

BTN 016

Design of Box Culverts and Underpasses

6 June 2023
Version 2.0

1. Scope and Application

Bridge Technical Note BTN 016 – Design of Box Culverts and Underpasses – states the Department of Transport and Planning’s (DTP’s) requirements for the design of precast and cast in-situ concrete box culverts and underpasses on DTP’s road network.

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

Bridge Technical Notes are a Code of Practice. Compliance with Bridge Technical Notes is mandatory.

BTN 016 is to be read in conjunction with the following documents:

- AS 1597.1 Precast reinforced concrete box culverts Part 1: Small culverts (not exceeding 1200 mm span and 1200 mm height)
- AS 1597.2 Precast reinforced concrete box culverts Part 2: Large culverts (exceeding 1200 mm span or 1200 mm height and up to and including 4200 mm span and 4200 mm height)
- AS 3850.3 Prefabricated Concrete Elements – Civil Construction
- AS 5100: Bridge Design - Series
- DTP’s Standard Sections
- BTN 011 - Approach Slabs
- BTN 023 - AS 5100 Part 3: Foundation and Soil-Supporting Structures

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

2. Definitions

Box Culverts - square/rectangular structures with single or multiple cells that allow water to flow under a road, railway, trail, or similar obstruction from one side to the other.

Underpasses - square/rectangular structures of passages under road, railway, trail, or similar obstruction to facilitate vehicles, pedestrian, reptiles, livestock or animal movement.

Minor Box Culverts and Underpasses (Minor BCUs) - are square/rectangular culverts and underpasses that have a maximum single span < 1.8 m and have a total waterway/open area < 3 m².

Minor BCUs include Type 1 and Type 2 as specified below:

- Minor Type 1 BCUs:
 - span of up to 1.2 m and;
 - height of up to 1.2 m and;
 - length up to 2.4 m and;
 - height of fill of up to 2 m



- Minor Type 2 BCUs:
 - span greater than 1.2 m or
 - height greater than 1.2 m or
 - length greater than 2.4 m or
 - height of fill greater than 2 m

The above dimensions are for single units.

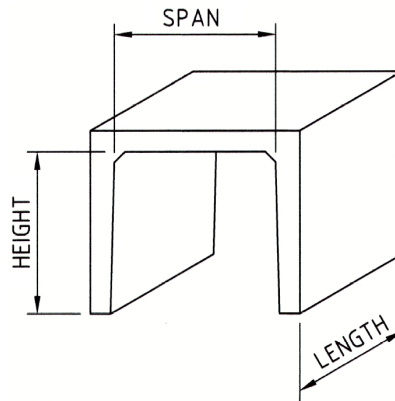


Figure 1: Typical box culvert and underpass unit

Major Box Culverts and Underpasses (Major BCUs) are square/rectangular culverts and underpasses with a minimum single span ≥ 1.8 m or have a single or combined waterway/open area ≥ 3 m².

Box culvert and underpass dimensions are measured between the internal faces (refer Figure 1). Height of fill is measured between top of structure and the finished road pavement level.

3. Design Requirements – General

The structural design of box culverts and underpasses must be in accordance with the following:

- Minor Type 1 BCUs - must meet the requirements of AS 1597.1, Standard Specification 619 and this BTN.
- Minor Type 2 BCUs - must meet the requirements of this BTN.
- Major BCUs - must meet the requirements of this BTN.

Designers should note that underpasses must be designed with appropriate clearances, finishes and lighting if required.

Soil reinforcement strips including metallic or synthetic strips are not allowed to be connected to the sides of any culverts or underpasses.

4. Materials / Durability

4.1. Concrete

Concrete must be in accordance with Standard Section 610.

The minimum concrete grade must be VR450/50.

Where underpasses are designed for livestock, the minimum concrete grade must be VR470/55.

4.2. Cover

For all culverts and underpasses, the minimum cover must be as specified in AS 5100.5 as read in conjunction with Standard Section 610 for the appropriate exposure classification.



4.3. Dimensional Tolerances

(a) Minor Type 1 BCUs

Tolerances must be in accordance with the requirements of Standard Section 619.

(b) All other box culverts and underpasses

Tolerances must be in accordance with the requirements of Standard Section 610.

4.4. Steel Reinforcement

Steel reinforcement must be in accordance with Standard Specification 611.

4.5. Foundation Material

Foundation material properties used for the design of box culverts and underpasses for a particular site must satisfy Section 5.11 and be determined from a suitable geotechnical investigation.

The geotechnical investigations must be carried out at locations as specified in BTN 023.

4.6. Defects

Minor Type 1 BCUs must be free from any surface finish defects as specified in Standard Section 619, Clause 619.14.

All other precast box culvert and underpass units must be free from any surface finish defects as specified in Standard Section 610, Clause 610.31.

5. Structural Design

The structural design must be in accordance with AS 1597.2 and AS 5100. No reference must be made to AS 3600. Where there are differences between AS 1597.2 and AS 5100, the AS 5100 requirements override those of AS 1597.2 unless noted otherwise in this BTN.

Design for all categories of box culverts and underpasses must be conducted by an engineering consultancy that is prequalified in accordance with DTP's Prequalification for Road & Bridge Design in Structures – Simple (SS).

Minor Type 2 BCUs and Major BCUs designs must be Proof Engineered by a Structural Proof Engineer prequalified in accordance with DTP's Prequalification Scheme.

5.1. Design Life

Box culverts and underpasses must have a design life of 100 years.

5.2. Durability

The minimum exposure classification for standard box culverts and underpasses must be B1. Where the exposure classification of the site is different, the culverts and underpasses must be designed in accordance with the requirements of AS 5100.5.

Underpasses designed for use for livestock must be designed for exposure classification C2.

5.3. Design Loads

5.3.1. General

All box culverts and underpasses must be designed using the requirements and design loads specified in AS 1597.2 and Section 3 of this BTN, except that the traffic loads must be as specified in AS 5100.2 (including dynamic load allowance) and as described in Section 5.3.2.

Culverts and underpasses must be designed for strength and serviceability limit states in accordance with AS 5100.5. The critical section for shear must be as shown in AS 1597.2 Figure 3.2.

Fatigue effects must be considered in accordance with AS 1597.2 and AS 5100.5.



5.3.2. Live Loads

All box culverts and underpasses must be designed for the worst load effect of W80, A160 Axle Load, SM1600 moving traffic load and where required for HLP400, as detailed in AS 5100.2. The dynamic load allowance factor as specified in AS 5100.2 with appropriate load factors must be used for these loads.

The methods described in AS 1597.2 Clause 3.3 is to be used to determine vertical and horizontal pressures due to these loads.

5.3.3. Site-specific Loads

All box culverts and underpasses must be designed for site-specific loads. For example resisting barrier loading on end walls, wingwall loads and settlement of foundation loadings.

5.3.4. Handling Loads

Provision must be made for lifting and handling all box culvert and underpass units in accordance with AS 5100 and AS 3850.3. The lifting devices and methods of handling must be determined by the Designer.

5.3.5. Construction Loads

Construction loads on all box culverts and underpasses must be in accordance with Standard Section 626, Clause 626.10 and Clause 626.11 or as specified.

5.4. Reinforcement

For Minor Type 1 BCUs, reinforcement must be in accordance with AS 1597.1.

Where the design incorporates low ductility Class L or normal Class N reinforcement for flexural strength, the Minor Type 1 BCUs must be designed using the capacity reduction factors shown in Table 1.

Table 1: Capacity Reduction Factor for Class L and N reinforcement

Reinforcement	Capacity Reduction Factor (Φ)
(a) For members with Class L reinforcement	0.65
(b) For members with Class L and Class N reinforcement	0.65
(c) For members with Class N reinforcement	AS 5100.5 Table 2.3.2

For all other box culverts and underpasses, the reinforcement must be in accordance with AS 5100.5 as modified by Standard Section 611. Class L reinforcement is not allowed to be used in the design for flexural strength as specified in AS 5100.5 Clause 1.2 (d).

For all box culverts and underpasses, the minimum reinforcement required in each direction must be no less than 454 mm²/m.

5.5. Width of Base Slab

The width of base slab must be a minimum of 100 mm wider than the outer face of the culvert or underpass units.

The width of bedding layer must be a minimum of 200 mm wider than the outer face of the base slab.

5.6. Hydraulic Requirements

For all box culverts that are designed for conveying water, the culvert walls must be a smooth continuous surface in the direction of the water flow to prevent entrapment of debris.

Shear keys in the base slab of box culverts carrying water must be sealed to prevent leakage.

The vertical joints between the box culvert units must be sealed to prevent any water escaping from inside the box culvert and penetrating the surrounding fill material.



5.7. Settlement

Where box culvert and underpass base slabs are to be cast in place in multiple sections, the base slabs must be connected by shear joints with dowels designed to prevent differential settlement between adjacent units. Precast base slabs must not be used.

The maximum total settlement of box culverts and underpasses must be no more than 20 mm over the design life of the structures.

Approved non-corrosive materials must be used for shear keys such as FRP or stainless steel with an elastic modulus equivalent or higher than the steel reinforcement.

5.8. Approach Slabs

If required, approach slabs are to be provided on both ends of box culverts and underpasses in accordance with BTN 011.

5.9. Wingwalls and End Walls

Wingwalls and end walls must be designed in accordance with AS 5100.

6. Load Testing for Design

Proposals for verification of product compliance that rely on the provisions stated in AS 1597.2 Appendix B (informative) must be submitted to the Superintendent for acceptance. The Superintendent may request further information to be submitted. The requested information must be provided within 7 days of the date the request is made.

7. Documentation

Two complete sets of final drawings must be supplied to DTP if requested.

7.1. Design Calculations

A copy of all design calculations must be supplied to DTP, for recording purposes if requested by the Superintendent. If requested, the information must be provided within 7 days of the date the request is made.

7.2. Test Load Results

Further to Section 6, if load-testing is used as a basis for design, the results of all load-testing must be made available to DTP if requested by the Superintendent. The load testing must be approved by DTP prior to the placement of any box culvert or underpass units.

In this case, records must be provided of routine sampling and testing in accordance with AS 1597.1 for Minor Type 1 BCU, and AS 1597.2 for other box culverts and underpasses.

7.3. Drawings

The following information must be shown on drawings for construction:

- fully dimensioned details;
- reinforcement details and tolerances;
- installation details for multi-cell culverts and underpasses;
- concrete exposure classification;
- grade of materials including the relevant Australian Standard to be used in the manufacture of the units;
- foundation soil type;
- foundation serviceability and ultimate limit state design-bearing pressures;
- calculated settlement values over the design life of the box culverts or underpass;
- traffic design loads including Dynamic Load Allowance;



- assumed dead load;
- any other live load;
- soil factors;
- fill depth over the culvert units;
- provisions for lifting of the culvert and underpass units;
- culvert unit volume and mass.
- the method of culvert and underpass installation.

8. Culvert Classes and Marking

It should be noted that the culvert classes specified in AS 1597.2 are for a fill height range. The minimum design requirement for culverts used on DTP's road network is Class 2-A.

Precast units must be marked permanently in accordance with Standard Section 619 Clause 619.15 and must include the exposure classification.

Contact Details

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



Document Control

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

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

Version	Description	Revision	Approved by
1.0	Original Publication	January 2018	Principal – Bridge Engineer
2.0	Amended Section 2, 3, 4, 5 and 7: <ul style="list-style-type: none">• Added definitions section• Added design requirement for different type of box culverts• Added tolerances and defects requirements• Added minimum reinforcement and reinforcement class requirements• Added requirement for width of base slab and precast base slab connection• Added settlement requirements• Amended the required documentation	6 June 2023	Senior Manager – Roads Engineering