

Australian Standard[®]

**Precast reinforced concrete box
culverts**

**Part 1: Small culverts (not exceeding
1200 mm span and 1200 mm height)**



This Australian Standard® was prepared by Committee CE-026, Precast Reinforced Concrete Box Culverts. It was approved on behalf of the Council of Standards Australia on 24 June 2010.

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 - Australasian Railway Association
 - Australian Chamber of Commerce and Industry
 - Concrete Pipe Association of Australasia
 - Engineers Australia
 - Institute of Public Works Engineering Australia
 - National Precast Concrete Association Australia
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-

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Australian Standard[®]

Precast reinforced concrete box culverts

Part 1: Small culverts (not exceeding 1200 mm span and 1200 mm height)

Originated as AS A136—1963.
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PREFACE

This Standard was prepared by the Standards Australia Committee CE-026, Precast Reinforced Concrete Box Culverts, to supersede AS 1597.1—1974, *Precast reinforced concrete box culverts*, Part 1: *Small culverts (not exceeding 1200 mm width and 900 mm depth)*.

The objective of this Standard is to provide designers, manufacturers, installers and specifiers of culverts with minimum requirements for the design, testing, manufacture and installation of precast reinforced concrete rectangular box culverts of spans up to 1200 mm.

The objective of this revision is to align the Standard with current manufacturing and installation practices as well as governing design codes.

The revised Standard provides for four types of culvert and a range of standard sizes up to and including 1200 mm span and 1200 mm height. Values for test loads are given, based on AS 5100, *Bridge design*, Part 2: *Design loads*.

Statements expressed in mandatory terms in notes to tables are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard
Precast reinforced concrete box culverts

Part 1: Small culverts (not exceeding 1200 mm span and 1200 mm height)

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out minimum requirements for the design, testing, manufacture and installation of precast reinforced concrete box culverts for conveying water not under pressure, and for carrying roadway and railway loadings permitted by AS 5100.2.

Culvert units, lids, link and base slabs manufactured in accordance with this Standard can be expected to achieve a design life in excess of 100 years.

Design requirements are focused on proving load and ultimate strength load testing. Alternatively, design by calculation in accordance with AS 1597.2 is acceptable.

1.2 APPLICATION

This Standard is applicable to rectangular precast culvert units having a maximum span of 1200 mm and maximum height of 1200 mm. Precast culvert units covered by this Standard have a nominal maximum length of 2400 mm and are used under a maximum fill height of 2 m (road load class) or 5 m (railway load class).

NOTES:

- 1 Guidelines to purchasers on requirements that may need to be agreed upon at the time of calling for tenders or quotations are detailed in Appendix A.
- 2 Information on means for demonstrating compliance with this Standard is given in Appendix B.
- 3 For precast reinforced box culverts of internal dimensions exceeding 1250 mm span or 1250 mm height, refer to AS 1597.2.
- 4 Additional design considerations may be required for special culverts, e.g., skewed ends, culvert units with large holes, roadway culverts subjected to loadings other than standard roadway loadings and fill heights greater than 2 m, and railway culverts subjected to loadings other than standard railway loadings and fill heights greater than 5 m.

1.3 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

1012	Methods of testing concrete
1012.1	Part 1: Sampling of fresh concrete
1012.8.1	Part 8.1: Method of making and curing concrete—Compression and indirect tensile test specimens
1012.8.2	Part 8.2: Method of making and curing concrete—Flexure test specimens
1012.9	Part 9: Determination of the compressive strength of concrete specimens

AS

- 1289 Methods of testing soils for engineering purposes
- 1289.3.6.1 Part 3.6.1: Determination of the particle size distribution of a soil—Standard method of analysis by sieving
- 1289.5.1.1 Part 5.1.1: Soil compaction and density tests—Determination of the dry density/moisture content ratio of a soil using standard compactive effort
- 1289.5.3.2 Part 5.3.2: Soil compaction and density tests—Determination of the field dry density of a soil—Sand replacement method using a sand pouring can, with or without a volume displacer
- 1289.5.3.5 Part 5.3.5: Soil compaction and density tests—Determination of the field dry density of a soil—Water replacement method
- 1289.5.4.1 Part 5.4.1: Compaction control test—Dry density ratio, moisture variation and moisture ratio
- 1289.5.5.1 Part 5.5.1: Determination of minimum and maximum dry density of a cohesionless material—Standard method
- 1289.5.6.1 Part 5.6.1: Compaction control test—Density index method for a cohesionless material
- 1379 Specification and supply of concrete
- 1478 Chemical admixtures for concrete, mortar and grout
- 1478.1 Part 1: Admixtures for concrete
- 1597 Precast reinforced concrete box culverts
- 1597.2 Part 2: Large culverts
- 1726 Geotechnical site investigations
- 2758 Aggregates and rock for engineering purposes
- 2758.1 Part 1: Concrete aggregates
- 3582 Supplementary cementitious materials for use with portland and blended cement
- 3582.1 Part 1: Fly ash
- 3582.2 Part 2: Slag—Ground granulated iron blast-furnace
- 3600—2009 Concrete structures
- 3972 Portland and blended cements
- 5100 Bridge design
- 5100.2 Part 2: Design loads
- 5100.5—2004 Part 5: Concrete
- AS/NZS
- 1554 Structural steel welding
- 1554.3 Part 3: Welding of reinforcing steel
- 3582 Supplementary cementitious materials for use with portland and blended cement
- 3582.3 Part 3: Amorphous silica
- 4671 Steel reinforcing materials

1.4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.4.1 Administrative

1.4.1.1 *Informative*

Not an integral requirement of this Standard and provided for information only.

1.4.1.2 *Manufacturer*

Person(s) or corporate body responsible for the manufacture of precast reinforced concrete box culverts.

1.4.1.3 *Normative*

An integral and mandatory requirement of this Standard.

1.4.1.4 *Purchaser*

Person(s), corporate body or regulatory authority to whom the manufacturer is contracted to manufacture the precast reinforced concrete box culverts.

1.4.1.5 *Regulatory authority*

An authority which is empowered by statute to exercise jurisdiction over the manufacture, supply and installation processes of a culvert.

1.4.1.6 *Specified*

Stated in writing in any document (including orders, drawings or specifications, or both) which forms a part, or the whole, of the contract between the purchaser and the manufacturer.

1.4.2 Technical

1.4.2.1 *Batch*

A group of culvert units, lids, link or base slabs of the same class and design, and produced under uniform conditions during a given production period, by the same process.

1.4.2.2 *Bed-zone*

The area between the foundation and the underside of the culvert (see Figure 1.1).

1.4.2.3 *Cover*

Distance between the outside of the reinforcing steel and the nearest permanent surface of the member excluding any surface finish, tie wire, bar chairs, nibs or spacers.

1.4.2.4 *Culvert*

A single cell or a multiple cell structure, and associated lids, link and base slabs.

1.4.2.5 *Culvert cell*

A complete conduit made up of a number of units placed end-to-end.

1.4.2.6 *Exposure classification*

A classification representing the degree of severity of exposure to the environment.

NOTE: For more information and determination of exposure classification, see AS 5100.5—2004.

1.4.2.7 *Fill*

One or more of the following:

- (a) *Backfill or embankment fill* Material placed over the overlay zone or adjacent to the side zone for the purpose of refilling a trench or creating an embankment (see Figure 1.1).
- (b) *Ordinary fill* Material obtained from excavation of the trench or elsewhere and containing no more than 20% by mass of stones with a size between 75 mm and 150 mm and none larger than 150 mm.
- (c) *Select fill* Material obtained from excavation of the trench or elsewhere with a particle size not greater than 75 mm, and which conforms with the following soil classes, as defined in AS 1726:
 - (i) SC.....clayey sands with fines of low plasticity.
 - (ii) SP.....poorly graded sands.
 - (iii) SW..... well-graded sand.
 - (iv) GC..... clayey gravels with fines of low plasticity.
 - (v) GW..... well-graded sand and gravel mixtures with little or no plastic fines.
 - (vi) GP.....poorly graded sand and gravel mixtures with little or no plastic fines.

1.4.2.8 *Foundation*

Naturally occurring or replaced material beneath the bed zone (see Figure 1.1).

1.4.2.9 *Height*

Height of culvert leg (see Figures 1.1 and 2.1).

1.4.2.10 *Height of fill*

Height of fill over the culvert, lid or link slab (see Figure 1.1).

1.4.2.11 *Lifting inserts*

An insert cast into the culvert unit, lid link or base slab that is designed specifically to facilitate handling of the precast unit.

1.4.2.12 *Load class*

Culvert strength classification system designated by the height of fill over the culvert, in metres, followed by the design live load description, separated by a hyphen.

1.4.2.13 *Maturity*

The product of the time, in hours, and the temperature of the concrete, in degrees Centigrade. The period commences at the completion of the mixing of the last batch of concrete to be included in the product.

1.4.2.14 *Monolithic*

Defines a culvert that has at least two corner joints of the cell that are fully rigid.

1.4.2.15 *Overlay zone*

The area extending directly above the top of the culvert, which has a depth of not less than 150 mm (see Figure 1.1).

1.4.2.16 *Precast unit*

Culvert units, lid, link or base slabs as described in Table 1.1 and Figures 1.1 and 2.1.

1.4.2.17 Proving test load (T_p)

The specified load applied to and sustained by a culvert without the appearance of cracks wider than the appropriate test crack.

1.4.2.18 Side zones

The areas bounded by the outside of the culvert leg, the top of the bed zone, the level of the top of the culvert and for a lateral extent as shown in Figure 1.1.

1.4.2.19 Size class

Culvert size classification system designated by the nominal span of the culvert unit in millimetres followed by the nominal height of the culvert unit in millimetres, separated by an 'X'.

1.4.2.20 Span

Span of culvert unit, lid or link slab (see Figures 1.1 and 2.1).

1.4.2.21 Standard feeler gauge

A feeler gauge of the shape and thicknesses specified in Appendix E.

1.4.2.22 Test crack

A crack developed in a culvert unit, lid, link slab or base slab when the proving test load has been applied and maintained in accordance with Appendix G.

1.4.2.23 Ultimate test load (T_u)

The maximum test load that can be sustained by a culvert without loss of load.

NOTE: Refer to Clause 3.3.4 for the specified minimum load to be sustained by a culvert unit, lid, link or base slab during an ultimate load test.

1.5 TYPES OF CULVERTS

The types of culverts covered by this Standard are listed in Table 1.1.

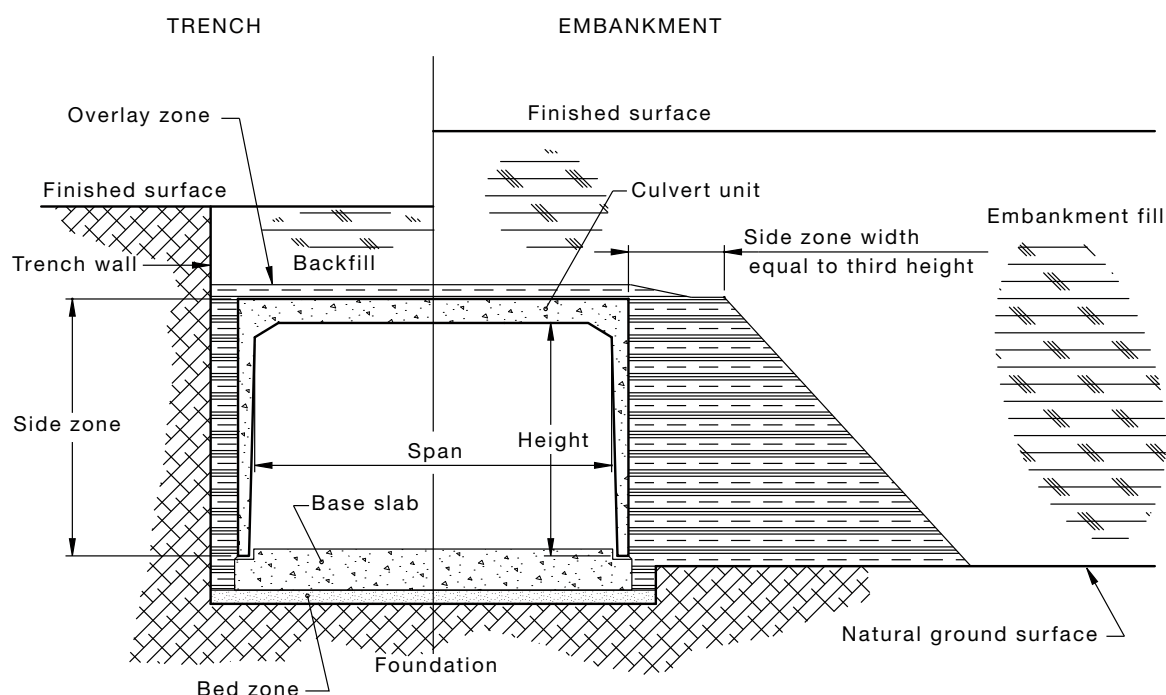
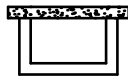
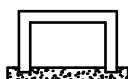
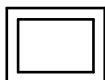
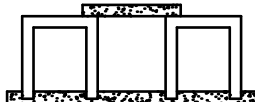


FIGURE 1.1 FILL AND CULVERT TERMS

TABLE 1.1
TYPES OF CULVERTS

Type of culvert	Description	Schematic illustration
U-shape (invert and lid)	A monolithic U-shaped section forming the invert and the two walls, and a separate top slab	
Inverted U-shape (crown unit and base)	A monolithic inverted U-shaped section forming the deck slab and the two walls and a separate base slab	
One piece	An integral hollow rectangle forming the top slab, the two walls and the base slab	
Link slab (crown and base with link)	A single slab supported by adjacent units or structures	

NOTE: U-shape and inverted U-shape culverts are sometimes supplied without the lid slab or base slab, respectively. The relevant information should be supplied by the purchaser (see Appendix A).

1.6 CLASSIFICATION

1.6.1 General

Precast units shall be classified on the basis of the criteria for size and load given in Clauses 1.6.2 and 1.6.3 respectively.

1.6.2 Size class

Culvert units shall be classified by the numerical value system given in Table 2.5.

Lid, link and base slabs shall be classified by the numerical value system given in Table 2.6.

1.6.3 Load class

Precast units shall be classified as ‘Roadway load class’ or ‘Railway load class’ as follows:

- (a) *Roadway load class* Culvert units, lid, link or base slabs that are subjected to fill material vertically over the culvert, from zero up to and including 2.0 m, and vehicle loadings in accordance with AS 5100.2, shall be designated as Class A.

NOTE: *Example* 1200X900/2-A.

- (b) *Railway load class* Culvert units, lid, link or base slabs that are subjected to fill material vertically over the culvert, from 0.3 m up to and including 5.0 m, and to railway live loadings in accordance with AS 5100.2, shall be designated as Class R.

NOTE: *Example* 900X600/5-R.

SECTION 2 MATERIALS, MANUFACTURE AND DIMENSIONING

2.1 SCOPE OF SECTION

This Section specifies the materials to be used, method of manufacture and dimensional requirements for precast units for compliance with this Standard.

2.2 FORMWORK

Forms shall be rigid and designed for intense compaction of the concrete during placement, such as obtained with vibrating tables or external vibrators. Forms shall be constructed to provide the shapes, dimensions and surface finish in the end product. The forms shall be mortar-tight, braced and tied together so that they maintain position and shape during placing and compaction of the concrete.

2.3 REINFORCEMENT

2.3.1 General

Steel reinforcement materials shall comply with AS/NZS 4671. At the time of placing concrete, the reinforcement shall be free of materials or coatings likely to impair its bond with the concrete.

NOTES:

- 1 Ductility Class L reinforcement is suitable for use in box culverts where they are designed and tested in accordance with the performance requirements of the Standard.
- 2 Where the alternative of design by calculation (in accordance with AS 1597.2) is adopted, Ductility Class L reinforcement is suitable for use where the requirements of AS 3600—2009 Clauses 1.1.2(c) and 17.2.1.1 have been considered.

2.3.2 Fabrication

Reinforcement shall be fabricated so that it can be easily placed and accurately held in the required position during manufacture.

Fixing welds may be used for grid assembly and shall not substantially reduce the cross-section of the reinforcing steel nor adversely affect its strength.

Locational tack welds to fix reinforcement shall be made in accordance with AS/NZS 1554.3.

Reinforcing wire to AS/NZS 4671 may be machine resistance welded.

Reinforcement grids shall be located in position within the formwork using steel nibs and spacers whose cross-section is in the plane of the concrete surface and is not more than 6 mm in diameter. Cover provisions do not apply to these fitments.

NOTE: Mild steel nibs and spacers may be used.

2.4 CONCRETE MATERIALS

2.4.1 Cement

Cement materials shall comply with AS 3972.

NOTE: Blended cements are often specified as their use can significantly benefit concrete durability. Individual authorities may specify minimum percentages for supplementary cementitious materials (e.g., typically fly ash and slag) where blended cements are nominated for use.

2.4.2 Supplementary cementitious materials

Supplementary cementitious materials shall comply with AS 3582.1, AS 3582.2 and AS/NZS 3582.3.

2.4.3 Aggregates

Aggregates shall generally comply with AS 2758.1 with the following variations in requirements:

- (a) Water absorption of aggregate shall be limited to a maximum of 2.5%, except for slag aggregates where the maximum limit shall be 6%.
- (b) Durability shall be in accordance with Table 2.1.

Lightweight aggregates and non-ferrous metallurgical slag aggregates shall not be used in concrete for culvert units.

TABLE 2.1
AGGREGATE DURABILITY

Exposure classification	Minimum wet strength	Maximum wet/dry strength variation
	kN	%
B1 (see Note 1)	80	35
B2 and C (see Note 2)	100	25

NOTES:

- 1 Includes slag aggregate.
- 2 Includes all surfaces subject to abrasion from traffic.

2.4.4 Water

Water shall comply with the requirements of AS 1379.

2.4.5 Admixtures

Chemical admixtures shall comply with AS 1478.1. Chemical admixtures shall not contain nitrates, calcium chloride, significant chlorides or other strongly ionized salts unless it can be shown that they do not adversely affect durability.

2.4.6 Restriction on chemical content

The materials shall not contain acid-soluble chloride or sulfate salts in excess of the values given in Table 2.2.

Other strongly ionized salts, such as nitrates, shall not be added to concrete unless it can be shown that they do not adversely affect durability.

TABLE 2.2
MAXIMUM VALUES OF ACID-SOLUBLE CHLORIDE AND SULFATE ION CONTENT IN CONCRETE AS CAST

Condition	Mass of maximum acid-soluble chloride ion content, kg/m ³ of concrete	Mass of maximum acid-soluble sulfate ion content, % by mass of cement
Concrete cured at ambient temperature	0.8	5.0
Steam-cured concrete	0.8	4.0

NOTE: Testing for acid-soluble chloride and sulfate ion content should be conducted in accordance with AS 1012.20.

2.5 CONCRETE SPECIFICATION AND COVER TO REINFORCEMENT

2.5.1 General

Minimum concrete strength grade and cover to reinforcement, with formwork in accordance with Clause 2.2, shall be as set out in Table 2.3.

TABLE 2.3
CONCRETE SPECIFICATION AND NOMINAL COVER
TO REINFORCEMENT

Exposure classification as defined in AS 5100.5—2004	Nominal cover (mm) for characteristic compressive strength of concrete, f'_c , at 28 days	
	40 MPa	50 MPa
B1	30	25
B2	45	35
C	—	50

NOTES:

- 1 Nibs and spacers for reinforcement are excluded from all the above cover requirements.
- 2 Table 2.3 is based on AS 5100.5—2004.

2.6 CONCRETE PRODUCTION, PLACEMENT AND CURING

2.6.1 Batching

Concrete shall be control batched and mechanically mixed to comply with AS 1379. The batching and mixing shall be controlled to produce fresh concrete of uniform quality throughout each production run.

2.6.2 Placing

The fresh concrete shall be cast using intense compaction such as obtained with vibrating tables or external form vibration, in rigid forms, to produce a dense mass free from defects that would impair the strength, serviceability and durability of the unit.

2.6.3 Curing

2.6.3.1 General

Concrete shall be cured, using one or a combination of the methods described in Clauses 2.6.3.2 to 2.6.3.4.

The concrete shall be protected from moisture loss until curing commences, which shall then continue until the concrete reaches—

- (a) the minimum specified age or maturity, whichever occurs first, as specified in Table 2.4; and
- (b) the strength set out in Table 2.4.

When combinations of curing methods are used, the resulting curing shall conform to Table 2.4.

The unit shall not be completely stripped from all forms or handled off the base forms until the compressive strength exceeds 15 MPa. Where curing is interrupted for more than 30 min, the unit shall be protected from moisture loss.

TABLE 2.4
CONCRETE CURING REQUIREMENTS

Exposure classification	Minimum characteristic compressive strength of concrete f'_c at 28 days MPa	Minimum compressive strength of concrete at completion of curing MPa (Note 2)	Minimum concrete curing— i.e., either age or maturity at completion of curing, whichever occurs first					
			Moist		Membrane		Accelerated	
			Age	Maturity	Age	Maturity	Age	Maturity
			Days	°C.h	Days	°C.h	Days	°C.h
B1	40	25	7	3864	7	3864	Note 4	Note 4
	50	32						
B2	40	25	7	3864	7	3864	Note 4	Note 4
	50	32						
C	50	32	7	3864	See Clause 2.6.3.3		0.25	550

NOTES:

- For concrete exposure classification U, curing should be agreed upon between the purchaser and manufacturer.
- The required concrete compressive strengths at completion of curing are based on Table 4.5 of AS 5100.5—2004, i.e., compressive strength at completion of curing = $0.625 f'_c$.
- Maturity for moist and membrane curing is calculated by adopting the minimum days $\times 24 \times 23^\circ\text{C}$. Minimum days are based on Table 4.4 of AS 3600—2009.
- Age and maturity for accelerated curing is dependent on the curing regime adopted. It includes time for placement, temperature ramp up, holding at maximum temperature and cooling down. The age and maturity adopted shall be sufficient to achieve the minimum concrete compressive strength at completion of curing specified in the Table, or as agreed with the customer. Requirements for accelerated curing are given in Clause 2.6.3.4 and Appendix C.

2.6.3.2 Moist curing

Concrete shall be kept continuously moist, the concrete maintained at a temperature above 5°C and all surfaces of the culvert shall remain fully saturated.

2.6.3.3 Membrane curing

Curing compounds approved by the purchaser may be used in accordance with Table 2.4 for exposure classifications B1 and B2. For exposure classification C, curing compounds may only be used in lieu of moist or accelerated curing if approved by the purchaser. Curing compounds shall be applied to all exposed concrete surfaces to the manufacturer's specifications. The concrete shall be maintained at a temperature above 5°C .

As an alternative to proprietary curing compounds, membrane curing may be done using tight, fully sealed plastic wrapping to prevent moisture loss from the concrete surface.

2.6.3.4 Accelerated curing

Accelerated curing shall be carried out by low pressure steam curing in accordance with Appendix C.

NOTE: Other methods may be used with the prior approval of the purchaser.

2.7 JOINTS

Joints between precast units shall be butt joints unless otherwise specified.