
SECTION 619 - MANUFACTURE, TESTING AND DELIVERY OF PRECAST REINFORCED CONCRETE BOX CULVERTS**619.01 GENERAL**

The supply of materials, manufacture, testing, handling and delivery of precast reinforced concrete box culverts up to 1200 mm in width shall be in accordance with the requirements of AS 1597.1 and this section.

619.02 STANDARDS

Australian Standards are referenced in an abbreviated form (e.g. AS 1379).

AS 1012	Methods of testing concrete
AS 1379	Specification and supply of concrete
AS 1478	Chemical admixtures for concrete, mortar and grout
AS 1597.1	Precast reinforced concrete box culverts - Small culverts
AS 2193	Calibration and classification of force-measuring systems
AS 2758.1	Aggregates and rock for engineering purposes - Concrete aggregates
AS 3582	Supplementary cementitious materials for use with portland and blended cement concrete
AS 3582.1	Part 1 : Fly ash
AS 3582.2	Part 2 : Slag - Ground granulated iron blast furnace
AS 3582.3	Part 3 : Amorphous silica
AS 3610	Formwork for concrete
AS 3799	Liquid membrane-forming curing compounds for concrete
AS 3972	General purpose and blended cements
AS 5100	Bridge Design

619.03 DEFINITIONS

Definitions of concrete related terms shall be as described in Section 610.

619.04 TYPES OF BOX CULVERTS

The types of culvert covered by this specification are as designated in AS 1597.1, Clause 1.5:

- (a) 'U' shape consisting of invert and lid.
- (b) Inverted 'U' shape consisting of crown and base.

Note: Where the word unit appears in this specification, it is deemed to mean a complete box culvert as described above.

619.05 STANDARD LENGTH

Unless otherwise specified or shown on the drawings the standard nominal length of box culverts shall be as follows:

- (a) where imperial moulds remain in use, 1.22 m and 2.44 m;
- (b) where metric moulds are in use, 1.20 m and 2.4 m.

All references to 1.22 m and 2.44 m units shall equally apply to 1.2 m and 2.4 m units and vice versa.

619.06 DIMENSIONAL TOLERANCES

- (a) Internal and External Dimensions

The actual internal dimensions of a unit shall not differ from the manufacturer's designated dimensions by more than ± 5 mm.

- (b) Thickness

The actual thickness of a unit shall not differ from the specified thickness by more than - 3 to + 5 mm.

- (c) Length

The actual length of a unit shall not differ from the manufacturer's designated length by more than ± 10 mm.

- (d) Straightness

When the inner surface of a unit is tested by means of a 1 m long straight edge, the deviation from straightness at any point shall not exceed 5 mm.

- (e) Ends

- (i) Squareness

The end faces shall not depart from planes at right angles to the sides and base by more than 5 mm or 1/200 of the height or width, whichever is the greater.

- (ii) Straightness

The end faces shall not depart at any point from a straight edge held against them by more than 5 mm.

- (f) Section

- (i) Squareness

The external cross-section anywhere in the length of the unit shall at no point depart from a true rectangle by more than 5 mm or 1/200 of the height or width, whichever is the greater.

- (ii) Straightness

When the surfaces of a unit are tested by means of a straight edge, the deviation from straightness at any point shall not exceed 5 mm for a 1.22 m unit or 5 mm for a 2.44 m unit.

The Contractor shall undertake a check for compliance with dimensional tolerances as stated in this clause at the frequency of one unit for every ten units manufactured of each size class of box culvert units.

619.07 DURABILITY REQUIREMENTS

Box culverts shall be designed for a minimum exposure classification of B1 in accordance with AS 5100.5 and AS 1597.1. Box culverts used in saltwater applications shall be designed for exposure classification C in accordance with AS 5100.5 and AS 1597.1. The minimum concrete strength grade and concrete cover to the steel reinforcement shall be as shown in Table 619.071.

Table 619.071

Exposure Classification	Minimum Cover to Steel Reinforcement (mm), for Characteristic Strength (f'_c) at 28 days	
	40 MPa	50 MPa
B1	30	25
B2	45	35
C	Not Applicable	50

619.08 MATERIALS

(a) Concrete General

Concrete used for the manufacture of precast reinforced concrete box culverts shall comply with the requirements of AS 1379. The concrete shall consist of a mixture of cementitious material, fine aggregate, coarse aggregate and water. **The concrete may also contain chemical admixtures, details of which shall be submitted for review by the Superintendent.** In its finished state concrete shall be sound and dense and durable and free from honeycombing and shall have the strength and other properties specified.

(b) Cementitious Material

(i) Cement

Cement shall comply with the requirements of AS 3972. Cement per batch of concrete shall be from one manufacturer and of one brand, type and grind. Cement more than three months old shall not be used in the Works unless it is re-tested to demonstrate compliance with the requirements of AS 3972.

(ii) Fly Ash, GGBF Slag and Amorphous Silica

Fly Ash, GGBF Slag and Amorphous Silica shall comply with the requirements of AS 3582.1, AS 3582.2 and AS 3582.3 respectively and shall be from one manufacturer and of one brand, type and fineness.

(iii) Minimum Portland Cement Content

The minimum mass of portland cement in concrete mixes containing GGBF Slag, Fly Ash or Amorphous Silica shall be 60%, 75% or 90% respectively, of the total mass of cementitious material in the concrete mix. The inclusion of GGBF Slag, Fly Ash or Amorphous Silica in concrete mixes shall only be in single or double combination with portland cement. In a triple blend concrete mix, the portland cement content shall be a minimum of 60% and the individual contribution of GGBF Slag, Fly Ash or Amorphous Silica shall be a maximum of 40%, 25% or 10% respectively, of the total mass of the cementitious material in the concrete mix.

(iv) Cementitious Type and Content for Saltwater Applications and Exposure Classification C

Box culverts used in saltwater applications or exposure classification C shall be manufactured with concrete containing at least 20% fly ash and 7% to 10% silica fume as a replacement of portland cement, or at least 30% fly ash as a replacement of portland cement.

(c) Chemical Admixtures

Chemical admixtures when used shall comply with the requirements of AS 1478. They shall be used in accordance with the requirements of Clause 2.5 of AS 1379 and the manufacturer's recommended method of use and shall not reduce the strength of concrete below that specified. Chemical admixtures shall be accurately measured by means of dispensers which are subject to regular maintenance and are calibrated as a minimum at three monthly intervals. Chemical admixtures shall not contain calcium chloride, calcium formate, chlorine, sulphur, sulphides or sulphites.

(d) Aggregates

Source rock shall comply with the requirements of Section 801 - Source Rock for the Production of Crushed Rock and Aggregates. Fine and coarse aggregate for concrete shall comply with the requirements of AS 2758.1 unless otherwise specified in Table 619.081.

Table 619.081

Property	Relevant Standard and Clauses	Test Limits for Product Acceptance
General Requirements		
1. Particle density	AS 2758 1-7.1	Greater than 2100 kg/m ³
2. Bulk density	AS 2758 1-7.2	Greater than 1200 kg/m ³
3. Water absorption	AS 2758 1-7.3	Less than 2.5% for Coarse Less than 1.5% for Fine
Dimensions		
1. Grading	AS 2758 1-8.1 Table 1,2,3	Single-sized aggregate Coarse and fine
2. Material finer than 75 microns	AS 2758 1-8.2	Coarse 2% max., Fine 5% max.
3. Particle shape	AS 2758 1-8.3	10% max. at 3:1 ratio for misshapen, flat and elongated
Durability		
1. Los Angeles Value	AS 1141.23	35% maximum
2. Unsound Stone Content	AS 1141.30	Unsound stone content: 5% max. Total of unsound stone and marginal stone: 10% max.
Impurities		
1. Organic impurities	AS 2758 1-14.1	Not darker than the Standard Reference Colour No. 3
2. Sugar	AS 2758 1-14.2	Less than 1 part in 10,000
3. Alkali-Aggregate Reactivity	610.11(c)	Limits as per 610.11(c)
4. Soluble salts (% to cementitious material mass)	610.07(k)	5.0% max. Sulphate salts (concrete cured at ambient temperature) 4.0% max. Sulphate salts (steam-cured concrete) 0.15% max. Chloride salts

(e) Water

The quality of mixing water to be used in the concrete mix shall comply with the requirements of Clause 2.4 of AS 1379. However, the amounts of chloride and chlorine in the water shall be not greater than 0.03%.

(f) Steel Reinforcement

Steel reinforcement used in the manufacture of precast reinforced concrete box culverts shall comply with Section 611.

619.09 PLACING AND COMPACTING CONCRETE

Concrete shall be deposited in horizontal layers in a manner to avoid segregation and displacement of the steel reinforcement or other embedded items or formwork.

The compaction of concrete shall be carried out by using external vibrators to achieve the desired level of compaction.

Immersion vibrators of adequate size, number and frequency shall only be used as back-up when external vibrators fail. Care shall be taken to ensure that no steel reinforcement or embedded items are displaced by vibration.

619.10 CURING, STRIPPING AND REMOVAL FROM FORMWORK

Concrete shall be cured using one or a combination of methods described in this clause.

The concrete shall be protected from moisture loss until commencement of curing, which shall continue until the concrete reaches the age or the maturity, whichever is the lesser, and the compressive strength is as shown in Table 619.101. The concrete compressive strength for checking the adequacy of curing shall be determined by test cylinders cured with and in the same manner as the concrete unit.

The unit shall not be completely stripped from all forms or handled off the base forms until the compressive strength reaches 15 MPa. Curing shall be carried out to meet the requirements of Table 619.101 and where curing is interrupted by more than 30 minutes the unit shall be protected from moisture loss.

Table 619.101

Exposure Classification	Minimum Characteristic concrete compressive strength (f'c) at 28 Days (MPa)	Required concrete compressive strength at completion of accelerated curing MPa	Required minimum concrete age (days) and minimum maturity (°C hrs) at completion of curing					
			Moist		Membrane		Accelerated	
			Age Days	Maturity °C hrs	Age Days	Maturity °C hrs	Age Days	Maturity °C hrs
B1	40	25	7	3864	7	3864	0.25	420
	50	32						
B2	40	25	7	3864	7	3864	0.25	420
	50	32						
C	50	32	7	3864	Not permitted		0.25	550

Notes:

- For concrete exposure classification U, curing should be as specified on the drawings and in this specification.
- 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 (°C hrs) for moist and membrane curing is calculated by adopting the minimum days x 24 x 23°C. Minimum days are based on Table 4.4 of AS 3600—2009.
- Maturity (°C hrs) for accelerated curing is calculated by adopting the minimum days x 24 x 70°C.

Where moist curing is used concrete shall be kept continuously moist and the concrete maintained at a temperature above 5°C and all surfaces of the culvert must remain fully saturated.

Membrane curing in the form of curing compounds may be used in accordance with Table 619.101 for exposure classifications B1 and B2 in lieu of moist curing. Curing compounds shall be applied to all exposed concrete surfaces to manufacturer's specifications. The concrete shall be maintained at a temperature above 5°C. Curing compounds shall comply with the requirements of AS 3799.

Accelerated curing shall be carried out by low pressure steam curing in accordance with Appendix C of AS 1597.1.

619.11 SAMPLING AND TESTING FOR COMPRESSIVE STRENGTH

A sample consisting of a minimum of four concrete compression cylinders shall be taken at not greater than ten hours of continuous manufacture of culvert units and tested for strength. The concrete compression cylinders shall be made in accordance with AS 1012.1 and AS 1012.8 and subsequently tested in accordance with AS 1012.9. The minimum compressive strength requirements for each strength grade shall be in accordance with Clause 619.10 and as shown in Table 619.101.

Curing of concrete compression cylinders shall be carried out in accordance with AS 1012.8. Concrete compression cylinders shall be cured initially with the product. As soon as practicable after a period of 18 hours from moulding, the test cylinders shall be placed under standard moist curing conditions. The time between moulding and entry into standard moist curing conditions shall not exceed 36 hours.

619.12 CONCRETE COVER TO STEEL REINFORCEMENT

The tolerance on concrete cover shall be 0 to +5 mm.

For normal service conditions spacers or bar chairs used to maintain cover to the steel reinforcement shall be made of plastic or steel, provided the box culvert is manufactured using rigid formwork and intense vibration.

Where box culverts are to be placed in saltwater applications, stainless steel spacers or plastic bar chairs shall be used.

The concrete cover to the steel reinforcement shall be measured with a calibrated cover meter to ensure compliance with the requirements of Clause 619.07. The Contractor shall select one unit for concrete cover measurements from each 100 units of a batch or a maximum period of 3 months production. The cover meter device shall be capable of detecting the presence of reinforcement and indicating the depth from the concrete surface to the nearest point on the surface of the reinforcement with an accuracy of ± 1 mm at a depth of 25 mm.

619.13 PROVISION FOR LIFTING AND HANDLING OF UNITS

Units shall be handled in a manner which will avoid damage to them and shall be lifted using the lifting points provided.

Where units are lifted in the legs-up position, a lifting beam shall be used in order to avoid inducing excessive bending moments.

Precast units shall not be handled before the concrete has reached compressive strength of 15 MPa and stored in a manner such that their:

- (a) serviceability is not impaired;
- (b) shape is not distorted to affect installation alignment; and
- (c) surface and edge finishes are not unduly damaged.

Provision shall be made for lifting and handling the precast units. Where lifting inserts are provided, they shall be installed in accordance with the lifting inserts supplier's recommendations. All provisions for lifting shall comply with the requirements of the appropriate regulatory authority.

619.14 WORKMANSHIP AND FINISH

All units shall be free from fractures, cracks and from any other defects.

(a) Surface Condition

The interior and exterior surfaces of the units shall be smooth and dense and free from voids, chipped edges, fins, protrusions, surface roughness and other defects.

Blowhole defects 6 mm diameter and 3 mm deep will be accepted provided that there are no more than 5 defects in an area 300 mm square, or an equivalent area of larger or smaller diameter holes providing they are not more than 3 mm deep.

Units with defects greater than this allowance shall be rejected.

Units shall not be coated with cement wash or any other preparation.

(b) Dents, Bulges and Defects

Dents not exceeding 3 mm deep, and bulges not exceeding 3 mm high, shall be accepted provided they do not extend over the surface for a distance greater than twice the wall thickness of the unit, and provided that the minimum cover is maintained.

Dents shall be repaired by the Contractor if necessary to maintain the minimum cover.

Units shall be free from fractures and cracks wider than 0.15 mm and residual test cracks wider than 0.08 mm in accordance with the requirements of Clause 619.17 and Appendix E of AS 1597.1.

619.15 IDENTIFICATION OF UNITS

All units shall be clearly stencilled by the Contractor with indelible ink on the interior surface of each unit prior to inspection. Lids shall be stencilled on the underside and base slabs on the top side.

Information required on each unit shall be as follows:

- (a) nominal dimensions
- (b) date of manufacture and identification number
- (c) name of the manufacturer and/or its registered trade mark
- (d) locality of the supplying factory
- (e) maximum mass of the unit
- (f) number of the relevant Australian Standard, i.e. AS 1597.1.

619.16 TESTING AT THE MANUFACTURERS WORKS

A batch is defined as a maximum of 50 number units of the same size and manufactured and cured at the same works within two calendar months.

Units supplied from more than one source, or manufactured outside of a two month period, then those units shall be deemed to be more than one batch and the requirements of the specification shall apply to each separate batch.

619.17 PROOF LOAD TEST

From each 25 units of a batch, the Contractor shall select one unit as defined in Clause 619.04 for proof-load testing in accordance with AS 1597.1. The two test units shall represent the first sample for the batch.

For batches of less than 25 units, a sample of one unit shall be selected by the Contractor for proof-load testing.

Every selected unit not more than 1.22 metres long shall sustain a vertical force of 112 kN without developing a test crack as defined in Note 1, and on removal of the load, no crack caused by the load shall be greater than that defined in Note 2 below as a residual test crack.

For batches greater than 25 units, if:

- (a) in the first sample two non-conforming units are found, then reject the batch; or
- (b) one unit in the first sample is non-conforming, select a second random sample of two units, one unit from each 25 units of the same batch, and subject them to the same crack load test in accordance with AS 1597.1. If any unit in the second sample fails, then reject the batch. If no units in the second sample fail, accept the batch.

For batches of less than 25 units, should the sample test unit fail to comply then select a random second sample of one additional unit from the same batch and subject it to the same crack load test in accordance with AS 1597.1. If the unit in the second sample fails, reject the batch. If no non-conforming unit is found in the second sample, accept the batch.

Note 1: A test crack is defined as one into which the point of a test crack measuring gauge conforming to the details given in Figure E1 of AS 1597.1 may be inserted to a depth of 2 mm over a length of at least 300 mm at intervals not exceeding 50 mm.

Note 2: A residual test crack is defined as one into which the point of a residual test crack measuring gauge conforming to the details given in Figure E1 of AS 1597.1 may be inserted to a depth of 2 mm over a length of at least 300 mm at intervals not exceeding 50 mm.

619.18 ULTIMATE LOAD TEST

From each 25 units of a batch, the Contractor shall select one unit as defined in Clause 619.04 for ultimate-load testing in accordance with AS 1597.1. The two test units shall represent the first sample for the batch.

For batches of less than 25 units, a sample of one unit shall be selected by the Contractor for ultimate-load testing.

Every selected unit not more than 1.22 metres long shall sustain a vertical force of 202 kN.

For batches greater than 25 units, if:

- (a) in the first sample two non-conforming units are found then reject the batch; or
- (b) one unit in the first sample fails to comply, select a second random sample of two units, one unit from each 25 units of the same batch, and subject them to the same ultimate load test in accordance with AS 1597.1. If any unit in the second sample fails, then reject the batch. If no units in the second sample fail, accept the batch.

For batches of less than 25 units, should the sample test unit fail to comply with the requirements of this clause then select a random second sample of one additional unit from the same batch and subject it to the same ultimate load test in accordance with AS 1597.1. If the unit in the second sample fails, reject the batch. If no non-conforming unit is found in the second sample, accept the batch.

619.19 LOAD TESTING OF 2.44 METRE UNITS

For unit sections of 2.44 m, the loads specified for proof and ultimate test shall be applied over each 1.22 m end of the culvert either separately or at both ends simultaneously.

When the unit is loaded at both ends simultaneously, the specified load for proof and ultimate shall be doubled.

619.20 CALIBRATION OF TESTING MACHINE

The testing machine used for load testing shall meet the requirements of AS 2193 Class B and shall be calibrated in accordance with the terms of laboratory accreditation for the specific testing machine type. A jack and pressure gauge system may be used provided that calibration is carried out at not more than six monthly intervals.

619.21 TRANSPORT AND STORAGE

(a) Transporting

Units shall not be transported from the precast yard within seven days after casting and the curing has been completed in accordance with Clause 619.10.

Units shall be supported on timber bearers which are fitted with rubber strips on top. Rubber strips shall also be placed between units, both laterally and longitudinally. All tie down straps and chains shall have rubber protection strips over box culvert edges. The legs of all box culverts shall be adequately braced to prevent whipping and bending. The precast invert base slabs and lids to be transported shall be loaded in the laid position.

(b) Stacking

- (i) Inverts or crowns shall be stored in separate stacks of identical units up to a maximum height of 2 metres or two units high separated by timber packers.
- (ii) Lids or base slabs shall be stored in separate stacks of identical units up to a maximum height of six units separated by timber packers.

(c) Final Visual Inspection of Units upon Delivery to Site

The Contractor shall undertake a final visual inspection of units upon transport and delivery to site and the findings of such inspection shall form part of the acceptance requirements of Clause 619.22.

619.22 ACCEPTANCE

Box culverts shall be accepted on the basis of full compliance with the requirements of this section and AS 1597.1.

Documentation supporting the following quality requirements shall be submitted for review by the Superintendent upon transport and delivery of units to site:

- (a) visual inspection
- (b) dimensional measurements
- (c) measurements of clear cover to steel reinforcement
- (d) concrete compressive strength test results
- (e) proof load test results
- (f) ultimate load test results.