before repainting steel box girder bridges.
7. Coating systems are applied in compliance with the manufacturer’s specifications.

8.2.4.6 Timber durability

1. Timber girders are not used for a bridge.
2. Timber decking is not used for a bridge.

8.2.4.7 Miscellaneous components durability

1. Structures are designed to enable items such as bearings, expansion joint seals, railings and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.2.5 Widening

1. If future widening of a bridge may be required, allowance is made in design for connection of the future widening and wherever possible, the connection is designed and constructed to minimise or eliminate the need to alter the parent structure.
2. A structure does not include exposed reinforcement or fixings that project from the structure in anticipation of a future widening.
3. The widening of any existing structures provides a structural solution that is consistent with the existing structure in terms of stiffness, fixity, continuity and appearance.
4. The effects of the widening on the capacity of the existing structure are considered and the existing structure strengthened as required to ensure no reduction in vehicle capacity.
5. Articulation of any widened bridge is consistent with existing bridge articulation.

8.2.6 Minimum clearances

Minimum vertical clearances for bridges are complaint with [Table 8.2.6.A](#Table8p2p6A).

Table 8.2.6.A—Minimum vertical clearances

|  |  |
| --- | --- |
| Location | Minimum clearance |
| Road overbridges – general |
| Structures over Council roads infrastructure | 5.5m |
| Structures over Department of Transport and Main Roads infrastructure | As required by [Standard specification roads](http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Standard-specifications-roads.aspx) |
| Pedestrian only pathways | 2.5m |
| Shared pathways or cycle pathways | 2.7m |
| Structures over or near Queensland Rail infrastructure | As required by [Guide for development in a railway environment](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Guide-to-development-in-a-transport-environment-rail.aspx) |

8.2.7 Separate carriageways

1. Bridges located on separate carriageways are designed as stand-alone structures and are not connected to bridges located on adjacent carriageways.
2. A minimum horizontal clearance of 50mm is maintained at all times between bridges.

8.2.8 Joints

1. Expansion joints are minimised or ideally avoided in the design.
2. Where unavoidable, expansion joints comprise steel nosings and waterproof flush neoprene seals.
3. All other joints (e.g. joints between pre-cast element and construction joints) are waterproofed.

8.2.9 Deck drainage

1. Deck drainage is in compliance with section 14 of [AS 5100.1-2004 Bridge Design](http://infostore.saiglobal.com/store/details.aspx?ProductID=320873).
2. Drainage from overbridges is not discharged into watercourses, onto railway lines, traffic lanes or shared use paths or footpaths below the bridge.
3. Drainage pipes are fire resistant and meet the durability requirements of this performance specification. The minimum diameter of scuppers is 150mm and the minimum diameter of drainage pipe is 200mm.
4. Parapets have a top surface that angle towards the road by a minimum of 2.5° to channel rainwater onto the bridge to minimise staining of the outside parapet face. To conceal any drainage or service pipes, the parapet must hang below the underside of the bridge deck slabs and girder flanges if applicable by a minimum of 100mm.

8.2.10 Bearings

1. The bearings on widened bridges are compliant with current standards and similar to the existing type in the bridge. All steelwork are hot dip galvanised to the standard in [AS/NZS 4680:2006 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles](http://infostore.saiglobal.com).
2. The condition of existing bearings, and their impact on the performance of a widened bridge, are considered and addressed.
3. Bearings for new girder bridges are designed and constructed for ease of replacement during the life of the bridge. 'Ease of replacement' is considered as placing a jack on the bearing shelf and jacking against the girder or diaphragm, using normal height commercially hired jacks.
4. Elastomeric bearings are in compliance with [DIN EN ISO 1523 (2002-08) Determination of flash point - Closed cup equilibrium method (ISO 1523:2002)](http://infostore.saiglobal.com).
5. All elastomeric bearings are in a 10mm recess, and where located within 1km of salt water the retraining plates are stainless steel.
6. All other types of bearings and fixings are marine grade stainless steel.

8.2.11 Bridge barriers

8.2.11.1 General

1. All bridges require standard [Department of Transport and Main Roads](http://www.tmr.qld.gov.au) bridge safety barriers or other barrier systems that are compliant with the [Department of Transport and Main Roads Planning and Design manual](http://www.tmr.qld.gov.au).
2. All road bridge barriers meet at least the regular performance level in [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
3. For bridges over Queensland Rail infrastructure/land, special performance level barriers are provided with protection screens.
4. Where a bridge structure is over permanent water deeper than 300mm or where the drop height exceeds 1.2m, vertical balustrade pedestrian handrails with appropriate bicycle offset rail or equivalent are provided on the structure’s outer edge.
5. Proposals do not include slip forming of concrete bridge barriers, or use of timber bridge barriers.

8.2.11.2 Pedestrian or bikeway barriers

Where pedestrian or bikeway barriers are liable to inundation they are:

1. durable, robust, tamper proof and capable of surviving up to a 20 year [ARI](Appendix1IndexGlossary.docx) flood without damage and with minimal maintenance throughout their 40-year design life;
2. designed to sustain coexistent 20 year [ARI](Appendix1IndexGlossary.docx) water drag forces with the [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) pedestrian barrier loads without damage;
3. designed so that in the event of failure above a 20 year [ARI](Appendix1IndexGlossary.docx) flood, there will be no damage to the supporting structure or base fixings to enable quick and easy repair or replacement with minimal disruption or nuisance to the public.

8.2.11.3 Collapsible barriers

1. Collapsible barriers or railings incorporating replaceable weak links (e.g. shear pins), will only be considered when tamper proof and a whole-of-life cost–benefit analysis shows that it is a better value solution than a normal installation.
2. Collapsible barriers or railings of any type are not to be relied upon to mitigate flood impacts to adjoining land or infrastructure.

8.2.11.4 Noise barriers and electrification barriers

1. Where it is required that noise barriers and electrification barriers be carried across the bridge, the noise barrier panels and posts and electrification barriers are located on the outside of the bridge behind the top horizontal face of the concrete parapet.
2. The barriers, including support systems, are designed to avoid potential spearing hazards in the event of a collision.

8.2.12 Public utilities

1. A bridge is designed to accommodate present and future requirements for services crossing the structure.
2. A road bridge incorporates provision for a minimum of 8 conduits 100mm in diameter as follows:
3. 3 x 100 diameter – white for telecommunications;
4. 2 x 100 diameter – orange for electricity;
5. 1 x 100 diameter – yellow or black with yellow stripes for gas;
6. 2 x 100 diameter – white spares.

8.2.13 Hydrology

1. Design for hydrology of road embankment stability is based on a 100 year [ARI](Appendix1IndexGlossary.docx) flood.
2. Design for hydrology for the ultimate limit state of bridges, major drainage structures and retaining walls stability is based on a 2000 year [ARI](Appendix1IndexGlossary.docx) flood.
3. The hydraulic loads on bridges are based on a 2000 year [ARI](Appendix1IndexGlossary.docx) flood for ultimate limit state flood levels and flows and a 20 year [ARI](Appendix1IndexGlossary.docx) flood for serviceability limit state flood levels and flows.
4. The impact of climate change during the structure’s life is assessed and taken into account in assessing flood levels and velocities.
5. Structures are designed to prevent or minimise increased flooding or flood pattern changes.

8.2.14 Crossfall on bridges

1. The minimum cross fall on new bridges is 2.5%.
2. Widened bridge decks have a crossfall similar to the existing bridge deck, and the minimum cross fall is 2.5%.
3. The existing deck wearing surface on all bridges subject to widening, including bridge approaches where required, is milled to a sufficient depth to allow placement of new asphaltic concrete wearing surface.
4. Milling does not damage the concrete deck or waterproof membrane if present.
5. The thickness of the deck wearing surface is minimised so as not to affect the existing load rating.
6. For existing bridges having a one-way crossfall of less than 2%, the deck wearing surface can be increased in thickness to result in a crossfall of 2% provided the load rating is not adversely affected.

8.2.15 Bituminous waterproof membrane

A bituminous waterproofing membrane is provided for:

1. all pre-stressed concrete deck unit bridges;
2. the entire deck of bridges with pre-cast girders and a composite reinforced concrete decks;
3. the negative moment zone for continuous bridges.

8.2.16 Deck wearing surface

1. On road bridges:
2. the deck wearing surface is asphaltic concrete dense grade asphalt and has a design life of 20 years;
3. the minimum thickness of deck wearing surface on bridges is 60mm in any traffic lane;
4. the minimum thickness in any other area is 45mm.
5. For pedestrian or bike bridges the deck wearing surface has a design life of 25 years with a slip resistance compliant with [HB 197:1999 An introductory guide to the slip resistance of pedestrian surface materials](http://infostore.saiglobal.com/store/details.aspx?ProductID=568795).

8.2.17 Post-tensioned concrete superstructure

1. Superstructures do not use external pre-stressing.
2. Where match cast joints in post-tensioned concrete are used, all match cast joints are epoxy coated, waterproofed and have a minimum compressive stress of 2MPa under all serviceability limit state load combinations.

8.2.18 Super-tee bridge girders – skew and stepped joints

1. Concrete trough and 'Super Tee' girders are not used on structures, which have a skew exceeding 35° to either of the abutments or any of the piers.
2. Stepped or half joints are not used in bridge girders.

8.2.19 Steel girder bridges

Steel bridges are designed in compliance with [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) and the following:

1. safe maintenance access to all faces of all steel members, without impact upon traffic or rail operations;
2. all steel box girders have access holes suitable for inspection and maintenance access;
3. access holes are located in the bottom flange in areas of low stress;
4. access holes are fitted with hinged doors and provided with locks;
5. access holes are provided in all diaphragms;
6. access holes are large enough to permit maintenance personnel access;
7. access provisions comply with the [Workplace Health and Safety Act 1995](http://www.legislation.qld.gov.au/LEGISLTN/SLS/2011/11SL240.pdf) and the [Workplace Health and Safety Regulation 1997](http://www.legislation.qld.gov.au/LEGISLTN/SLS/2011/11SL240.pdf) which includes, but is not limited to, the provisions for the design of confined spaces;
8. provision is made for ventilation and drainage of the interior of all box sections;
9. outside openings in steel box sections are screened to exclude unauthorised persons, birds and vermin;
10. water, gas or drainage pipes are not permitted within steel box girders.

8.2.20 Pier protection for overbridges

1. Piers for overbridges are designed for the impact loads in compliance with [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
2. For road safety requirements, a barrier is placed around the pier to prevent impact by an errant vehicle. The barrier is in compliance with the [Department of Transport and Main Roads Road Planning and Design Manual](http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Guide-for-development-in-a-railway-environment.aspx).

8.2.21 Abutments

1. Where practical, abutments of road overbridges spill through type with a 750mm wide shelf at the top to allow easy inspection of bearings and shelf. The preferred batter slope is 1V:1.5H.
2. The scour potential at abutments and piers is minimised. The design takes into account this scour and the design life for abutment protection in streams subject to scour is 100 years.
3. Abutment slope protection provided for all new bridges. The abutment slope protection for road overbridges is at least over the area directly beneath the superstructure and sufficient of the sides for the embankment to prevent erosion and undermining.
4. The abutment protection of a widened bridge is similar in style to the existing bridge.
5. Where reinforced soil system walls are used as the front face of the abutment, the design includes a primary support system for the abutment headstock with a design life of at least 100 years.

8.2.22 Applied loads

8.2.22.1 New structure vehicle loads

All new structures are designed for SM 1600 and a heavy load platform (HLP320 and HLP400) traffic loads in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).

8.2.22.2 Heavy load platform position

All new road bridges are designed for SM1600 and heavy load platform (HLP320 and HLP400) traffic loads in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) and [Table 8.2.22.2.A](#Table8p2p22p2A).

Table 8.2.22.2.A—Heavy load platform position for road bridges

|  |  |
| --- | --- |
| Bridge type | Clarification of heavy load platform position |
| Two marked lane bridge | Heavy load platform positioned ± 1m either side of centre-line of 2 marked lanes. |
| Three or more marked lanes | In 2 marked lanes with the vehicle travelling ± 1m either side of centre of any 2 adjacent marked lanes. Consideration should be given to the most likely path of the vehicle. The [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) coexistent half SM1600 on the adjacent ramp is applied to create the worst effect. |
| One lane ramp | Positioned on a one-lane ramp so located by the designer. The tolerance on lateral position is specified. |

8.2.22.3 Widening of existing structure vehicle loads

Where structures are widened, the design loading of the widened section complies with the SM 1600 loading and the heavy load platform loading requirements of [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) except where the conditions of [Table 8.2.22.3.A](#Table8p2p22p3A) apply.

Table 8.2.22.3.A—Vehicle loads for widening of bridges

|  |  |
| --- | --- |
| Bridge widening type | Clarification of heavy load platform position |
| Widening < 1 lane in width | The existing bridge design load is adopted for all lanes. |
| Widening > 1 lane but fewer than 2 lanes | The widening is designed for the SM1600 load and the heavy load platform loading used for the existing bridge design. |

8.2.22.4 Pedestrian loads

1. All structures with walkways are designed to support pedestrian loads as specified in [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
2. Isolated pedestrian and bikeway bridges protected by ‘banana rails’ with maximum 1.5m clearance against vehicle access are designed to accommodate a minimum 1,800kg GVM mini tractor, ride-on mower or equivalent assuming a 1.2m track width and 2m wheel base anywhere on the deck.
3. Where full width access greater than 1.8m is possible, the structure accommodates either a 6,100kg GVM full size tractor, 2,500kg utility vehicle or a mini tractor as described above.
4. For man-made materials subject to loss of strength with increasing temperature [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) section 17 is used to guide assessment of possible deck temperature.

8.2.22.5 Thermal loads

Bridge structures are designed for thermal effects as detailed in [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) section 17. For determination of temperature effects, all structures are considered as coastal, taking into account the impact of climate change over the structure's design life.

8.2.23 Material standards and specifications

1. Material standards for bridge design are described in [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
2. Materials complying with [Department of Transport and Main Roads](http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Guide-for-development-in-a-railway-environment.aspx) specifications are used.

8.3 Culverts

8.3.1 Design principles

1. This section outlines the design specifications, guidelines and standards in relation to the design and construction of all new culverts.
2. The design and construction of culvert assets aligns with the following:
3. culvert structures are typically constructed using either box or pipe barrels, with open inlet and outlet ends so as to convey water not under pressure. Culvert asset boundaries must extend beyond the barrels to include the head walls (or parapet walls), wing walls, aprons, base slabs to support the barrels (if any), and guardrails (or handrails) structurally attached to the culvert;
4. culvert design in urban areas considers constraints of adjacent infrastructure and housing;
5. ground disturbance during construction is minimised and adequate access for maintenance is provided.

8.3.2 Design specifications and guidelines

1. Culverts and associated elements are:
2. designed in compliance with the following:
3. [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
4. [AS 1597.1-2010 Precast reinforced concrete box culverts - Small culverts (not exceeding 1200mm span and 1200mm height)](http://infostore.saiglobal.com);
5. [AS/NZS 4058:2007 Precast concrete pipes (pressure and non-pressure)](http://infostore.saiglobal.com);
6. [AS 4139-2003 Fibre reinforced concrete pipes and fittings](http://infostore.saiglobal.com);
7. [AS/NZS 3725:2007 Design for installation of buried concrete pipes](http://infostore.saiglobal.com);
8. [AS 3600 Supp 1-1994 Concrete structures](http://infostore.saiglobal.com);
9. [AS/NZS 3845:1999 Road safety barrier systems](http://infostore.saiglobal.com);
10. [Guide to Road Design Practice (Austroads)](http://www.austroads.com.au/);
11. [Waterway Design: a guide to the hydraulic design of bridges, culverts and floodways (Austroads, 1994)](http://www.austroads.com.au/);
12. [Department of Transport and Main Roads](http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Guide-for-development-in-a-railway-environment.aspx) specifications (as appropriate);
13. [Queensland Rail specifications](http://www.queenslandrail.com.au/Pages/Default.aspx) (as appropriate).
14. designed by a [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld).
15. Where the above references are silent on any matter, a culvert is designed in compliance with one of the following technical publications:
16. British Standards (BS 5400);
17. American Standards (AASHTO LRFD);
18. European Codes (Euro codes).

8.3.3 Design life

1. A culvert and its associated structures are designed to achieve the minimum design life in [Table 8.3.3.A](#Table8p3p3A) without major maintenance or replacement of elements whilst remaining safe and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, its design satisfies the design life requirements of the asset of which it forms a part.
3. If replacing cells of extending existing culvert crossings, the new works have a design life of 100 years.

Table 8.3.3.A—Minimum-required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Culvert structures and roadway support structures including underpasses | 100 years |
| Reinforced embankments, retaining walls, including reinforced soil structures | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management, and control systems | 100 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Roadway noise barriers and architectural or structural noise attenuation devices | 40 years |
| Signage support structures, roadside barriers and other roadside furniture | 40 years |
| Tolling system structures, gantries and other equipment structures | 40 years |

8.3.4 Durability

8.3.4.1 General

A culvert and its associated works meet the following minimum requirements for durability.

8.3.4.2 Exposure classification

A culvert is designed to comply with the [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/) exposure classification specified in [Table 8.3.4.2.A](#Table8p3p4p2A).

Table 8.3.4.2.A—Minimum-required exposure classifications

| Structure | Minimum-required exposure classification |
| --- | --- |
| Above-ground structures (head walls, barriers etc.) | B2 |
| Structures cast against ground | B2 |
| Structures in freshwater | B2 |
| Structures in saline water and tidal zones | C |
| Structures in aggressive groundwater | C |

8.3.4.3 Concrete durability

1. Minimum concrete strengths and associated nominated concrete covers comply with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/) to suit the required exposure classification.
2. Cover spacers and permanent fixings incorporated within the concrete covers zone are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete, with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.3.4.4 Steel durability – steel culverts

Steel pipe or arch culverts are not used for stormwater management purposes.

8.3.4.5 Steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure Category E as a minimum, and is:
2. of suitable grade to resist corrosion; or
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
4. At the end of that maintenance-free life, the coating remains soundly adhered to the metal substrate and suitable for overcoating without removal.
5. A re-coating is to have a minimum maintenance-free life of 25 years.
6. The minimum surface preparation for coating includes Class 2 1/2 (SA 2 1/2) abrasive blasting in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com).

8.3.4.6 Miscellaneous components durability

1. Structures are designed to enable items such as tidal flaps, debris grates, silt traps, railings and drainage connections to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems, including concrete covers can be easily inspected, maintained or renewed.

8.3.5 Widening

1. If future widening of a culvert may be required allowance is made in design for connection of the future widening connection.
2. A connection for a future widening is designed and constructed to minimise or eliminate the need to alter the parent structure.
3. Details of the widening methodology, including outline drawings, method of attachment and transmitted forces are allowed for in design and included on the contract general arrangement drawings.
4. Exposed reinforcement does not project from a structure in anticipation of a future widening.
5. The widening of any existing structures provides a construction solution that is consistent with the existing structure in terms of stiffness, fixity, continuity and appearance.
6. The effects of the widening on the capacity of the existing structure are considered and the existing structure strengthened as required to ensure no reduction in vehicle capacity or flood immunity.

8.3.6 Barriers and rails

1. All barriers and railings:
2. are durable, robust, tamper proof and capable of surviving up to a 20 year [ARI](Appendix1IndexGlossary.docx) flood without damage and with minimal maintenance throughout their 40 year design life;
3. when required to prevent falls from height barriers and railings are designed in addition to the normally applied load cases and combinations to sustain coexistent 20 year [ARI](Appendix1IndexGlossary.docx) water drag forces with the [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/) pedestrian barrier loads without damage;
4. are designed so that in the event of failure above a 20 year [ARI](Appendix1IndexGlossary.docx) flood, there will be no damage to the supporting structure or base fixings to enable quick and easy repair or replacement with minimal disruption or nuisance to the public.
5. Collapsible barriers and railings incorporating replaceable weak links (e.g. shear pins) are used if a whole-of-life cost–benefit analysis shows that it is a better value solution than a normal installation
6. Collapsible barriers and railings are tamper proof.
7. Collapsible barriers or railings of any type are not relied upon to mitigate flood impacts to adjoining land or infrastructure.

8.3.7 Public utilities

1. A culvert is designed to accommodate present and future requirements for services crossing the structure.
2. A culvert incorporates provision for a minimum eight 100mm diameter conduits as follows:
3. 3 x 100 diameter white for telecommunications;
4. 2 x 100 diameter orange for electricity;
5. 1 x 100 diameter yellow or black with yellow stripes for gas;
6. 2 x 100 diameter white spares.

8.3.8 Hydrology

8.3.8.1 General

1. The hydraulic design of culverts must not result in adverse impacts, such as increase in water levels or flow velocities, and significant change of flood patterns. Design minimises the impacts on the waterway environment.
2. Regard is given to catchment management plans or stormwater management plans for the watercourse.
3. All culverts are designed to ensure that the total waterway (including culvert) can pass flows up to the 100 year [ARI](Appendix1IndexGlossary.docx) flood without significant damage to the road embankments and/or culvert structure.
4. Consideration is given to the need to assess the 2,000 year [ARI](Appendix1IndexGlossary.docx) flood for an ultimate limit state where multi-cell culverts are being proposed along arterial transport routes.
5. The hydraulic loads on major culverts and retaining walls is based on a 2000 year [ARI](Appendix1IndexGlossary.docx) flood and probable maximum flood for ultimate-limit state flood levels and flows and a 20 year [ARI](Appendix1IndexGlossary.docx) flood for serviceability-limit state flood levels and flows.
6. Stability of road embankments is designed according to a 100 year [ARI](Appendix1IndexGlossary.docx) flood.
7. The impact of climate change during the structure’s life is assessed and taken into account in assessing flood levels and velocities.

8.3.8.2 General hydraulic standards

Modelling to assess the flood impact of crossings for various pavement heights above the invert of a waterway uses the following standards:

1. height of pavement above invert less than 500mm – a handrail or barrier may not be required, although a ‘lip’ not exceeding 150mm high to act as a bump stop for wheelchairs (etc.) may be required. If the handrail or barrier can be avoided, no representation of blockage is required in the hydraulic model, other than the deck and supporting piers;
2. height of pavement above invert between 500mm and 1,000mm – a standard tubular hand and mid-rail barrier without infill is generally required. This is represented by 50% blockage in the hydraulic model;
3. height of pavement above invert greater than 1,000mm – a balustrade barrier is generally required. This is represented by 100% blockage in the hydraulic model;
4. unless otherwise advised by the [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld) civil/structural designer, handrail height above the pavement height shall be taken as 1,100mm for pedestrian crossings and 1,400mm for bikeways or shared paths.

8.3.8.3 Particular hydraulic standards

1. Crossings are designed to have no adverse impacts on flooding and flood patterns.
2. If afflux or debris build up associated with a barrier or railing is an issue, a no handrail crossing may be considered by the designer if the height of pavement above invert is 1m or less and the pavement of the crossing is widened accordingly, provided the design is supported by a risk management assessment report and includes:
3. a minimum 1.5m-wide concrete shoulder on either side of path to taper back to standard path width after extent of crossing;
4. a red coloured shoulder with a 100mm-wide painted yellow line along its internal edge;
5. flexible road edge guide posts at 2m (minimum) spacing installed along each side of the crossing;
6. local flood depth indicator posts installed on crossing approaches.

8.3.9 Applied loads

1. Design based on load testing for large box-sectioned culverts as directed by [AS 1597.2-1996 Pre-cast reinforced concrete box culverts - Large culverts (from 1,500 mm span and up to and including 4,200 mm span and 4,200 mm height)](http://infostore.saiglobal.com) section 4, is not permitted.
2. Loading applied to culverts includes dead load, vertical and horizontal soil pressure, traffic loads for culverts under roadways, bikeways and pedestrian paths, and internal water pressure. Handling and transporting loads is also considered for pre-cast culverts.
3. Pipe culverts are designed for a range of fills from zero to the maximum design height.
4. Box culverts have a minimum design height of fill of 2m.
5. Surcharge loads from road traffic loads influencing earth pressure are calculated according to [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
6. Fibre-reinforced concrete pipe, long-term design loads, or the test crack loads, accord with [AS 4139-2003 Fibre reinforced concrete pipes and fittings](http://infostore.saiglobal.com) for Classes 1-4.
7. A culvert supporting road traffic is designed for SM1600 and heavy load platform (HLP320 and LHP400) traffic loads in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
8. The position for a heavy load platform complies with [Table 8.3.9.A](#Table8p3p9A).
9. If roadways over culverts are widened and the culverts are extended, the design loading of the extended culvert units complies with the SM1600 loading and the heavy load platform loading of [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873), except as specified in [Table 8.3.9.B](#Table8p3p9B).
10. All culvert structures under footpaths or bikeways are designed to support pedestrian or bicycle path loads as specified in [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
11. Materials complying with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) are used.

Table 8.3.9.A—Heavy load platform position for roadways over culverts

| Crossing type | Clarification of heavy load platform position |
| --- | --- |
| 2 marked lanes | Heavy load platform positioned ± 1m either side of centreline of 2 marked lanes. |
| 3 or more marked lanes | In 2 marked lanes with the vehicle travelling ± 1m either side of centre of any 2 adjacent marked lanes. Consideration should be given to the most likely path of the vehicle. The [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) coexistent half SM1600 on the adjacent ramp is applied to create the worst effect. |
| One-lane ramp | Positioned on a one-lane ramp so located by the designer. The tolerance on lateral position is specified. |

Table 8.3.9.B—Vehicle loads for widening roadways over culverts

|  |  |
| --- | --- |
| Roadways widening type | Clarification of heavy load platform position |
| Widening < 1 lane in width | The existing culvert design load is adopted for all lanes. |
| Widening > 1 lane but fewer than 2 lanes | The widening is designed for the SM1600 load and the heavy load platform loading used for the existing culvert design. |

8.4 Tunnels

8.4.1 Design principles

1. This section outlines the design specifications, guidelines and standards in relation to the design and construction of tunnels.
2. The design and construction of tunnels aligns with the following:
3. structural design is based on proven methods, materials and technology;
4. all structures present smooth, clean lines with minimum structural depth consistent with their spans and method of construction.

8.4.2 Design specifications and guidelines

1. All tunnels and associated elements are:
2. designed in compliance with the following:
3. [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
4. [AS 4825-2011 Tunnel fire safety](http://infostore.saiglobal.com);
5. [AS 4678-2002 Earth-retaining structures](http://infostore.saiglobal.com);
6. [AS/NZS 3845:1999 Road safety barrier systems](http://infostore.saiglobal.com);
7. [AS/NZS 3000:2007 Electrical installations](http://infostore.saiglobal.com/store/Details.aspx?ProductID=366926): Buildings, Structures and Premises (SAA Wiring Rules);
8. [AS 1158.5 Lighting for Roads and Public Spaces](http://infostore.saiglobal.com/store/Details.aspx?ProductID=1387409);
9. [Guide to Road Design Practice (Austroads)](http://www.austroads.com.au/);
10. [Waterway Design: a guide to the hydraulic design of bridges, culverts and floodways (Austroads, 1994)](http://www.austroads.com.au/);
11. [Chapter 13](Ch13CommunityFacilities.docx) of this planning scheme policy;
12. [Standard drawings](Ch1Introduction.docx#Section114);
13. [Department of Transport and Main Roads](http://www.tmr.qld.gov.au/Business-industry/Technical-standards-publications/Guide-for-development-in-a-railway-environment.aspx) and [Queensland Rail](http://www.queenslandrail.com.au/Pages/Default.aspx) specifications (as appropriate);
14. designed by a [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld).
15. Where the above references are silent in relation to specific standards or technical requirements, compliance is with one of the following technical publications:
16. British Standards BS 5400;
17. American Standards (AASHTO LRFD);
18. European Codes (Euro codes);
19. Department of Transport and Main Roads Bridge Design Criteria.

8.4.3 Design life

1. All tunnels and associated structures are designed and constructed to achieve the minimum design life in [Table 8.4.3.A](#Table8p4p3A) without major maintenance or replacement of elements whilst remaining safe and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset which it forms a part.
3. A replacement methodology is specified for components that have a life shorter than the structure design life.

Table 8.4.3.A— Minimum required design life

| Asset | Design life |
| --- | --- |
| Tunnel structures including linings and waterproofing/sealing | 100 years |
| Bridge structures and roadway support structures including underpasses | 100 years |
| Reinforced embankments, retaining walls, including reinforced soil structures | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management, and control systems | 100 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Tunnel architectural panels and support systems | 40 years |
| Roadway noise barriers and architectural or structural noise attenuation devices | 40 years |
| Signage support structures, roadside barriers and other roadside furniture | 40 years |
| Tolling system structures, gantries and other equipment structures | 40 years |
| Mechanical equipment including ventilation plant, water treatment and fire protection systems and associated infrastructure including support systems accessible for inspection, maintenance, renewal and replacement. | 25 years |
| Electrical equipment including substations, switchboards, variable message signs, lighting, communication systems and associated infrastructure, including support systems accessible for inspection, maintenance, renewal and replacement. | 25 years |

8.4.4 Durability

8.4.4.1 General

A tunnel structure and its associated works meet the following minimum requirements for durability.

8.4.4.2 Exposure classification

A tunnel is designed to comply with the [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) exposure classification specified in [Table 8.4.4.2.A](#Table8p4p4p2A).

Table 8.4.4.2.A—Minimum required exposure classifications

|  |  |
| --- | --- |
| Structure | Minimum required exposure classification |
| Above ground structures (bridge superstructure, pier column and headstocks, barriers) | B2 |
| Structures cast against ground | B2 |
| Structures in saline water and tidal zones | C |
| Structures in aggressive groundwater | C |

8.4.4.3 Concrete durability

1. Minimum concrete strengths and associated nominated concrete covers comply with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) to suit the required exposure classification.
2. Cover spacers or permanent fixings incorporated within the concrete covers zone are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.4.4.4 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150) exposure category E as a minimum, and is:
2. of suitable grade to resist corrosion; or
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
4. At the end of that maintenance-free life, the coating remains soundly adhered to the metal substrate and suitable for overcoating without removal.
5. The re-coating has a minimum maintenance-free life of 25 years.
6. The minimum surface preparation includes Class 21/2 (SA 21/2) abrasive blasting in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150).

8.4.4.5 Miscellaneous components durability

1. Tunnels are designed to enable items such as lighting, ventilation and fire protection systems, plant and equipment, bearings, expansion joint seals, railing and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Tunnels are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.4.5 Minimum clearances

Minimum vertical clearances for tunnels are compliant with [Table 8.4.5.A](#Table8p4p5A).

Table 8.4.5.A—Minimum vertical clearances

|  |  |
| --- | --- |
| Location | Minimum clearance |
| Tunnels – general |
| Structures carrying Council road infrastructure | 5.5m |
| Structures carrying Council shared use paths and footpaths | 3m |
| Emergency egress openings, passages and stairs | 2.4m |

1. Lateral clearances are sufficient to ensure vehicles operating legally and allowing for dynamic sway in compliance with the Department of Transport and Main Road’s '[Road Planning and Design Manual'](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Road-planning-and-design-manual.aspx) requirements do not damage adjacent or overhead tunnel structures, utilities, mechanical or electrical plant or equipment.
2. Pedestrian service and emergency access passages and stairs are not less than 1.5m clear width.
3. Openings into pedestrian service and emergency access passages and stairs are not less than 1m clear width.
4. Public shared use paths and footpaths are not less than 3m clear width.

8.4.6 Barriers

Department of Transport and Main Roads standard bridge safety barriers or other barrier systems complying with the [Department of Transport and Main Roads Road Planning and Design Manual](http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Road-planning-and-design-manual.aspx) are provided.

8.4.7 Public utilities

A tunnel is designed to accommodate present and future requirements for services running through the structure.

8.4.8 Hydrology

1. Climate change is taken into account when assessing flood impacts.
2. Structures are designed to prevent or minimise increased flooding or flood pattern change.

8.4.9 Flood immunity

1. Drainage and flood control systems are designed, constructed, operated, maintained and renewed to ensure the tunnel and associated assets are protected against flooding.
2. The tunnel and associated assets are designed so that the connection ramps and tunnels are protected by non-mechanical fixed means from external catchment run-off under a minimum 10,000 year [ARI](Appendix1IndexGlossary.docx) flood.

8.4.10 Drainage

Tunnel drainage systems:

1. are of sufficient capacity to maintain all traffic lanes flood free in both directions for stormwater run-off from portal areas for the design 100 year [ARI](Appendix1IndexGlossary.docx) flood;
2. accommodate credible combinations of stormwater, road traffic incident, groundwater, maintenance, fire fighting and other water ingress events;
3. collect portal and in tunnel run-off via trash rack, grated gullies at maximum 60m intervals with longitudinal pipe work and sumps;
4. have sufficient fire and explosion resistance to minimise associated post-event operational recovery;
5. have facilities necessary to identify, isolate, treat and safely dispose of contaminated run-off and water arising from road traffic incident, groundwater, maintenance, fire fighting and other water ingress events without harm or nuisance;
6. have separate systems for safely dealing with contaminated, uncontaminated, groundwater and groundwater seepage;
7. all sumps that are to discharge to holding tanks are to be suitably lined, sealed and vented to atmosphere with minimum duty and 2 standby pumps;
8. all sumps and equipment are designed and constructed for easy inspection, maintenance, operation and renewal and incorporate automatically controlled, with manual back up duty, and standby forced ventilation systems;
9. all pumps are easy and safe to install operate, maintain, renew and replace;
10. all pumps are equipped with flood-resistant monitoring, alarm systems and remote automatic and manual control systems.

8.4.11 Groundwater impacts

1. Tunnels do not cause nuisance, damage or environmental harm as a result of changes in groundwater levels and flows associated with their design, construction, operation, maintenance, renewal or retirement.
2. Tunnels requiring permanent dewatering are not provided.
3. Tunnels have dry exposed faces or linings without structural or other damage, mould or chemical staining as a result of seepage or damp.
4. All seepage is able to be collected and discharged without causing harm or nuisance to tunnel users, inspectors and maintenance personnel.
5. Drained tunnels are designed and constructed so that:
6. gross total seepage does not exceed 8L/s;
7. average seepage rate per 100m tunnel length does not exceed 0.25L/s;
8. there is no seepage through the pavement, floors and work platforms.
9. Undrained tunnels are designed and constructed so that:
10. gross seepage does not exceed 0.2L/m2 of tunnel circumference per day;
11. gross seepage does not exceed 0.4L per 10m length of tunnel per day;
12. there is no discernible water flow through the tunnel lining;
13. there is no seepage through the pavement, floors and work platforms.

8.4.12 Fire resistance and rating

1. To comply with fire resistance or fire rating requirements, tunnel structures include:
2. driven tunnels;
3. cut and cover tunnels;
4. bridging slabs between adjacent tunnels;
5. concrete filler walls;
6. rock pillars.
7. A suitably qualified and experienced [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld) fire safety engineer is engaged prior to start of site works to provide a fire resistance and fire rating assessment report that includes:
8. a risk-based assessment of the fire resistance requirements for all tunnel structures in compliance with [AS 4825-2011 Tunnel fire safety](http://infostore.saiglobal.com) and Queensland Fire and Rescue Service requirements and guidelines;
9. detailed drawings identifying and referencing all load bearing and fire separation elements including smoke ducts and ventilation equipment critical to the asset performing as required in a fire event to ensure public, tunnel workers and emergency services personnel safety;
10. a schedule of the fire resistance or fire rating to be achieved for each element during construction, operation, maintenance, renewal and replacement;
11. details of the materials used including inspection frequency, life-to-first maintenance and maintenance, renewal and replacement need to perform as required throughout the tunnel's life.
12. Roadway tunnels are designed and constructed to incorporate:
13. emergency egress points at no greater than 120m intervals;
14. shoulders wide enough to adequately function as emergency access and egress routes;
15. BCA Class 9b compliant emergency egress routes from all work areas including plant rooms, switch rooms, maintenance walkways and platforms.

8.4.13 Access engineering

1. A suitably qualified and experienced [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld) is engaged prior to the start of site works to provide an egress report that includes:
2. detailed drawings identifying protected routes, egress travel paths and minimum required passage width;
3. functional, operational and maintenance details of protected routes, egress travel paths, refuges, stretcher access routes and emergency communication systems;
4. total and mobility impaired population capacity numbers;
5. BCA compliance confirmation.

8.4.14 Air quality

1. Tunnels are ventilated so that internal air quality is controlled and pollutants do not exceed the following maximum limits:
2. carbon monoxide concentration not greater than 70ppm with traffic speeds between 20km/h and 80km/h;
3. carbon monoxide concentration no greater than 90ppm with traffic speeds less than 10km/h;
4. average nitrogen dioxide throughout the tunnel length no greater than 1ppm assuming that nitrogen dioxide is greater than 10% of the total oxides of nitrogen in the atmosphere;
5. pollution level measurements are averaged for control purposes over no greater than 15 minutes;
6. Traffic management systems are used to maintain normal average traffic speeds greater than 20km/h with occasional minimum speeds allowed down to 10km/h.
7. Airflow velocity through any tunnel shall be controlled to not exceed 10m/s.
8. Ventilation systems are designed, constructed, operated, maintained and renewed to minimise any negative impact of exhaust gases on the external environment.

8.4.15 Applied loads

1. Roadways are designed for SM1600 and heavy load platform (HLP320 and HLP400) traffic loads complying with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).
2. Suspended pedestrian walkways are designed to support pedestrian loads as specified in [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873).

8.5 Earth-retaining structures

8.5.1 General

1. Section 8.5 outlines the design principles, specifications, guidelines and standards in relation to the design and construction of earth-retaining structures.
2. Section 8.5 applies to free-standing earth-retaining structures.
3. Section 8.5 does not apply to:
4. earth-retaining structures less than 1m high supporting soft landscape;
5. earth-retaining structures forming part of or directly associated with bridge, drainage, stormwater or culvert structures;
6. earth-retaining structures liable to inundation causing scour ([section 8.8](#SeeandRiver) applies);
7. sea or river walls.

8.5.2 Design principles

The design and construction of earth-retaining structures aligns with the guidelines and structural design is based on proven methods, materials and technology.

8.5.3 Design specifications and guidelines

1. All retaining walls are designed and constructed in compliance with the following:
2. [AS 4678-2002 Earth-retaining structures](http://infostore.saiglobal.com);
3. [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
4. [Guide to Road Design Practice (Austroads)](http://www.austroads.com.au/);
5. [Chapter 13](Ch13CommunityFacilities.docx) of this planning scheme policy.
6. A retaining wall structure is designed by a [Registered Professional Engineer Queensland](Definitions.docx#RegProfEngQld).
7. Where the above references are silent in relation to specific standards or technical requirements, compliance is with one of the following technical publications:
8. British Standards (BS 5400);
9. American Standards (AASHTO LRFD);
10. European Codes (Euro codes).

8.5.4 Design life

1. All earth-retaining structures are designed to achieve the minimum design life in [Table 8.5.4.A](#Table8p5p4A) without major maintenance or replacement of elements whilst remaining safe and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset of which it forms a part.
3. A replacement methodology is specified for components that have a life shorter than the structure design life.

Table 8.5.4.A—Minimum required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Reinforced embankments, retaining walls, including reinforced soil structures | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management, and control systems | 100 years |
| Reinforced embankments, retaining walls supporting [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com/store/Details.aspx?ProductID=260163) structures | 50 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Signage support structures, roadside barriers and other roadside furniture | 40 years |

8.5.5 Durability

8.5.5.1 General

A retaining wall and its associated works meet the following minimum requirements for durability.

8.5.5.2 Concrete durability

1. Concrete strengths and associated concrete covers comply with the [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) and [AS 3600-2009 Concrete structures](http://infostore.saiglobal.com) as appropriate to the structure.
2. Cover spacers or permanent fixings incorporated within the concrete covers zone are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.5.5.3 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150) exposure category E as a minimum, and is:
2. of suitable grade to resist corrosion; or
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
4. At the end of that maintenance-free life, the coating remains soundly adhered to the metal substrate and suitable for overcoating without removal.
5. The re-coating has a minimum maintenance-free life of 25 years.
6. The minimum surface preparation includes Class 21/2 (SA 21/2) abrasive blasting in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150).

8.5.5.4 Timber durability

Timber earth retaining structures are not used.

8.5.5.5 Miscellaneous components durability

1. Structures are designed to enable items such as expansion joint seals, railing and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.5.6 Minimum clearances

Minimum clearances for retaining walls are compliant with [Table 8.5.6.A](#Table8p5p5A).

Table 8.5.6.A— Minimum clearances

| Location | Minimum horizontal clearance |
| --- | --- |
| Exposed faces and structure to all other assets | 0.6m |
| Exposed face to all other assets longer than 2m | 2m or ½ retained height if greater |
| Structure (including drainage) to property or easement boundary | 2m or ½ retained height if greater |

8.5.7 Ground anchors

1. All ground anchors are removed unless there is no other reasonable technique enabling the project to proceed.
2. If ground anchors cannot be avoided or removed they are located within the zone indicated in [Figure 8.5.6.a](#Figure856a).
3. All temporary ground anchors are distressed and removed.
4. Approval in writing is required from the adjoining property owners (including Council where adjoining Council land) for proposed ground anchor systems (permanent or temporary) which extend beyond the applicant’s legal property boundaries prior to installation.



8.5.8 Barriers

Where fall from height, pedestrian, bikeway or vehicle barriers are required they, their fixings and supporting structure are:

1. designed to accord with all relevant Australian Standards;
2. safe, durable, robust and tamper proof.

8.5.9 Public utilities

An earth-retaining structure is designed to accommodate present and future requirements for services that run through or close to the structure.

8.5.10 Hydrology

1. The impact of climate change on earth-retaining walls, during the structure’s life, is assessed and taken into account in assessing flood levels and velocities, where liable to inundation and they are:
2. designed to survive all water and debris forces in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) arising from a 20 year [ARI](Appendix1IndexGlossary.docx) flood without structural damage;
3. designed to survive all water and debris forces in compliance with [[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) arising from a 100 year [ARI](Appendix1IndexGlossary.docx) flood with a low risk of total structural failure, third party harm or injury;
4. designed to minimise scour potential;
5. take into account any remaining scour potential and appropriate protection provided to ensure the new asset is not undermined or cause harm to pre-existing structures or the natural environment.
6. Structures are designed to achieve zero afflux and no significant change to flood patterns.

8.5.11 Bituminous waterproof membrane

Water ingress or penetration will not cause accelerated degradation of the asset’s structure or unsightly staining/mould growth.

8.5.12 Applied loads

Applied loads are assessed in compliance with [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873), AS 4678-2002 Earth-retaining structures or [AS 1170 Loading Standard Series](http://infostore.saiglobal.com) whichever the greater.

8.5.13 Material standards and specifications

Materials complying with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) are used.

8.6 Elevated structures

8.6.1 Design principles

1. [Section 8.5](#Section85) applies to:
2. [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com);
3. elevated lookout structures with little or no injury risk arising from structural failure.
4. [Section 8.5](#Section85) does not apply to:
5. on-ground structures;
6. elevated lookout structures with injury risk arising from structural failure ([section 8.2](#Bridges) applies);
7. bridge structures ([section 8.2](#Bridges) applies);
8. building structures such as picnic shelters and barbeques.
9. The design and construction of elevated structures aligns with the following:
10. structural design is based on proven methods, materials and technology;
11. all structures present smooth, clean lines with minimum structural depth consistent with their spans and method of construction.

8.6.2 Design specifications and guidelines

1. All elevated or suspended footpath or shared path structures and associated elements designed in compliance with the following:
2. [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com) – Part 1 and Part 2;
3. [Guide to Road Design Practice (Austroads)](http://www.austroads.com.au/);
4. [Waterway Design. A guide to the hydraulic design of bridges, culverts and floodways (Austroads, 1994)](http://www.austroads.com.au/);
5. [Chapter 13](Ch13CommunityFacilities.docx) of this planning scheme policy.
6. An elevated structure is designed by a Registered Professional Engineer in Queensland.

8.6.3 Design life

1. All elevated structures and elements are designed to achieve the minimum design life in [Table 8.6.3.A](#Table8p6p3A) without major maintenance or replacement of elements whilst remaining safe and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset of which it forms a part.
3. A replacement methodology is specified for components that have a life shorter than the structure design life.

Table 8.6.3.A—Minimum-required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Elevated lookout structures in an aggressive environment. | 100 years |
| Reinforced embankments, retaining walls, including reinforced soil structures | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management, and control systems | 100 years |
| AS 2156.1-2001 Walking Track structures | 50 years |
| Elevated lookout structures with little or no injury risk arising from structural failure | 50 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Signage support structures, roadside barriers and other roadside furniture | 40 years |

Note—All structures over saline water, or within 100m of saline water (i.e. structures over or adjacent to or liable to inundation) are considered to be in an aggressive environment.

8.6.4 Durability

8.6.4.1 General

An elevated structure and its associated works meet the following minimum requirements for durability.

8.6.4.2 Concrete durability

1. Minimum concrete strengths and associated nominated concrete covers comply with the relevant Australian Standard.
2. Cover spacers or permanent fixings incorporated within the concrete covers zone are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.6.4.3 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150) exposure category E as a minimum, and is:
2. of suitable grade to resist corrosion; or
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
4. At the end of that maintenance-free life, the coating remains soundly adhered to the metal substrate and must be suitable for overcoating without removal.
5. The re-coating has a minimum maintenance-free life of 25 years.
6. The minimum surface preparation includes Class 21/2 (SA 21/2) abrasive blasting in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com/store/Details.aspx?ProductID=365150).

8.6.4.4 Structural steel durability – steel girder bridges

1. Steel girders are not used over or immediately adjacent to salt water or where they may be inundated by brackish water in less than a 100 year [ARI](Appendix1IndexGlossary.docx) flood.
2. Where steel girders are used, all steel surfaces are protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and is of suitable grade to resist corrosion or protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
3. Internal areas too small to paint and repaint during maintenance are sealed and filled with either an inert gas or a water-absorbing product, such as Corroless.
4. Bolts are provided with tabs to monitor internal condition for all sealed sections.
5. Coating systems are capable of being repainted by brush. Coating systems are applied in compliance with the manufacturers’ specifications.

8.6.4.5 Timber durability

1. Timber girders, joists, headstocks and piles are not used for any elevated structure other than those supporting [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com) Class 3 or 4 walking track structures.
2. Timber decking is not used for structures other than those supporting [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com/store/Details.aspx?ProductID=260163) Class 3 or 4 walking tracks.
3. Timber decking is used for [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com) Class 3 or 4 walking tracks where it can easily be replaced.
4. If timber planks are fixed directly to steel, the planks are kiln dried and 136mm x 42mm structural grade 1, for example 150mm x 50mm off saw.
5. If timber is fastened to steel, a steel fastener (e.g. Simpson Strong-Tie TBG Series) to suit the plank and underlying steel joist thickness is used.
6. The tops of steel joists are covered with Denso Tape to counter the effects of water held at the joist-deck interface by capillary forces.
7. If timber is fastened to timber, 14 gauge, type 17 screws with a countersunk or bugle head and a recessed hexagonal drive are used.
8. Decking thickness for top-down fixing is a maximum of 57mm to suit the maximum 100mm long available screw.
9. Stainless steel screws, grade 304, are used.
10. All screw holes are pre-drilled with an appropriate bit combined with a countersink.
11. Minimum screw length for 35mm thick decking is 75mm, and for 45mm thick decking is 85mm.
12. Deck fixings are staggered with edge; end and spacing’s are designed in compliance with [AS 1720.1-2010 Timber structures - Design methods](http://infostore.saiglobal.com).
13. Minimum joist width is 75mm.
14. Bolts for timber joists etc. to structural steel or timber joist to timber bearer etc. are minimum M12-316 stainless steel threaded rod with Glenlock nut and washer one end and normal nut, lock nut and washer the other.
15. The top of timber joists and other horizontal interfaces are coated with CN emulsion and a Malthoid damp proof course laid and coated with CN emulsion to counter the effects of water held at the joist-deck interface by capillary forces.
16. Timber is selected from the following species: spotted gum; tallowwood or ironbark.
17. Timber is grade 1 and the exposed sawn (upper) face surface is free of:
18. loose and unsound knots;
19. shakes;
20. loose gum veins;
21. knot holes;
22. termite galleries;
23. want, wane and bark;
24. checks wider than 1mm;
25. end splits wider than 1mm;
26. included bark;
27. borer holes larger than 3mm diameter.
28. Defects do not cover more that 15% of the top face.
29. Defects on the upper face include no more than 1 borer hole up to 6mm diameter per plank.
30. Treatment, natural durability classes and combinations of timbers complies with [AS 1604.1-2012 Specification for preservative treatment - Sawn and round timber](http://infostore.saiglobal.com) and the [Timber Utilisation and Marketing Act 1987](http://www.legislation.qld.gov.au/Repealed/repealed_T.htm).
31. Sapwood is treated to Level H3 in compliance with the [Timber Utilisation and Marketing Act 1987](http://www.legislation.qld.gov.au/Repealed/repealed_T.htm), and a certificate of treatment is obtained.

8.6.4.6 Miscellaneous components durability

1. Structures are designed so that components such as bearings, expansion joint seals, railing and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.6.5 Widening or extension

1. If future widening or extension of a structure may be required, allowance is made in design for connection of the future widening or extension.
2. A connection point for an extension is designed and constructed to minimise or eliminate the need to alter the parent structure.
3. Details of the widening methodology, including outline drawings, method of attachment and transmitted forces are allowed for in design and included on the contract general arrangement drawings.
4. A structure does not include exposed reinforcement or fixings that project from the structure in anticipation of a future widening.
5. The widening or extension of any existing structures provides a structural solution that is consistent with the existing structure in terms of stiffness, fixity, continuity and appearance.
6. The effects of the widening or extension on the capacity of the existing structure are considered and the existing structure strengthened as required to ensure no reduction in capacity.

8.6.6 Minimum clearances

Minimum clearances are compliant with [Table 8.6.6.A](#Table8p6p6A).

Table 8.6.6.A— Minimum clearances

|  |  |
| --- | --- |
| Location | Minimum clearance |
| Elevated lookout structures to shared use paths and footpaths | 0.5m H, 3m V |
| [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com) walking track structures to property boundary | 3m H |

8.6.7 Joints

Expansion joints are minimised or ideally avoided in the design. All joints are detailed to ensure that the underlying structure is not damaged by damp or water ingress.

8.6.8 Deck drainage

1. Where there is a risk of contamination, decks must not discharge directly into watercourses or onto underlying shared paths or footpaths.
2. All structures are designed to ensure water does not pond.

8.6.9 Barriers

8.6.9.1 General

1. Where a structure is over permanent water deeper than 0.3m or where the drop height exceeds 1.2m, vertical balustrade pedestrian handrails with appropriate bicycle offset rail or equivalent are provided on the structures outer edge.
2. Timber barriers are not permitted other than on [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com) Class 3 or 4 walking tracks.

8.6.9.2 Pedestrian or bikeway barriers

Where pedestrian or bikeway barriers are liable to inundation they are:

1. durable, robust, tamper proof and capable of surviving up to a 20 year [ARI](Appendix1IndexGlossary.docx) flood without damage and with minimal maintenance throughout their 40 year design life;
2. designed to sustain coexistent 1 to 20 year [ARI](Appendix1IndexGlossary.docx) water drag forces with the [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com) pedestrian barrier loads without damage;
3. designed so that in the event of failure above a 20 year [ARI](Appendix1IndexGlossary.docx) flood, there will be no damage to the supporting structure or base fixings to enable quick and easy repair or replacement with minimal disruption or nuisance to the public.

8.6.9.3 Collapsible barriers

1. Collapsible barriers or railings incorporating replaceable weak links (e.g. shear pins) will only be considered when tamper proof and a whole-of-life cost–benefit analysis shows that it is a better value solution than a normal installation.
2. Collapsible barriers or railings of any type are not relied upon to achieve zero afflux or to mitigate flood impacts to adjoining land or infrastructure.

8.6.10 Public utilities

An elevated structure is designed to accommodate present and future requirements for services crossing the structure.

8.6.11 Hydrology

1. Elevated structures are designed to survive all water and debris forces in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com) arising from a 20 year [ARI](Appendix1IndexGlossary.docx) flood without structural damage.
2. Elevated structures are designed to survive all water and debris forces in compliance with [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com) arising from a 100 year [ARI](Appendix1IndexGlossary.docx) flood with a low risk of total structural failure, third party harm or injury.
3. The impact of climate change during the structure’s life must be assessed and taken into account in assessing flood levels and velocities.
4. Structures are designed to prevent or minimise increased flooding or flood pattern change.

8.6.12 Bituminous waterproof membrane

Water ingress or penetration will not cause accelerated degradation of the asset’s structure or unsightly staining/mould growth.

8.6.13 Deck wearing surface

The deck wearing surface of elevated structures has a design life of 25 years with a slip resistance compliant with [HB 197:1999 – An introductory guide to the slip resistance of pedestrian surface materials](http://infostore.saiglobal.com/store/details.aspx?ProductID=568795).

8.6.14 Post-tensioned concrete superstructure

1. The superstructure does not use external pre-stressing.
2. Where match cast joints in post-tensioned concrete are used, all match cast joints are epoxy coated, waterproofed, and have a minimum compressive stress of 2MPa under all serviceability limit state load combinations.

8.6.15 Scour requirements

The design of elevated and [AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com/store/Details.aspx?ProductID=260163) structures takes into account scour potential to ensure the acquisition of the new asset does not result in harm to pre-existing structures or the natural environment.

8.6.16 Applied loads

1. Applied loads are assessed in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873), [[AS 2156.1-2001 Walking tracks - Classification and signage](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=260163)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=260163) and [AS/NZS 1170.1:2002 Structural design actions - Permanent, imposed and other actions](http://infostore.saiglobal.com), whichever the greater.
2. Crowd loads are generally not applicable.

8.6.17 Thermal loads

1. Elevated structures are designed for thermal effects as detailed in [[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com) section 17.
2. For determination of temperature effects, a structure is considered as coastal where it is located, taking into account the impact of climate change over the structure design life.

8.6.18 Material standards and specifications

Materials complying with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) are used.

8.7 Water access structures

8.7.1 Design principles

1. Section 8.7 outlines the specifications, guidelines and standards in relation to the design and construction of water access structures.
2. Section 8.7 applies to:
3. wharves, jetties and pontoons;
4. boat ramps;
5. fishing platforms.
6. The design and construction of elevated structures aligns with the following:
7. structural design is based on proven methods, materials and technology;
8. all structures have an attractive appearance appropriate to their general surroundings and any adjacent structures;
9. unless a feature of the architectural design, all structures are of uniform colour and surface finish, even after repair.

8.7.2 Design specifications and guidelines

1. Waterway access structures are designed to accord with the following:
2. [AS 4997 Guidelines for the design of maritime structures](http://infostore.saiglobal.com);
3. British Standard BS 6349 Maritime Structures;
4. [Department of Transport and Main Roads Design guidelines for boat ramps](http://www.tmr.qld.gov.au/);
5. [Chapter 13](Ch13CommunityFacilities.docx) of this planning scheme policy.
6. If design requirements are not addressed in the listed standards, the design is to conform to other international codes of practice and design guidelines.

8.7.3 Design life

1. All waterway access structures are designed to achieve the minimum design life in [Table 8.7.3.A](#Table8p7p3A) without major maintenance or replacement of elements whilst remaining safe and functional.
2. If part of an asset, including asset items and asset sub-items, is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset of which it forms a part.
3. A replacement methodology is specified for components that have a life shorter than the structure design life.

Table 8.7.3.A—Minimum required design life

| Asset | Design life |
| --- | --- |
| Sea- and river walls, armoured embankments and scour protection | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management, and control systems | 100 years |
| Wharves, jetties and fishing platforms | 100 years |
| Boat ramps | 50 years |
| Pontoon abutments, piles, and gangways | 50 years |
| Drainage elements that are accessible for refurbishment and maintenance | 40 years |
| Signage support structures, barriers and other furniture | 40 years |
| Floating pontoons and pile guides | 25 years |

8.7.4 Durability

8.7.4.1 General

A waterway access structure and its associated works meet the following minimum requirements for durability.

8.7.4.2 Concrete durability

1. Minimum concrete strengths and associated nominated concrete covers thickness is to comply with the relevant Australian Standard.
2. Any cover spacers or permanent fixings to be incorporated within the concrete covers zone are structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.7.4.3 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork is protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and is:
2. of suitable grade to resist corrosion; or
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years.
4. At the end of that maintenance-free life, the coating is to remain soundly adhered to the metal substrate and suitable for overcoating without removal.
5. The re-coating has a minimum maintenance-free life of 25 years.
6. The minimum surface preparation includes Class 21/2 (SA 21/2) abrasive blasting in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com).

8.7.4.4 Timber durability

Timber waterway access structures are not permitted.

8.7.4.5 Miscellaneous components durability

1. Structures are designed to enable items such as expansion joint seals, railing and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.7.5 Minimum clearances

Minimum clearances for water access structures are compliant with [Table 8.7.5.A](#Table8p7p5A).

Table 8.7.5.A—Minimum clearances

|  |  |
| --- | --- |
| Location | Horizontal clearance min |
| Exposed faces and substructure to all other assets  | 0.6m |
| Exposed face and substructure to all other assets longer than 2m | 2m |
| Structure (including drainage) to property or easement boundary | 2m |

8.7.6 Barriers

Where barriers are required they, their fixings and supporting structure are:

1. designed to accord with all relevant Australian Standards;
2. safe, durable, robust and tamper proof.

8.7.7 Public utilities

A waterway access structure is designed to accommodate present and future requirements for services crossing the structure.

8.7.8 Hydrology

8.7.8.1 General

1. The impact of climate change during the structures life is assessed and taken into account in assessing tide height, flood levels and velocities.
2. Structures are designed to prevent or minimise increased flooding or flood pattern change.
3. Structures are designed as ‘fail safe’ so not to cause harm, injury or loss in the event of structural failure due to flood water and debris forces.

8.7.8.2 Fixed structures

Fixed waterway access structures are designed to:

1. survive all water and debris forces in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) arising from a 20 year [ARI](Appendix1IndexGlossary.docx) flood without structural damage;
2. survive 2000 year [ARI](Appendix1IndexGlossary.docx) floodwater and debris forces in compliance with [[[[AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=320873)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
3. minimise scour potential and incorporate appropriate scour protection to ensure the asset, pre-existing structures or the natural environment is not significantly undermined, damaged or structurally compromised as a result of a 100 year [ARI](Appendix1IndexGlossary.docx) flood.

8.7.8.3 Floating structures

Floating structures are designed to:

1. survive all water and debris forces in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) arising from a 20 year [ARI](Appendix1IndexGlossary.docx) flood without structural damage;
2. survive 100 year flood water and debris forces in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) with negligible risk of any part of the structure breaking loose or floating clear and causing harm;
3. minimise scour potential and incorporate appropriate scour protection to ensure the asset, pre-existing structures or the natural environment is not significantly undermined, damaged or structurally compromised as a result of a 100 year [ARI](Appendix1IndexGlossary.docx) flood.

8.7.9 Waterproofing

The designer ensures that water ingress, pressure or penetration will not cause accelerated degradation of the asset’s structure or unsightly staining/mould growth.

8.7.10 Material standards and specifications

Materials fit for purpose in the aggressive marine environment complying with relevant Australian Standards are used.

8.7.11 Applied loads

Applied loads are assessed in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873), [[AS 4997 Guidelines for the design of maritime structures](http://infostore.saiglobal.com/store2/Details.aspx?ProductID=319441)](http://infostore.saiglobal.com/store/Details.aspx?ProductID=319441), [AS 4678-2002 Earth-retaining structures](http://infostore.saiglobal.com/store/Details.aspx?ProductID=317062), [AS 1170 Loading Standard Series](http://infostore.saiglobal.com/store/Details.aspx?ProductID=356304) or British Standard BS 6469, whichever the greatest.

8.7.12 Structural inspections

All new, rehabilitated or extended structures have a Level 2 inspection at practical completion (On Maintenance) and end of the defects liability period (off maintenance) by a qualified inspector and the report issued electronically to Council for their records.

8.8 Sea- and river wall structures

8.8.1 Design principles

1. Section 8.8 outlines the design specifications, guidelines and standards in relation to the design and construction of sea- and river wall structures intended to be owned or maintained by Council.
2. Section 8.8 applies to sea and river wall structures and earth retaining structures liable to inundation causing scour.
3. Section 8.8 does not apply to other free standing earth retaining structures not liable to inundation causing scour.
4. The design and construction of sea- and river wall structures aligns with the following:
5. structural design is based on proven methods, materials and technology;
6. all structures have an attractive appearance appropriate to their general surroundings and any adjacent structures;
7. sea- and river walls must use simple, straight or large radius curved alignments sympathetic to foot or shared path alignment and interfaces with adjoining development, pathways, structures and environmental features;
8. sea- and river walls to conform to a consistent modular pattern, with emphasised vertical joints;
9. fixings for retaining structures are concealed or integrated as a design feature;
10. unless a feature of the architectural design, all structures are of uniform colour and surface finish, even after repair.

8.8.2 Design specifications and guidelines

1. All sea- and river wall structures are designed to accord with the following:
2. [AS 4997 Guidelines for the design of maritime structures](http://infostore.saiglobal.com);
3. [AS 4678-2002 Earth-retaining structures](http://infostore.saiglobal.com);
4. British Standard BS 6349 Maritime Structures;
5. [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
6. [Chapter 13](Ch13CommunityFacilities.docx) of this planning scheme policy.
7. Where the above references are silent in respect of a particular design aspect, the design is to conform to other international codes of practice and design guidelines.

8.8.3 Design life

1. All sea- and river walls are designed to achieve the minimum design life in [Table 8.8.3.A](#Table8p8p3A) without major maintenance or replacement of elements whilst remaining save and functional.
2. If part of an asset including asset items and asset sub-items is not readily accessible for maintenance or replacement, it satisfies the design life requirements of the asset of which it forms a part.
3. A replacement methodology is specified for components that have a life shorter than the structure design life.

Table 8.8.3.A—Minimum required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Sea- and river walls, armoured embankments and scour protection | 100 years |
| Inaccessible elements of the drainage, fire protection, lighting, mechanical, electrical, traffic management and control systems | 100 years |
| Drainage elements that are accessible for refurbishment and maintenance  | 40 years |
| Signage support structures, barriers and other furniture  | 40 years |

8.8.4 Durability

8.8.4.1 General

A sea or river wall structure and its associated works meet the following minimum requirements for durability.

8.8.4.2 Concrete durability

1. Minimum concrete strengths and associated nominated concrete cover thickness must comply with the relevant Australian Standard.
2. Any cover spacers or permanent fixings incorporated within the concrete cover zone must be structurally adequate, durable and compatible with the material characteristics of the surrounding concrete with good adhesion, so that their inclusion will not cause any cracking, spalling or other defect leading to corrosion of the reinforcement within the structure’s design life.

8.8.4.3 Structural steel durability – miscellaneous metalwork

1. Exposed metalwork must be protected in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com) exposure category E as a minimum, and:
2. are of suitable grade to resist corrosion;
3. protected by a high-grade protective coating having a minimum maintenance-free life of 25 years. At the end of that maintenance-free life, the coating must remain soundly adhered to the metal substrate and are suitable for overcoating without removal. The re-coating must have a minimum maintenance-free life of 25 years;
4. include a minimum surface preparation of Class 21/2 (SA 21/2) abrasive blasting as in compliance with [AS/NZS 2312:2002 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings](http://infostore.saiglobal.com).

8.8.4.4 Timber durability

Timber sea and river wall structures are not permitted.

8.8.4.5 Riprap durability

Riprap comprises of suitable rock greater than 450mm nominal diameter.

8.8.4.6 Miscellaneous components durability

1. Structures are designed to enable items such as expansion joint seals, railing and drains to be readily accessible for inspection, maintenance, renewal or replacement.
2. Structures are designed so that all corrosion protection systems including concrete covers can be easily inspected, maintained or renewed.

8.8.5 Minimum clearances

Minimum clearances for sea- and river walls are compliant with [Table 8.8.5.A](#Table8p8p6A).

Table 8.8.5.A—Minimum clearances

|  |  |
| --- | --- |
| Location | Horizontal clearance min |
| Exposed faces and structure to all other assets | 0.6m |
| Exposed face to all other assets longer than 2m | 2m or ½ retained height if greater |
| Structure (incl. drainage) to property or easement boundary | 2m or ½ retained height if greater |

8.8.6 Barriers

Where fall from height, pedestrian, bikeway or vehicle barriers are required they, their fixings and supporting structure are:

1. designed to accord with all relevant Australian Standards;
2. safe, durable, robust and tamper proof.

8.8.7 Public utilities

1. A seawall or river wall is designed to accommodate present and future requirements for services running through or close to the structure.
2. Services do not run within the wall.
3. Services do not run parallel to the wall within a distance of 2m or half of the retained height of the nearest structural face.

8.8.8 Hydrology

1. Sea- and river walls:
2. are designed to survive all water and debris forces in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873) arising from a 20 year [ARI](Appendix1IndexGlossary.docx) flood without structural damage;
3. are designed to survive 2000 year [ARI](Appendix1IndexGlossary.docx) flood water and debris forces in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873);
4. are designed to minimise scour potential;
5. incorporate appropriate scour protection to ensure the asset, pre-existing structures or the natural environment is not significantly undermined, damaged or structurally compromised as a result of a 100 year [ARI](Appendix1IndexGlossary.docx) flood.
6. The impact of climate change during the structure’s life is assessed and taken into account in assessing tide height, flood levels and velocities.
7. Structures are designed to prevent or minimise increased flooding or flood pattern change.
8. A structure is protected from accelerated degradation of the asset’s structure or unsightly staining or mould growth from water ingress, pressure or penetration by use of a bituminous membrane.

8.8.9 Material standards and specifications

Materials complying with the Department of Transport and Main Roads specifications must be used.

8.8.10 Applied loads

Applied loads are assessed in compliance with [AS 5100 Set-2007 Bridge Design Set](http://infostore.saiglobal.com/store/Details.aspx?ProductID=320873), [AS 4997 Guidelines for the design of maritime structures](http://infostore.saiglobal.com/store/Details.aspx?ProductID=319441), [AS 4678-2002 Earth-retaining structures](http://infostore.saiglobal.com/store/Details.aspx?ProductID=317062), [AS 1170 Loading Standard Series](http://infostore.saiglobal.com) or British Standard BS 6469 whichever the greater.

8.9 Fences

8.9.1 Design principles

1. Section 8.9 outlines the design specifications, guidelines and standards in relation to the design and construction of fences.
2. Section 8.9 applies to free-standing fence structures.
3. Section 8.9 does not apply to edge protection vehicle barriers.
4. The design and construction of fences aligns with the guideline, structural design is based on proven methods, materials and technology as per below.
5. Typical fence types and their application are identified in Table 8.9.1.A.

Table 8.9.1.A—Fence types and typical application

|  |  |  |  |
| --- | --- | --- | --- |
| Fence Type | Application | Benefits | Hazards |
| Two rail, post and rail fence | Pedestrian protection from slopes and other hazards | 1. Highly visible (with appropriate delineators
2. Low visual impact
 | 1. Potential hazard to vehicle if too close to roadway
2. Easily climbed
 |
| Traffic delineation along split level roadways – not preferred use | 1. Highly visible
2. Cost effective to construct
 | 1. End treatment can present spear hazard to vehicles
2. Will not restrain errant vehicle
 |
| Galvanised tubular handrail | Pedestrian protection or guidance on pathways | 1. Strong fence, not easily damaged
2. Good use for function, especially fences with mesh
 | 1. Potential hazard to vehicle if too close to roadway
2. Can be climbed over or through (no mesh)
 |
| Traffic delineation along split level roadways | None | 1. End treatment can present spear hazard to vehicles
2. Low visibility
 |
| Welded mesh fencing | Pedestrian protection or guidance on footpaths, traffic islands and similar | Good use for function | 1. Can have low visibility – requires appropriate colour and delineators
2. Easily damaged by vehicle strike
 |
| Pedestrian safety fencing | Pedestrian protection or guidance on footpaths, traffic islands and similar | 1. Strong fence, not easily damaged by pedestrian activity
2. Good use for function
 | 1. Risk of spear hazard from top rail
2. Can have low visibility – requires appropriate colour and delineators
3. Easily damaged by vehicle strike
 |

8.9.2 Design specifications and guidelines

1. A fence is:
2. designed and constructed in compliance with the following:
3. [AS 1926 Swimming Pool Safety](http://infostore.saiglobal.com);
4. [AS 1170 Loading Standard Series](http://infostore.saiglobal.com/store/Details.aspx?ProductID=356304);
5. [Noise impact assessment planning scheme policy](NoiseImpactAssessmentPSP.docx).
6. designed by a Registered Professional Engineer Queensland where regulation dictates.

8.9.3 Design life

All fence structures are designed to achieve the minimum design life in [Table 8.9.3.A](#Table8p9p3A) without major maintenance or replacement of elements whilst remaining safe and functional.

Table 8.9.3.A—Minimum required design life

|  |  |
| --- | --- |
| Asset | Design life |
| Open post and rail fencing | 40 years |
| Collapsible fencing | 40 years |
| Swing fencing | 40 years |
| Lifting fencing | 40 years |
| Timber acoustic fencing | 40 years |
| Concrete fencing | 40 years |
| Pool fencing | 40 years |

8.9.4 Requirements

1. The minimum standard of pedestrian safety fence is the galvanised tubular handrail as shown on [BSD-5207](Ch1Introduction.docx#Section114).
2. Powder-coated galvanised steel or aluminium pool fencing to [AS 1926 Set-2010 Swimming pool safety Standards Set](http://infostore.saiglobal.com) of minimum 1.2m height is the preferred barrier installation at a traffic island, signalised crossing or refuge island.
3. If there is a risk of children gaining access to high risk areas or if the drop height exceeds 1m, a fence is:
4. tubular handrail with chain wire to comply with [BSD-5207](Ch1Introduction.docx#Section114); or
5. galvanised weld mesh fencing [BSD-5207](Ch1Introduction.docx#Section114).
6. If the drop height exceeds 1.5m, a fence is powder-coated steel fence (hunter rod top or equivalent capable of sustaining the imposed actions specified in [AS/NZS 1170.1:2002 Structural design actions - Permanent, imposed and other actions](http://infostore.saiglobal.com).
7. Where required, a log barrier fence including a lock rail for access is provided in compliance with [BSD-5207](Ch1Introduction.docx#Section114).
8. The construction standards of a typical 2m high timber acoustic fence are shown in [BSD-7021](Ch1Introduction.docx#Section114) and [BSD-7022](Ch1Introduction.docx#Section114). These drawings do not represent suitable noise attenuation for all developments. Site specific attenuation solution for each development should be determined in accordance with the attenuation criteria and methodologies set out in the Noise impact assessment planning scheme policy.
9. Fencing does not hinder general maintenance. Fencing incorporates vehicular access gates, or fencing panels are designed for easy removal to allow vehicular access.
10. Pedestrian gates are incorporated in fences on road frontages.
11. A concrete (extruded or cast in situ) mowing strip is provided under a timber fence or wall or a galvanised steel fence (including an acoustic barrier) where the fence interfaces with lawn and landscaped areas.
12. A concrete mowing strip is a minimum of 140mm wide x 100mm deep, and is flush with the surrounding ground.
13. A mowing strip is not required under masonry or concrete fences if the footings provide access for mowing.
14. Under the [Neighbourhood Disputes Resolution Act 2011](https://www.legislation.qld.gov.au/Acts_SLs/Acts_SL_N.htm), Council is required to share the cost of a dividing fence where the Council has freehold ownership of the adjoining property. Council is not liable for costs where the land it controls is crown land held in trust (e.g. parkland or roads) nor is Council responsible for sharing fencing costs at easements that are granted in favour of Council inside private properties.
15. Council approvals are required where:
16. Council contributes towards the cost of fencing;
17. fencing is proposed inside any drainage easement or overland flow path or flood regulation line or waterway corridor hydraulic constraints.
18. It is preferred that fencing is not erected inside a drainage easement, overland flow path, flood regulation line or waterway corridor.
19. Fences that inhibit the conveyance of floodwaters (e.g. debris retaining, solid fences) are not preferred.
20. If solid fences are used between private lots where the overland flow is shallow (generally less than 200mm deep), solid fences can be constructed provided that openings are installed at ground level to accommodate overland flows.
21. Fencing styles that are appropriate inside a drainage easement, overland flow path, flood regulation line or waterway corridor are open post and rail, collapsible fencing, swing fencing and lifting fencing.
22. Open post and rail is where no panels of fencing are incorporated between the post and rail structure to provide minimum resistance to flood flows (e.g. log barrier fencing, galvanised tubular handrail).
23. Collapsible fencing is where sections of the fence are designed to collapse under flood loading so as not to increase flood levels, but are also anchored to avoid being washed away.
24. Collapsible fencing has low strength ties holding it in place during non-flood times.
25. Swing fencing is where sections of the fence are designed to yield under the pressure of flood flows so as not to increase flood levels, but are also anchored to avoid being washed away.
26. Panels in swing fencing are fitted with hinges or pivot points to allow opening during floods.
27. Swing fencing has low strength ties holding it in place during non-flood times.
28. Lifting fencing is where sections of the fence may be temporarily raised to not obstruct flood flows.