DPTI DESIGN STANDARD: STRUCTURAL

CONTENTS
1. General
2. References
3. Safety in Design
4. Design Requirements for Bridges
5. Interpretation of the Bridge Design Standard
6. Materials and Durability
7. Design Requirements for Major Sign Structures
8. Design Requirements for Noise Barriers
9. Design Requirements for Anti Throw Screens
10. Records
11. Appendix 1: AS 5100 – Corrections and Additional Requirements
   Appendix 2: Precast reinforced concrete culverts shear design guidelines
   Appendix 3: Design summary
   Appendix 4: Structure capacity summary

1. GENERAL
This Design Standard specifies the requirements for the design of the following structures:
(a) bridges and associated structures which support loading from road traffic, light
railways, heavy railways, pedestrians and / or bicycles;
(b) underpasses (traffic and pedestrian);
(c) culverts with a clear span greater than or equal to 1.5 m;
(d) major drainage structures and structures for Utility Services;
(e) noise barriers; and
(g) non-standard sign support structures, such as cantilever signs and gantries.

Refer to DPTI Design Standard:"Retaining Walls" for the design of (bored pile / continuous
flight auger (CFA) / secant pile / and soil nailed) retaining walls.

Refer to DPTI Design Standard:"Reinforced Soil Structures" for the design of reinforced
soil structures.

“Small Box Girder” means girders which are inaccessible internally, including Super –T
and voided slab structures.

“Medium Box Girder” means a box girder with internal access and an internal vertical
clearance less than 2.0 m.
“Large Box Girder” means a box girder with an internal vertical clearance greater than or equal to 2.0 m.

“Design Life” in regard to concrete, means the time for de-passivation of concrete at the reinforcing layer to occur plus 20 years to when surface cracks start to appear.

In this Design Standard, “Part” means a part of the DPTI Master Specification.

2. REFERENCES

Unless specified otherwise, all design and/or documentation must comply with the following:

1. DPTI: Structures Group Drafting Guidelines for Consultants
2. DPTI: Shear Design Guidelines for Culverts
3. AS 1100: Technical Drawing
4. AS 1312: Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
5. AS 1428: Design for Access and Mobility
6. AS 2865: Confined Spaces
7. AS 4678: Earth Retaining Structures
8. AS 4680: Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
9. AS 5100: Bridge Design


3. SAFETY IN DESIGN

The design process must take safety into account to ensure that the structures can be safely constructed, operated and maintained. Risks must be eliminated or minimised “so far as is reasonably practicable”. The design of girder bridges must comply with the requirements of the Worksafe Victoria Publication: “Construction and Erection of Bridge Beams”.

The Contractor shall design structures that do not permit easy or unauthorised pedestrian access (e.g. ledges and overhanging structures that can be easily accessed etc.). The design of measures to prevent unauthorised access shall be incorporated into the design of the structure(s).

Use of loose material, that could represent a hazard if used by a vandal to throw into the path of traffic, shall not be permitted as part of any treatment.
4. DESIGN REQUIREMENTS FOR BRIDGES

4.1. General
Bridges (and where relevant, other structures) must be designed to meet the requirements of this clause and Clause 5 “Interpretation of the Bridge Design Standard”.

4.2. Accessibility for Inspection and Maintenance
All structures must be designed and constructed to provide for ease of inspection and maintenance in accordance with the relevant Australian Standards.

Deck joints must be readily accessible with provision to allow for inspection, maintenance and replacement in accordance with AS 5100.4, Clause 17.3 "Requirements". Where stormwater pipes are embedded within the structure, the pipes must be accessible for cleaning and must be fire-proof in the event of a hydrocarbon fire.

Bearings must be readily accessible with provision to allow for inspection, maintenance and replacement (including jacking of components) in accordance with AS 5100.4, Clause 7 "General Design Requirements".

The design / drawings must:
(a) ensure that bearing replacement can take place without the need to close the bridge;
(b) include a procedure for replacement, including details of any traffic speed / lane restrictions required during replacement; and
(c) indicate permissible jacking locations and estimated jack loads on the drawings.

4.3. Box Girder Bridges
Safe access for inspection of medium and large box girders must be provided in accordance with the following:

<table>
<thead>
<tr>
<th></th>
<th>Medium Box Girder</th>
<th>Large Box Girder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal lighting and</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>power supply for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to each internal cell</td>
<td>Lockable hatch in bottom flange, located at least every second span.</td>
<td>Lockable hatch through abutments and/or in bottom flange, located at least every second span.</td>
</tr>
<tr>
<td>Access through internal diaphragms</td>
<td>Minimum opening 1.0 m wide x 0.6 m high</td>
<td>Minimum opening 0.9 m wide x 2.0 m high</td>
</tr>
<tr>
<td>Position of internal diaphragm access openings</td>
<td>The opening invert must be positioned at a convenient height to crawl through - i.e. not level with the bottom flange floor, with ramps provided to the invert.</td>
<td>The opening invert must be level with the top surface of the box girder bottom flanges.</td>
</tr>
<tr>
<td>Ventilation holes</td>
<td>One 75 mm diameter hole in the bottom flange of each box girder span covered with bird proof mesh.</td>
<td>One 100 mm diameter hole in the bottom flange of each box girder span covered with bird proof mesh.</td>
</tr>
</tbody>
</table>

Access hatches must be positioned to allow for practical ease of access and to minimise the need for traffic control when in use. Accessibility design must comply with the requirements of AS 2865 Confined Spaces.
All box girders must incorporate bird proofing.

Large Box Girders constructed of concrete must have circular internal fillets of sufficient radii to mitigate stress concentrations due to torsional shear flow.

Large Box Girders must include additional post-tensioning ducts and anchorages for installation of future tendons.

4.4. **Super T-Beams – Bearings**

Where Super T-beams are used and are designed to be placed with the top flange of the beam matching the deck crossfall, the bearings must be placed horizontally and consideration given to have the bearing centreline vertically in line with the centre of gravity of the beam to ensure beam stability during erection. The design must compensate for crossfall by providing a tapered plate between the beam and the bearing.

Bridges with a skew angle of 35 degrees or greater must have special consideration given to the detailing at the ends of the beams.

4.5. **Post-tensioned Elements**

Where structural components incorporate post-tensioned elements, the design must clearly state whether the basis of the design is bonded or unbonded stressing tendons with appropriate annotations being made on the construction drawings.

Segmental precast post-tensioned structures must use oversize ducts to allow for additional strand capacity in the event of duct blockages.

4.6. **Drainage of Voids in Bridge Superstructures**

Where bridge superstructures contain voids (e.g. box girder, super T-Beam, voided slab construction and voids under footway slabs, etc.) provision must be made for drainage to ensure no pooling of water within any void. For voids in beams, the drainage outlet must have an opening not less than 25 mm in diameter. For all other voids, the drainage outlet must have an opening not less than 50 mm in diameter. For voids under footway slabs, provision must be made for drainage of the void with drainage taken to drainage pits off the structure and connected to an appropriate drainage system.

4.7. **Joints in Girder Bridges**

Stepped or half-joints must not be used in girder bridge designs.

4.8. **Bridge Approach Slabs**

Bridges must be provided with adequately designed and suitably proportioned approach slabs with a minimum length of 3 m in cuts and 5 m in fills.

At each bridge abutment, one end of the approach slab must be tied to the abutment to prevent sliding of the approach slab relative to the abutment and settlement of the road surface next to the bridge. In fill areas provision must be made to jack the bridge approach slabs after any settlement occurs. The methodology for re-levelling of bridge approach slabs after settlement occurs must be included in the design drawings.

Approach slabs shall be designed in two equal width parts with a construction joint along the centreline (of the bridge/approach slab). Lift points shall be included at the approach slab end (away from the bridge deck) to facilitate lifting of the approach slab. The methodology for re-levelling of bridge approach slabs after settlement occurs shall be included in the design drawings.
The approach slab nosing adjacent to the bridge shall be designed to allow a minimum pavement thickness of 325 mm to be placed over the remainder of the approach slab. The approach slab shall then grade downwards away from the bridge deck at a 10% slope.

4.9. Bridge Abutments

Where an abutment has a sloping embankment beneath the bridge superstructure, slope protection must be provided at least over the area directly underneath the bridge superstructure. The slope protection must:

(a) blend in and harmonise with the environment;
(b) require minimal maintenance;
(c) be structurally stable; and
(d) have a uniform plane surface; and
(e) paving bricks or rock and the like, if used, must be adequately bonded in place to prevent removal by vandals.

Where the depth of soft soil over weathered bedrock exceeds 3 m, raking pile configurations must not be used in abutments. Care must be taken in the design to avoid damage to the bridge abutment from movements of soft soil caused by loading from the approach embankment. Down drag (negative skin friction) effects due to settlement on piles must be allowed for in the design of such piles together with methods to reduce such effects.

The design and prediction of soil movement must be undertaken and documented by a qualified geotechnical and foundation Professional Engineer.

4.10. Utility Services and Lighting

Where required, the design must provide for road lighting, feature lighting, telecommunications and/or incident management systems in bridge structures by the provision of conduits on both sides of the structure and if practicable, incorporated into the kerb or footpath. Conduits must not be visible. All conduits must be provided with draw cords.

Where road lighting poles and/or incident management columns to be positioned on a bridge structure, provision must be made for conduit connections including cable junction boxes between the poles / columns and the street lighting / incident management system conduits. Any conduits, poles or columns must not be positioned inside the traffic and pedestrian barriers and must satisfy roll allowance requirements where within the clear zone. These items shall ideally be positioned outside the clear zone else behind a barrier and they shall (wherever possible) be fixed independently of the barrier so as not to fall onto traffic in a design barrier impact accident. This may require an independent footing system passing through the barrier.

Gas and water mains must not be located inside box girders. Other services may be located inside box girders provided they are carried by appropriate racks or brackets. In multi-beam bridges, services must be located between beams, above the soffit plane.

Exposed fixtures must be grade 316 stainless steel. Fixtures inside box girders must be hot-dip galvanised steel or stainless steel. Fixtures must not be attached by drilling into concrete.

Any ferrules cast into the structure must be hot-dip galvanised steel or grade 316 stainless steel.
Design of Utility Services and lighting on structures must be in accordance with the requirements of Part “D027 Design -Utility Services” and Part D029 “Design – Lighting” respectively.

All infrastructure (e.g. supports, brackets, pits, etc) associated with services shall be approved by the relevant service authority.

There shall be no sag under dead loads and utility services loads.

4.11. Plaques
Note, bridge / culvert identifying plaques are no longer required on new structures as of May 2015.

4.12. Attachments
Attachments to concrete sections of the structure (e.g. holding down bolts) must be cast into the structure and not fitted after construction. These must be hot-dip galvanised steel or grade 316 stainless steel.

4.13. Pedestrian / Bicycle Bridges
Bridges that are exclusively for pedestrians and/or bicycles must comply with the following:
(a) provision for the disabled must be made in accordance with AS 1428 "Design for Access and Mobility";
(b) where a level rest area is provided (including a rest area on the approaches), straight edge kerbs must be provided in order to conceal the deck when viewed in elevation;
(c) the requirements of Austroads: Guide to Road Design;
(d) include provision for the incorporation of fully enclosed screens in accordance with AS 5100.1 – 12.3 “Protection screens for objects falling or being thrown from bridges”; and
(e) where the bridge passes over a road, piers must not be located in a road median or the clear zone wherever possible. The protection barrier provisions of section 4.19 apply to piers within a median or clear zone.

4.14. Deck Waterproofing
At a minimum, bridge deck waterproofing membranes must:
(a) be applied over the whole deck area; and
(b) as far as practicable – over (vertical) negative moment regions of fully integral abutment bridges; and
(b) consist of an approved modified bitumen product over negative moment regions. Other approved products may be used elsewhere on the deck.

4.15. Lightning Strike Protection
This clause applies where metallic structures that protrude more than 2 m above the deck surface are attached to the bridge (such as lighting support structures, traffic signal supports and traffic sign structures).

The bridge must incorporate lightning strike protection that effectively provides an electrical connection between the metallic structures and earth. This must include one or more of the following:
(a) electrical connectivity of all reinforcement and support structures;
(b) installation of lightning conductors of cross sectional area and frequency in accordance with AS 1768; and
(c) installation of flexible electrical conductors to bypass bearings (if present) complying with AS 1768.

Any ITS equipment mounted on the bridge must incorporate lightning strike protection in accordance with AS 1768.

4.16. Earthquake Design Provision

Bridges must be designed using the provisions of AS 5100.2 and AS 1170.4, using an earthquake annual probability of exceedance of 1 in 2000 years. Notwithstanding any conflicting terminology used in these standards, the following provisions must apply:

(a) the Acceleration coefficient (a) is assumed to be equal to the Hazard factor (Z).
(b) the Probability Factor (kp) must be taken as 1.7.
(c) the Site Factor (S) must be determined using the soil profile definitions from AS 1170.4-2007 and the following:
   - for Site sub-soil Class Ae, S is assumed to be 0.67
   - for Site sub-soil Class Be, S is assumed to be 1.0
   - for Site sub-soil Class Ce, S is assumed to be 1.25
   - for Site sub-soil Class De, S is assumed to be 1.5
   - for Site sub-soil Class Ee, S is assumed to be 2.0

Note: In determining the Bridge earthquake design category (BEDC) using AS 5100.2 Table 14.3.1, the Probability factor kp is not applied.

(d) The Importance factor (I) is assumed to be 1.0.
(e) Static analysis must be undertaken using the provisions of AS 5100.2, except that the Horizontal design earthquake force (H*u) must be taken as equal to V and calculated using AS 1170.4-2007 and the following:
(f) The Structural performance factor (Sp) is deemed to be 1.0.
(g) The Structural ductility factor (μ) is deemed to be 0.7Rf, where Rf is the Structural response factor from AS 5100.2 Table 14.5.5.
(h) The H*u upper limit from AS 5100.2 Clause 14.5.2 is increased by a factor of 1.7.

The detailing of reinforcement must comply with Section 10.7.3.5 in AS 5100.5.

Lapping of reinforcement (including legs of ligatures) will not be permitted within concrete cover zones, in the area between the outside face of the main flexural reinforcement and the surface of the member.

Lapping of reinforcement in potential plastic hinge zones is not permitted. The location of potential plastic hinge zones must recognise the possibility of a seismic event larger than that used in the design. Potential laps within adjacent piles in piled retaining walls shall also be staggered to avoid issues with potential plastic hinges.

Pile helices must be anchored in accordance with AS 2159. If it is not possible to extend helices into capping beams, pile caps or footings, they must be anchored at their ends by an extra 1½ turns and then welded onto themselves in accordance with AS 1554.3, or coggd into the pile around a longitudinal bar. This ligature shall end within 50 mm of the pile concrete end adjacent to the capping beam, pile cap or footing. A series of ligatures must then extend into the capping beam, pile cap or footing to restrain the longitudinal pile starter bars as per relevant code(s) requirements.
4.17. Anti Graffiti Coating
Where an anti-graffiti treatment has been specified, it must:
(a) be approved to APAS – 1441/1 where a permanent clear finish is required;
(b) be approved to APAS – 1441/2 where a colour is required; and
(c) comply with the technical requirements specified in Vicroads Standard Specification
Section 685 Anti-Graffiti Protection and Graffiti Removal, available from:

4.18. Aesthetic Requirements
White cements are not permitted for use in any part of any structure.
Where there is significant variability in the colour of concrete finishes in highly visible
areas, painting of concrete must be used to provide a consistent uniform appearance.
Soffit planes of bridges must be in plane (i.e. girder underside levels shall be the same
height as adjacent girder(s)). These planes will allow for the necessary crossfalls and
longitudinal falls required above and below the bridge soffit.

Piers are to be avoided in a road median or the clear zone wherever possible. Where
piers are used the following provisions must be applied.
Irrespective of protection provided, all piers and vertical abutments must be designed for
the collision load specified in AS 5100.2 – 10.2. Where the road speed environment
is 80 kph or greater, the collision load must be increased to 3000 kN.
Protection barriers must extend past the limits of the pier / abutment to a minimum of 15 m
on the approach side, and a minimum of 8 m on the trailing side for a road speed
environment of 80 kph or greater. The barrier length may be reduced for lower speed
environments (as per Austroads requirements) however a minimum of 4 m must be
provided on the trailing side.
Bridge piers and vertical bridge abutments must have TL5 rigid concrete barrier protection
in accordance with the following options, in order of precedence:

Option 1 – Barrier with > 3.0m clearance from the back of barrier to the face of the
pier/abutment
A 1070 mm high TL 5 barrier shall be used where there is at least 3 m clearance from the
back of barrier to the face of the pier, and meet the following requirements:
1a Roll allowance to Austroads, Part 6, Table 6.8.
1b Designed in accordance with drawing S-4064, Sheet 2.
1c A minimum 1500 mm wide 75 mm thick asphalt strip (adjacent to the back of the
barrier) between the barrier and the pier.
1d Barrier set 75 mm into the asphalt.

Option 2 – Barrier with 0.3 m to 3.0 m clearance from the back of barrier to the face
of the pier
A 1300 mm high TL 5 barrier shall be used for 0.3 m to 3 m clearance from the back of the
barrier to the face of the pier, and meet the following requirements:
2a Roll allowances to Austroads, Part 6, Table 6.8.
2b Designed for a 500 kN transverse impact load as per AS 5100.2, Table A1.
2c The barrier and integrated footing/piles shall either be structurally designed and
have reinforced concrete footing/piles with full strength, moment and shear barrier
connections or the barrier, footing and connection can be based on full scale crash
testing (reference note 3 – barriers at front of rigid structural hazards, Drawing S-
4064, Sheet 3).

2d  Shall span the length of the pier and be approved by the Commissioner.

2e  Backfill between the barrier and the pier shall be subject to approval by the
Commissioner.

Option 3 – Barrier separated 0.05 m to 0.3 m from the back of barrier to the face of
the pier

The design impact load for the pier footing must be the collision load from AS 5100.2-
10.2, increased if the speed environment is 80 kph or greater.

The barrier shall be connected to the pier footing where there is 0.05 m to 0.3 m clearance
from the back of the barrier to the face of the pier, and meet the following requirements:

3a  Roll allowances to Austroads, Part 6, Table 6.8.

3b  Designed for a 500 kN transverse impact load as per AS 5100.2, Table A1. No
component of barrier impact loading shall be transferred to the pier behind.

3c  Backfill between the barrier and the pier shall be subject to approval by the
Commissioner.

Approval of alternative barrier treatments will be at the sole discretion of the
Commissioner.

The clear zone for barrier deflection purposes adjacent to layback abutments shall be
taken from the carriageway edge line to the toe of the layback abutment.

Layback abutments shall be treated as non-frangible elements for the purpose of
calculating barrier deflection requirements.

4.20. Bridge Deck and Upper Retaining Wall Traffic Barriers

Bridge barrier components, including precast concrete elements, must be placed with a
tolerance of ± 5 mm from the design location.

Concrete finish and installation tolerances shall be in accordance with AS 3610 (Class 3)
and AS/NZS 3845.1 Draft. The concrete colour shall be standard portland grey.

Attachments such as light poles, signs, cameras, throw screens, noise walls and urban
design attachments will not be permitted to be attached to bridge traffic barriers. Any
such items shall be set behind the roll allowance clear width.

Clear widths for roll allowance behind the barrier shall be in accordance with Table 6.8 of
Austroads, Part 6 Guide to Road Design. This clear width shall be measured from the toe
(bottom) of the barrier and extend upwards above the barrier over the full 4.3 m height of
the design vehicle envelope.

Barrier transitions must be designed for the appropriate design loading at each end of the
transition element.

At its leading end, the barrier shall be transitioned into the crash cushion or another type
of barrier with a suitable crashworthy terminal. Alternatively it shall have another type of
impact protection as approved by DPTI.

Design drawings must show an isometric view of the connecting element between the
bridge barrier and the approach barrier, if appropriate.

Installation of service conduits within the barrier is not allowed.
4.21. Traffic Barriers and Roll Allowance

Roll allowance clear widths to Austroads, Part 6, Table 6.8 must be provided behind all barriers from the toe of the barrier up to a height of 4.3m. Where non-rigid barriers are used, design barrier deflection widths must be added to the roll allowance clear width.

4.22. Bridge piers

Horizontal reinforcement near the base of piers for vertical crack control must take into account the restraining effect of the footing or pile cap.

4.23. Elastomeric bridge bearings

All elastomeric bearings shall have keeper plates top and bottom. A tapered steel bearing plate between the bridge girder and upper (flat) bearing plate shall be used.

4.24. Deck Joints

Decks of bridges shall be continuous over the full length of the bridge with movement joints permitted at the abutments only for bridges less than 100 m long. Adequate provision shall be made for end diaphragms to move against the fill (where applicable).

Intermediate deck joints shall not be used in bridges where the deck length is less than 100 m. Where abutment movement joints are not used, adequate provision shall be made for end diaphragms to move against the fill.

For bridges over 100 m long, joints shall be used. Free draining finger plate type joints are preferred provided joint geometry is suitable for cyclists as appropriate. Bonded steel/rubber type joints shall not be used. Where finger plate type joints are used, adequate measures, including drainage, shall be taken to prevent water or other liquids from staining any pier or abutment, causing any damage to any bearing or restraint or causing corrosion or deterioration to concrete or metal surfaces.

Joints shall not inhibit the proper placement of concrete and shall have adequate provision for maintenance and inspection access. Joints shall be detailed and constructed such that the noise generated by traffic crossing the joint is kept to a minimum. If modular type joints are used they shall comply with the Road Traffic Authority New South Wales (RTA) specification B316 "Modular Bridge Expansion Joints".

The maximum open gap of deck joints shall be limited to 70 mm at the serviceability limit state and 85 mm at the ultimate limit state. The use of steel angles exposed at deck level as part of the joint system is not permitted. Sliding plate expansion joints shall not be used for road bridges except for adjacent footpaths. Anchorage of deck joints shall be in accordance with AS 5100.4, Clause 17.4 "Anchorage of Deck Joints."

4.25. Substructures

Depending upon the grade separation type, pile caps shall be designed so the top of the pile cap is below ground level and not visible (i.e. road (at grade) and under the elevated bridge) or the piles and pilecaps shall be covered by an approved facade (i.e. where the bridge (at grade) is over the depressed road).

Driven piles may be used subject to Clause 3 “Environmental Authorisations” of Part G50 “Environmental Management Requirements” and approval by the Superintendent.
5. **INTERPRETATION OF THE BRIDGE DESIGN STANDARD**

The design must be undertaken using the clarifications and interpretations of AS 5100 Bridge Design contained within this Clause.

AS 5100 must be read to incorporate the corrections listed in Appendix 1: “AS 5100 – Corrections”. The Design Report must include details of any additional interpretations or clarifications proposed.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Requirement</th>
</tr>
</thead>
</table>
| AS 5100.1 – 6.2  
"Design Life" | **ELEMENT**  
Structures, excluding the elements listed below | DESIGN LIFE (Years) |
| AS 5100.1 – 9.6  
"Horizontal Clearance to Substructure Components of Bridges over Roadways" | All piers adjacent to roadways must be designed for collision load in accordance with AS 5100.2 - 10 "Collision Loads". Where the design speed of the adjacent roadway is 80 kph or greater, the collision load applied in AS 5100.2 - 10.2 must be increased to 3000 kN. The clear distance between the edge of the lane and the face of such barrier must be in accordance with Austroads: Guide to Road Design; Part 6A - Roadside Safety. |
| AS 5100.1 – 14  
"Drainage" | Drainage water from the bridge must not discharge directly into any water course, railway line, traffic lane or footpath. The drainage system must be designed so that a minimum amount of water flows across deck joints. Free draining scuppers through decks must not be used. All pipework for structure drainage must be corrosion resistant, fire proof and must be concealed from all public view except from directly underneath. All drainage structures must be readily accessible for cleaning and maintenance purposes. All drainage must be conducted to the ends of the bridge or culvert for disposal. |
| AS 5100.3 – 14  
"Buried Structures" | For the design of culverts, the culvert units are assumed to be able to sway. |
### Clause Requirement

<table>
<thead>
<tr>
<th>Clause</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS 5100.4 – 5 &quot;Functions of Bearings and Deck Joints&quot;</td>
<td>Intermediate deck joints must not be used in bridges where the deck length is less than 100 m. Where abutment movement joints are not used, adequate provision must be made for end diaphragms to move against the fill. For bridges over 100 m long, joints must be used. Free draining finger plate type joints are preferred provided joint geometry is suitable for cyclists as appropriate. Bonded steel / rubber type joints must not be used. Where finger plate type joints are used, adequate measures, including drainage, must be taken to prevent water or other liquids from staining any pier or abutment, causing any damage to any bearing or restraint or causing corrosion or deterioration to concrete or metal surfaces. Joints must not inhibit the proper placement of concrete and must have adequate provision for maintenance and inspection access. Joints must be detailed and constructed such that the noise generated by traffic crossing the joint is kept to a minimum. If modular type joints are used, the joints must comply with the Road and Maritime Services (New South Wales) specification B316 &quot;Modular Bridge Expansion Joints&quot;, available from: <a href="http://www.rta.nsw.gov.au/doingbusinesswithus/specifications/bridgeworks.html">http://www.rta.nsw.gov.au/doingbusinesswithus/specifications/bridgeworks.html</a> The maximum open gap of deck joints is limited to 70 mm at the serviceability limit state and 85 mm at the ultimate limit state. The use of steel angles exposed at deck level as part of the joint system is not permitted. Sliding plate expansion joints must not be used for road bridges except for adjacent footpaths. Anchorage of deck joints must be in accordance with AS 5100.4, Clause 17.4 &quot;Anchorage of Deck Joints&quot;.</td>
</tr>
<tr>
<td>AS 5100.5 – 9.2.2 &quot;Design Shear Strength of Slabs&quot;</td>
<td>The shear strength of culvert slabs must be calculated in accordance with Appendix 2: &quot;Precast Reinforced Concrete Culverts Shear Design Guidelines&quot;.</td>
</tr>
<tr>
<td>AS 5100.5 – 2.8 “Cracking”</td>
<td>Minimum reinforcement must be 500 mm²/m for any 300 mm length or width of concrete element.</td>
</tr>
</tbody>
</table>

### 6. MATERIALS AND DURABILITY

#### 6.1. General

In addition to the requirements specified in Division CC “Concrete”, Division S “Structures” of the DPTI Master Specification and AS 5100, the Works must be designed to comply with the requirements of this clause.

Materials, components and processes for all permanent works must provide the required durability for each element of the works. Where an item is not readily accessible for maintenance or replacement, it must be designed so that it will function for the life of the structure without maintenance.

The Design Documents must clearly display details of all materials to be incorporated into the Works.
6.2. **Concrete**

6.2.1 Durability design for concrete must be in accordance with the AS 5100 with the following additional requirements:

(a) Dense, durable high strength concrete must be used. The minimum strength of concrete to be used must be 40 MPa except for blinding, mass or unreinforced concrete. In areas of severe exposure (equal to or exceeding AS 5100.5 – 4.3 exposure classification B2), blended cements must be used.

(b) Where the exposure equals or exceeds AS 5100.5 – 4.3 exposure classification B2, the concrete must be specified as High Durability Concrete (refer Clause 320.9 “High Durability Concrete”).

(c) Concrete mix design must include design for the prevention of the deleterious effects of erosion, delayed ettringite attack, acid attack, sulphate attack and alkaline aggregate reaction as applicable.

(d) Special measures must be taken to minimise the possible deleterious effects of heat of hydration in thick concrete sections, e.g. by the use of blended cements, cooling the concrete during curing, insulated forms and larger aggregates.

(e) For thick concrete members, the Design Documents must include details of the methodology to ensure that the maximum differential temperature between core and surface concrete does not exceed 25°C and the maximum concrete temperature anywhere does not exceed 82°C.

(f) Epoxy coated reinforcement must not be used.

(g) Cast-in-place stitch pour concrete (i.e. such as that used to connect precast concrete barriers to concrete bridge decks) must have a maximum shrinkage of 600 microstrain.

(h) Reinforcement elements crossing construction joints must be galvanised, where the construction joint;
   
   (i) is subject to constant exposure to weather; or
   
   (ii) is located in a highly visible area; or
   
   (iii) is in a critical location where it is possible that water may enter through a crack at the construction joint and cause corrosion of the reinforcement in the life of the structure. This includes construction joints below the water table and in-situ infill concrete within precast traffic barriers.

(i) All bridge and culvert structures must conform to the following requirements:

   (i) Durability planning and design must incorporate the recommendations of the Concrete Institute of Australia publication: *Recommended Practice, Durability, Z7*; and

   (ii) The design must incorporate a Durability Plan prepared by a durability consultant, in accordance with (i) and 6.5.

6.2.2 Testing to verify that the proposed concrete mix design will achieve the specified properties may be undertaken sufficiently early to enable the test results to be incorporated into the design. If this is not practicable, the design must incorporate a range of concrete properties, as indicated in AS 5100.5.

6.2.3 Creep and shrinkage testing.

The designer may choose to undertake the following testing to refine their design;

(a) Prior to the receipt of long term testing results on creep, shrinkage and modulus of elasticity of the concrete mix design, the Structural Engineer shall use a range of parameters equal to plus and minus 30% of the creep factor and design shrinkage...
strain and plus and minus 20 % of the modulus of elasticity of concrete determined from AS 5100.5.

(b) Following receipt of shrinkage and creep testing, the Contractor may adopt the actual values in the design for creep, shrinkage and modulus of elasticity. The concrete mix components tested in accordance with this clause, including aggregate, additives and cement, must be obtained from a single material source with sufficient dedicated resources to ensure that the concrete in all components constructed from that mix has constant concrete properties, including heat generation, shrinkage and creep.

(c) The results of this testing plus any available past testing of similar concrete mixes using the proposed constituent materials, shall be used to inform the Contractor and may be used to modify the range of creep and shrinkage parameters adopted in the design, subject to the approval of the Superintendent.

6.3. Steelwork

Unless specified otherwise, all exposed steelwork must be either:

(a) hot dipped galvanised in accordance with AS 4680; or

(b) protected by a high grade protective coating system.

The life to major maintenance of a protective coating system must not be less than 25 years. Coating systems must include a primer and finish coat as a minimum.

Any painting system over galvanised steel shall have a 10 year warranty against chipping, flaking, peeling or bubbling without the need for periodic preventative maintenance.

The assessment of the corrosivity at the location of the structure must be carried out in accordance with AS 4312 and take account of any knowledge of microclimates or other influencing factors specific to the location. The use of uncoated corrosion resistant steel in a situation where the steelwork can be seen by pedestrians or road users is not permitted.

The Design Documents must include the Contract Specific Requirements (CSR) for Part 435 “Protective Treatment of Structural Steelwork” and include full details of the protective treatment design in the CSR.

Where hot dipped galvanizing is to be used, the Design Documents must include all specific details necessary for Part 437 “Galvanizing”, which includes the information listed in Appendix A “Purchasing Guidelines” of AS 4680.

Site welding of the steelwork must be used as a last resort, in order to minimise damage to steelwork protective treatment(s).

Selection of the coating system must be based on Table 6.3 of AS 2312 for the appropriate corrosivity category.

The coating system used must be selected from the following system designations, as detailed in Table 6.3 of the 2004 amendment to AS/NZS 2312:

1) EHB6 (Primer must be PRN C01a, C01b or C01c).
2) PSL1 (System must include an additional intermediate coat of PRN C13 epoxy MIO to 125µm).
3) PUR5 (Primer must be PRN C01a, C01b or C01c).
4) Where a decorative or aesthetic finish is desired, only systems PSL1 and PUR5 may be used.
The total minimum dry film thickness for each coat must be as specified for the designated system detailed in Table 6.3 of AS/NZS 2312, measured in accordance with test procedure MAT-TP913.

Submission and Acceptance of steel coating systems shall constitute a HOLD POINT.

Fasteners to be hot dip galvanized in accordance with AS 1214 (bolts and nuts) and AS 4680 (washers).

6.4. Balustrades and Barriers
Replaceable pedestrian balustrades and barriers must have a minimum life to major maintenance of 30 years. Non-replaceable balustrades and barriers must have a design life as specified in Clause 5.

Ferrules must be galvanised or stainless steel. Zinc plated ferrules will not be permitted.

6.5. Durability Plan
This clause applies where a Durability Plan has been specified.

The Durability Plan must address all key elements addressing how the required design life will be achieved and be prepared by a person with appropriate qualifications and extensive experience in this field.

For concrete structures, the Durability Plan must:
(a) use chloride diffusion and carbonation coefficients that are based on testing of the concrete mix designs to be utilised in each of the concrete elements;
(b) adopt a probabilistic performance based durability design approach; and
(c) account for the expected variation in these concrete properties and in the concrete cover and surface chloride concentration; and
(d) conform to 6.2(i).

Durability of uncompacted concrete must be demonstrated by a rapid chloride permeability test on the proposed concrete mix design prior to commencement of construction.

In thick concrete members, special measures must be taken to limit the maximum differential temperature between core and surface concrete to 25°C and the maximum concrete temperature anywhere must not exceed 82°C.

6.6 Super T Girders
Strand cutting and coating of the end of the strand must be delayed for as long as practical, with a minimum of 3 days, after de-moulding of beams. The strand end face coating shall allow for further shortening of the girder (relative to the remaining debonded strands) by providing suitably sized voids at the end of each individual debonded strand prior to epoxy coating of the girder end.

Strands that are debonded along their entire length must be fully removed as soon as practical after de-moulding of the beams. The void left from the removed strand must be plugged with a high build, non sagging epoxy paste.

The inside (void) face of the bottom flange of Super T girders does not require reinforcement normal to the longitudinal axis of the girder.

Prestressing wire strand must comply with AS 4672.
7. **DESIGN REQUIREMENTS FOR MAJOR SIGN STRUCTURES**

Major sign structures (including cantilever signs and gantries over traffic) must comply with AS 5100.2 clause 23. Where a structure supports electric or electronic devices or equipment, the structure must incorporate provision for all necessary ducts, cables, cable trays and junction boxes.

Fatigue provisions in accordance with AS 5100.6, Section 13 will apply. The number of fatigue stress cycles at the serviceability limit state must be taken as 100,000 cycles. The fatigue strength of members and welded connections must be determined using full stress reversal for the stress range. For bolted connections and holding down bolts stress reversal need not apply. For holding down bolts where levelling nuts are used, full stress reversal must be considered.

If the structure supports a Variable Message Sign, an access platform must be provided for the full length of the overhead structure (refer Part 266 Clause 9 "Access Platform"). The platform must be free of sharp corners and projections that may cause injury and must not obstruct the rear access doors to the sign.

The design tolerances for Gantries shall be as in DPTI gantry drawing 7276, Sheet 1, and in AS/NZS 5100.6.

The allowable clearance under a Gantry sign to the pavement shall be a minimum of 6.5 m.

All components shall be hot dip galvanized after fabrication in accordance with AS/NZS4680 prior to galvanizing, steel work to be blast cleaned to Class 3 in accordance with AS 1627.4, to preparation grade SA-3 in accordance with ISO 8501-1.

If painting of galvanized steel is required, all galvanised surfaces to be abrasive sweep (brush) blast cleaned in accordance with AS/NZS 4680, Appendix 1 and painted with primer suitable for the selected brand of the top coat.

The top coat shall be one coat of a two pack polyurethane gloss finish as approved under APAS-2911 to a minimum dry film thickness of 50 um.

The location of the gantries shall be assessed for traffic safety in accordance with Austroads GRD Part 6: Roadside Design, Safety and Barriers to determine appropriate level of traffic protection. The Contractor shall provide the proposed safety protection drawings for each gantry for the Superintendent's approval before the gantry installation.

Submission of designs for major sign and gantry structures, including traffic barrier protection systems and urban design elements shall constitute a **HOLD POINT**.

8. **DESIGN REQUIREMENTS FOR NOISE BARRIERS**

This clause applies where noise barriers are specified.


Where noise barriers are located in the vicinity of traffic barriers, the noise barriers must be located outside of the traffic barriers with sufficient clearance to avoid any damage in the event of vehicular impact upon the traffic barriers. The noise barriers must:

(a) not rattle or vibrate;

(b) be vandal resistant;

(c) facilitate straightforward and efficient maintenance, repair and replacement. The construction and material of the screen shall result in little or no maintenance over the period of its design life;
The Design Report must include information on resistance of the barrier to the following:
(a) impact resistance from 4 kg projectile dropped from height of 3.0 m;
(b) defacement by sharp implements;
(c) graffiti; and
(d) ignition by cigarettes or similar.

9. DESIGN REQUIREMENTS FOR ANTI THROW SCREENS
(a) design loads for the anti–throw screen shall be as per the AS 5100.2 Draft Code;
(b) maximum deflection shall be h/300 (h = height of the screen) for a 1 in 20 ARI windload;
(c) must be designed for fatigue based on a wind speed of 20 m/s and 100,000 cycles;
(d) typical screen geometry and details such as mesh size must be in accordance with AS 5100.1 cl. 12.3;
(e) screens must be located outside the roll allowance clear width behind the barrier which shall be in accordance with Table 6.8 of Austroads, Part 6 Guide to road design. This clear width shall be measured from the toe (bottom) of the barrier (traffic side face) and extend upwards above the barrier over the full 4.3 m height of the design vehicle envelope. For flexible barrier systems, deflection shall also be allowed for;
(f) all screen panels (where used) to be tethered to the post and depending on the material type shall be of an anti-shatter type;
(g) to prevent electrochemical reaction, isolation shall be provided between incompatible materials of the screen system;
(h) the use of weathering steel will not be permitted where it is possible for water runoff from the element to stain other elements, and that this staining is visible and likely.
(i) the screen design (and general structural form) shall prevent climbing by unauthorised person(s). Anti-climbing devices should be included in the screen design if there is a risk of accessing the screen or behind screen. Anti-climbing devices must be approved by the Principal and the submission of their design shall constitute a HOLD POINT.

10. RECORDS
The following records must be prepared:

**Drawings**
Construction drawings in hard copy and AutoCAD format. The drawings must be to a level of detail such that no further production of drawings (e.g. ‘shop detail drawings’) will be required to assist construction. Any reference to any standard or ancillary drawings on any sheet must have the reference to its sheet number.

**As constructed drawings**
The drawings shall be drafted and presented in accordance with the DPTI: Road Design Standards and Guidelines and Part D10 “Design – General”.

**Reports**
The design report(s) must include:
(a) A full set of design calculations, incorporating calculations and determinations for all elements, appropriate sketches and details;
(b) Details of structural design, including:
**Maintenance Plan**

A plan providing comprehensive details of the maintenance required for the structure, including procedures and time schedules for the repair and/or replacement of elements such as bearings and expansion joints.

As a minimum, the procedures shall include in detail:

(a) a copy of the Durability Plan;
(b) details of the frequency and extent of inspection required;
(c) details of the frequency and extent of monitoring required;
(d) Deterioration levels at which rectification work or replacement is required;
(e) intervention methods; and design limitations/considerations;
(f) details of how to safely access locations for regular maintenance, inspections or replacement of elements;
(g) method of replacement of specific elements;
(h) contact details of suppliers of replacement elements and spares;
(i) warranties on proprietary products;
(j) any manuals and drawings available from the manufacturer of all externally supplied components used in the works, including mechanical and electrical elements; and
(k) a historical record of construction issues and their resolutions.

### 11. HOLD POINTS

In addition to the Hold Points required under Part D10: Design requirements – General, and Part D35, the following is a summary of Hold Points referenced in this Part:

<table>
<thead>
<tr>
<th>Clause Ref.</th>
<th>Hold Point</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Submission of Durability Plan and Report</td>
<td>10 Days</td>
</tr>
<tr>
<td></td>
<td>Inspection and Maintenance Procedures</td>
<td>10 Days</td>
</tr>
<tr>
<td></td>
<td>Anti-throw screen design(s)</td>
<td>10 Days</td>
</tr>
<tr>
<td></td>
<td>Major sign structures and associated traffic barrier protection system designs</td>
<td>10 Days</td>
</tr>
<tr>
<td></td>
<td>Concrete mix designs and testing for concrete design parameters</td>
<td>10 Days</td>
</tr>
</tbody>
</table>
ATTACHMENT D35.A

PRECAST REINFORCED CONCRETE CULVERTS

SHEAR DESIGN GUIDELINES

For the design of precast culvert slabs, the strength of slabs in shear shall be calculated as follows.

The factored shear resistance at any location shall be taken as

\[ V_r = \phi V_n \]

and

\[ V_n = (bd) V_b S_m (F_d / F_n) \]

For which:

\[ \phi = 0.9 \text{ (as in AASHTO for precast units)} \]

\[ V_b = 5.23 \sqrt{f_c (0.0175 + \rho)} \leq 0.191 \sqrt{f_c} \]

\[ b = \text{width of section} \]

\[ d = \text{distance from compression face to centroid of tension reinforcement} \]

\[ \rho = \frac{A_s}{\phi bd} \leq 0.02 \text{ (\% steel at section)} \]

\[ F_d = 0.8 + \left( \frac{40}{\phi d} \right) \leq 1.25 \]

\[ F_n = 0.5 - \left( \frac{N_u}{6V_u} \right) + \left[ 0.25 + \left( \frac{N_u}{6V_u} \right)^2 \right]^{0.5} \]

\[ f_c = \text{cylinder strength} \leq 50\text{Mpa} \]

\[ N_u = \text{thrust (axial load) at the section, compression +ve.} \]

\[ V_u = \text{shear at the section} \]

\[ M_u = \text{moment at the section} \]

\[ S_m = \frac{4}{[(M_u / V_u \phi d) + 1]} \text{ ** See below} \]

*** Where \( (M_u / V_u \phi d) > 3 \), use \( (M_u / V_u \phi d) = 3 \) (i.e. \( S_m = 1.0 \))

*** Where \( (M_u / V_u \phi d) < 3 \), limit \( (V_b) (S_m) \leq 0.373 \sqrt{f_c} \)

## APPENDIX 1

**AS 5100 – CORRECTIONS AND ADDITIONAL REQUIREMENTS**

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>EXISTING WORDING (where applicable)</th>
<th>CORRECTED / ADDITIONAL WORDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 – Scope and General Principals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix B</td>
<td>Figures B3.3.1 to B3.3.4</td>
<td>Figures B5 to B8</td>
</tr>
<tr>
<td>Figure B1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix B</td>
<td>Figures B3.3.1 to B3.3.4</td>
<td></td>
</tr>
<tr>
<td>Figure B1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix B</td>
<td>Figures B3.3.1 to B3.3.4</td>
<td></td>
</tr>
<tr>
<td>Figure B1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 2 – Design Loads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause 6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Load Platform Loads</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The design loads for bridges are the W80, A160, SM1600 and HLP400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The lateral placement of the HLP400 is: -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) <strong>Two marked lane bridge</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>± 1.0 m either side of centreline of the bridge, or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) <strong>Three or more marked lanes</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In two <strong>marked</strong> lanes with the vehicle travelling ± 1.0 m either side of centre of any two adjacent <strong>marked</strong> lanes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consideration should be given to the most likely path of the vehicle. The code co-existent half SM1600 on the adjacent lane(s) shall be applied to create the worst effect. An Accompanying Lane Factor of 1.0 shall be applied to this co-existent load.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) <strong>One lane ramp</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shall be positioned on a one lane ramp as located by the designer. The tolerance on lateral position shall be specified.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) The designer location of the HLP400 shall be shown on the General Arrangement drawing.</td>
<td></td>
</tr>
<tr>
<td>Clause 6.7.3(ii)</td>
<td>0.1 for a cover depth of 2 m or more for all loads excluding S1600</td>
<td></td>
</tr>
</tbody>
</table>
## AS 5100 –CORRECTIONS AND ADDITIONAL REQUIREMENTS

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>EXISTING WORDING (where applicable)</th>
<th>CORRECTED / ADDITIONAL WORDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause 8.5.1 2nd paragraph, 2nd line</td>
<td>8.5.4 8.5.5</td>
<td>8.5.5</td>
</tr>
<tr>
<td>Clause 11.2.1 First sentence</td>
<td>The design criteria, including loads and geometric requirements, provided in this Clause 11 and in AS 5100.1, Clause 10 shall be used for the following</td>
<td></td>
</tr>
<tr>
<td>Fig 15.2.1 Horizontal axis, right end</td>
<td>0.2 2000</td>
<td>2000</td>
</tr>
<tr>
<td>Fig 17.3 structure depth d</td>
<td>structure depth D</td>
<td>structure depth D</td>
</tr>
</tbody>
</table>

### Section 4 – Bearings and Deck Joints

| Clause 12.6.8 (c) | For plain pads and strips: For plain pads and strips the value of the compressive strain (εc) to be used in deriving the compressive deflections (dc) shall be determined as follows: |
| Clause 14.2 2nd paragraph | AS 1449 ASTM A240/A240M-03b |

### Section 5 – Concrete

<p>| Additional requirements to AS 5100.5 for prestressed members | Maximum compressive stress at transfer: 0.6f_{cp} (in accordance with Clause 8.1.4.2) Maximum compressive stress at all other times: 0.4f_{c} Maximum compressive stress when HLP320 or HLP400 present: 0.6f_{c} |
| Clause 8.6.2(a) (ii) | The increment in steel stress beyond decompression shall be 170 MPa for SM1600 and 200 MPa for the HLP400 loading combinations. |</p>
<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>EXISTING WORDING (where applicable)</th>
<th>CORRECTED / ADDITIONAL WORDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clause 8.6.2(b)</td>
<td>Segmental members at unreinforced joints under all serviceability limit state loadings except those incorporating the HLP320 or HLP400, a minimum pre-compression of 1.0 MPa shall exist. For all serviceability limit state loadings incorporating the HLP320 or HLP400, tension stress shall not be permitted. For dry joints, a minimum pre-compression of 1.5 MPa and 0.5 MPa shall exist for these loadings respectively.</td>
<td></td>
</tr>
<tr>
<td>Table 4.10.3(A)</td>
<td>Concrete decks on deck units and T girders only For: • exposure classification B2, and • concrete decks on deck units and T girder superstructures, the cover of the top reinforcing steel shall conform to AS 5100. However, the cover on the bottom reinforcement above the deck units and/or T girder may be reduced to 40 mm. The cover of the bottom reinforcement on the cantilever shall be: • 40 mm in a benign environment • In accordance with AS 5100 in wet areas or over salt water.</td>
<td></td>
</tr>
<tr>
<td>Equation 8.1.6(1)</td>
<td></td>
<td>$\delta_{pu} = \delta_{p,ef} + 6200 \times \frac{(d_p - k_u d)}{L_{pe}}$</td>
</tr>
<tr>
<td>Clause 8.6.1 (a)</td>
<td>This clause is deleted</td>
<td></td>
</tr>
<tr>
<td>Clause 13.3.2 Third paragraph</td>
<td>0.1$L_p$</td>
<td>0.1$L_{pt}$</td>
</tr>
<tr>
<td>Appendix H Figures H1(B) and H1(C) - Bottom flange thickness on all cross sections</td>
<td>1$b$</td>
<td>$t_b$</td>
</tr>
<tr>
<td><strong>REFERENCE</strong></td>
<td><strong>EXISTING WORDING (where applicable)</strong></td>
<td><strong>CORRECTED / ADDITIONAL WORDING</strong></td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td><strong>Section 6 – Steel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clause 5.1.8.3</td>
<td>( \alpha_s = 0.6 \left( \frac{M_s}{M_{oa}} \right)^2 + 3 \left( \frac{M_s}{M_{oa}} \right) )</td>
<td>( \alpha_s = 0.6 \left( \frac{M_s}{M_{oa}} \right)^2 + 3 \left( \frac{M_s}{M_{oa}} \right) )</td>
</tr>
<tr>
<td>Equation 5.6.1.1(2)</td>
<td>( \alpha_s = 0.6 \left( \sqrt{\frac{M_s}{M_{oa}}} \right)^2 + 3 \left( \sqrt{\frac{M_s}{M_{oa}}} \right) )</td>
<td>(Error: length of square root sign)</td>
</tr>
<tr>
<td>Equation 5.6.1.2(1)</td>
<td>( M_o = \frac{\pi^2 EI_y}{L_e^2} \sqrt{GJ + \left( \frac{\pi^2 EI_w}{L_e^2} \right) + \left( \frac{\beta_x}{2} \frac{\pi^2 EI_y}{L_e^2} \right) + \left( \frac{\beta_x}{2} \frac{\pi^2 EI_y}{L_e^2} \right)} )</td>
<td>( M_o = \frac{\pi^2 EI_y}{L_e^2} \left[ GJ + \left( \frac{\pi^2 EI_w}{L_e^2} \right) + \left( \frac{\beta_x}{2} \frac{\pi^2 EI_y}{L_e^2} \right) + \left( \frac{\beta_x}{2} \frac{\pi^2 EI_y}{L_e^2} \right) \right] )</td>
</tr>
<tr>
<td>Equation 5.6.2</td>
<td>( \alpha_s = \left( \sqrt{\frac{M_s}{M_{ob}}} \right)^2 + 3 \left( \sqrt{\frac{M_s}{M_{ob}}} \right) )</td>
<td>( \alpha_s = 0.6 \left( \frac{M_s}{M_{ob}} \right)^2 + 3 \left( \frac{M_s}{M_{ob}} \right) )</td>
</tr>
<tr>
<td>Table 5.6.5(A)</td>
<td>( 1 + \frac{\left( \frac{d_1}{L} \right) \left( \frac{\ell_f}{2w} \right)^3}{n_w} )</td>
<td>( 1 + \frac{\left( \frac{d_1}{L} \right) \left( \frac{\ell_f}{2w} \right)^3}{n_w} )</td>
</tr>
</tbody>
</table>
## AS 5100 – CORRECTIONS AND ADDITIONAL REQUIREMENTS

### Table 5.6.5/B

<table>
<thead>
<tr>
<th>Table</th>
<th>Longitudinal position of the load</th>
<th>Restraint arrangement</th>
<th>Load height position</th>
<th>Longitudinal position of the load</th>
<th>Restraint arrangement</th>
<th>Load height position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shear centre</td>
<td>Top flange</td>
<td></td>
<td>Shear centre</td>
</tr>
<tr>
<td></td>
<td>Within segment</td>
<td>FF, FP, FL, PP, PL, LL, FU, PU</td>
<td>1.0 1.0</td>
<td>1.4 2.0</td>
<td>FF, FP, FL, PP, PL, LL,</td>
<td>1.0 1.4</td>
</tr>
<tr>
<td></td>
<td>At segment end</td>
<td>FF, FP, FL, PP, PL, LL, FU, PU</td>
<td>1.0 1.0</td>
<td>1.0 2.0</td>
<td>FU, PU</td>
<td>1.0 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>At segment end</td>
<td>FF, FP, FL, PP, PL, LL,</td>
<td>1.0 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FU, PU</td>
<td>1.0 2.0</td>
</tr>
</tbody>
</table>

### Equation A4 (3)

\[ K = \sqrt{\pi^2 \frac{EI_w}{GL^2}} \]

**Appendix A**

### Equation E (5)

\[ M_p = f_y[A d_g - b_f (d_h + d_s) d_b] \]

**Appendix E**

\[ M_p = f_y[A d_g - b_f (d_h - d_s) d_b] \]

### Equations

\[ \lambda_d = 0.018 \left( \frac{L_b}{r_y} \right)^{1/2} \left( \frac{d_w}{t_w} \right)^{1/3} \]

**Error:** ‘– 0.4’ missing

\[ \lambda_d = 0.018 \left( \frac{L_b}{r_y} \right)^{1/2} \left( \frac{d_w}{t_w} \right)^{1/3} - 0.4 \]

\[ K = \pi \sqrt{\frac{EI_w}{GJ}} \]
<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>EXISTING WORDING (where applicable)</th>
<th>CORRECTED / ADDITIONAL WORDING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 7 Rating of Existing Structures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix A</td>
<td>Diagram of Fig. A11, A12, A13</td>
<td>Shifted to Fig. A13, A11, A12</td>
</tr>
<tr>
<td></td>
<td>Diagram of Fig. A12</td>
<td>Shifted to Fig. A13</td>
</tr>
<tr>
<td></td>
<td>Diagram of Fig. A13</td>
<td>Shifted to Fig. A12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All three Figures should have two notes: ‘Dimensions in metres’ and ‘Axle loads in kN’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The title of Fig. A12 should be ‘Figure A12 300-A-12 Railway Traffic Loadings Axle Group Spacings’</td>
</tr>
<tr>
<td>Appendix A</td>
<td>Figure A12</td>
<td>Figure A11</td>
</tr>
<tr>
<td>Clause A 3.2, first sentence Line 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appendix A</td>
<td>Figure A13</td>
<td>Figure A12</td>
</tr>
<tr>
<td>Clause A 3.2, first sentence Line 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2

PRECAST REINFORCED CONCRETE CULVERTS

SHEAR DESIGN GUIDELINES

For the design of precast culvert slabs, the strength of slabs in shear shall be calculated as follows.

The factored shear resistance at any location shall be taken as

\[ V_r = \phi V_n \]

and

\[ V_n = (bd) V_b S_m (F_d / F_n) \]

For which:

\[ \phi = 0.9 \] (as in AASHTO for precast units)

\[ V_b = 5.23 \sqrt{f_c} (0.0175 + \rho) \leq 0.191 \sqrt{f_c} \]

\[ b = \text{width of section} \]

\[ d = \text{distance from compression face to centroid of tension reinforcement} \]

\[ \rho = \frac{A_s}{\phi bd} \leq 0.02 \] (\% steel at section)

\[ F_d = 0.8 + \left(40 / \phi d\right) \leq 1.25 \]

\[ F_n = 0.5 - (N_u / 6V_u) + [0.25 + (N_u / 6V_u)^2]^{0.5} \]

\[ f_c = \text{cylinder strength} \leq 50\text{Mpa} \]

\[ N_u = \text{thrust (axial load) at the section, compression +ve.} \]

\[ V_u = \text{shear at the section} \]

\[ M_u = \text{moment at the section} \]

\[ S_m = \frac{4}{\left[(M_u / V_u \phi d) + 1\right]} \] ** See below

*** Where \((M_u / V_u \phi d) > 3\), use \((M_u / V_u \phi d) = 3\) (i.e. \(S_m = 1.0\))

*** Where \((M_u / V_u \phi d) < 3\), limit \((V_b) (S_m) \leq 0.373 \sqrt{f_c} \)

## APPENDIX 3

### Form STR-DP1-2

**DESIGN SUMMARY**

<table>
<thead>
<tr>
<th>Plan No.</th>
<th>Project Leader:</th>
<th>Date:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Project:</th>
</tr>
</thead>
</table>

**Structure Description:**

**Design Standard:**

**Roadway Width:**

**No. Design Lanes:**

**Vehicle Loads:**

<table>
<thead>
<tr>
<th>Load Type</th>
<th>DLA (%)</th>
<th>Transverse positions of loads considered</th>
</tr>
</thead>
</table>

**Load Distribution:**

**Other relevant design decisions:**

*Include the following where applicable:*

- variations from Codes,
- information critical to the design or future structure performance
APPENDIX 4
Form STR-DP1-3
STRUCTURE CAPACITY SUMMARY

Designer: ___________________ Date: _______________ PLAN NO. _______________

Checked: ___________________ Date: _______________

Structure / Road names:

Structure Description: ____________________________________________________________

Design Year: ___________ Design Standard: _______________________________________

Line Diagram of Structure (show spans used in analysis):

Diagram of cross section:

LIVE LOAD CAPACITIES

<table>
<thead>
<tr>
<th>ULTIMATE STRENGTH:</th>
<th>Edge Beam²</th>
<th>Internal Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate LL Moment Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERVICEABILITY: (PSC only)³ Required: Yes [ ] No [ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LL Moment Capacity  - (steel stress increment)</td>
<td>- 150 MPa</td>
<td>- 200 MPa</td>
</tr>
</tbody>
</table>

Shear or Reaction check required? Yes [ ] No [ ] If yes, complete capacity information on reverse side

Live Load Distribution Factor⁴
Comments:

DLA used in design

If Shear or Reaction is likely to be critical, complete the following capacities:
(only complete if required. Insert dash in cell if not critical)

LIVE LOAD CAPACITIES

<table>
<thead>
<tr>
<th>ULTIMATE STRENGTH:</th>
<th>Edge Beam</th>
<th>Internal Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate LL Shear Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultimate Reaction on Substructure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES

1. These forms are suitable only for simply-supported structures. For continuous structures, capacities are required at tenth points along each span. Attach capacities as appropriate. For continuous structures, the dead load effects, superimposed dead load effects, and any other load effects considered, shall also be included, together with the limit state load factors applied. If negative moment redistribution has been applied in the design, the redistribution percentage shall be given.

2. For structures without beam components (e.g. box girders, slabs etc), only complete one column. For slabs, indicate the width of slab to which the capacity applies. For culvert structures, provide corner and mid-span live load moment capacities.

3. Serviceability capacities are only required for prestressed concrete structures. The crack control provision of AS 5100.5 - clause 8.6.2 (a) (ii) and (b) shall be used for two cases as follows:

<table>
<thead>
<tr>
<th>Steel Stress Increment Past Decompression</th>
<th>Stress Past</th>
<th>Min. Compression at Joints</th>
<th>Concrete Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 MPa Case</td>
<td>150 MPa or 0.55fy†</td>
<td>1.0 MPa (1.5 MPa dry joints)</td>
<td></td>
</tr>
<tr>
<td>200 MPa Case</td>
<td>200 MPa or 0.75fy†</td>
<td>0 MPa (0.5 MPa dry joints)</td>
<td></td>
</tr>
</tbody>
</table>

†Whichever is lesser, fy refers to reinforcement only (this governs for low strength steel e.g. grade 230).
‡Segmental structures only.

4. The Live Load Distribution Factor is that proportion of load from a standard design lane that is distributed to the critical structural element, i.e. it is the actual load effect in the critical structural element divided by the load effect from one full design lane of load on the same structural element.

5. Designer to assess if shear or reaction capacity may be critical in assessing future vehicle loads on the structure. If likely to be critical, shear or reaction capacities are required.