

Main Roads Standard Specification

MRS11.24

Manufacture of Precast Concrete Culverts

December 07



Queensland Government
Department of Main Roads

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Manufacture of Precast Concrete Culverts

1 INTRODUCTION

This specification applies to the manufacture of precast reinforced concrete rectangular culverts for the conveyance of stormwater which does not place the culvert under internal pressure.

This specification shall be read in conjunction with Standard Specifications MRS11.01 *Introduction to Standard Specifications*, MRS11.50 *Specific Quality System Requirements* and other Standard Specifications as appropriate.

This specification forms part of the Standard Specifications Roads Manual.

2 MEASUREMENT OF WORK

This specification contains no Standard Work Items. Supply of precast concrete culverts may not be measured separately under the Contract but may be included in related Standard Work Items described in MRS11.03 *Drainage, Retaining Structures and Protective Treatments*.

3 MATERIAL

Concrete used in the manufacture of precast concrete culverts shall comply with the requirements of MRS11.70 *Concrete* except for the modifications specified in Clause 11.

Reinforcement used in the manufacture of precast concrete culverts shall comply with the requirements of MRS11.71 *Reinforcing Steel*, except for the modifications specified in Clause 12.

4 LIMITS OF THIS SPECIFICATION

This specification is limited to culverts of maximum length of 3600 mm, a maximum height of 4200 mm and a maximum span of 4200 mm.

5 CLASSES AND SIZES

The classes and standard dimensions of box culverts covered by this specification have been divided into –

- small culverts according to the sizes shown in Table 1; and
- large culverts in accordance with AS 1597.2.

Unless specified otherwise in the Contract Documents, the nominal lengths of culverts shall be 3.6 metres, 2.4 metres or 1.2 metres.

Table 1 - Small Box Culverts

Span (mm)	Height (mm)							
	150	225	300	450	600	750	900	1200
300	X							
375	X	X						
450	X	X	X					
600		X	X	X				
750		X	X	X	X			
900			X	X	X	X		
1200			X	X	X	X	X	X

6 TYPES OF CULVERT AND LINK SLAB

Culverts shall consist of –

- a) a single inverted U-shaped section forming the deck and two walls; or
- b) an inverted U-shaped section forming the deck and two walls separated from the adjacent section by a separate link slab.

Link slabs shall be simply supported on mortar seatings on the top of the culverts. Four steel bars, hot-dipped galvanised to the requirements of AS 4680, shall be provided to locate the assembly. The bars shall pass through cored holes in the slab and be grouted into holes provided in the legs of the culvert crowns.

Precast bases shall not be substituted for cast in situ bases unless otherwise approved by the Superintendent.

7 CONDITIONS FOR MANUFACTURE OF PRECAST CONCRETE CULVERTS

Precast concrete culverts shall be manufactured only by an approved manufacturer.

To be recognised as an approved manufacturer of precast concrete culverts, a manufacturer shall –

- a) operate a quality system certified to ISO/AS 9001;
- b) include an inspection and test plan acceptable to Main Roads for manufacturing culverts which demonstrates compliance with this specification;
- c) obtain approval of its culvert designs in accordance with this specification; and
- d) demonstrate ability to manufacture culverts of the required size.

Unless specified otherwise in the Contract, the manufacturer shall provide to Main Roads the following information prior to the manufacture of precast concrete culverts for the Contract –

- i) drawings showing the profile dimensions of the culverts, reinforcement details and grade of concrete;
- ii) the calculated mass of individual units;
- iii) the place of manufacture; and
- iv) outline of the method of manufacture and Quality Plan.

The above information shall be provided for all large culverts. If requested by Main Roads, the above information shall also be provided for small culverts.

The drawings shall be subject to approval by Main Roads.

8 CASTING

Culverts shall be cast legs down or on end.

Unless specified otherwise in the documents, the joints between adjacent culverts shall be plain butt joints.

9 DESIGN REQUIREMENTS

9.1 Height of Fill

Culverts shall be designed for the worst combination of loads for corresponding load cases for fill heights from zero to the height stated in the Annexure to MRS11.03 *Drainage, Retaining Structures and Protective Treatments*. For fill heights of less than 2 metres, culverts, link slabs and bases shall be designed for the worst combination of loads for corresponding load cases for fill heights from zero to 2 metres.

9.2 Durability Requirements

Small and large box culverts shall be designed for a minimum exposure classification of B2 in accordance with AS 5100. Culverts used for saltwater applications shall be designed for an exposure classification of C in accordance with AS 5100.

9.3 Large Culverts

Large box culverts must be designed in accordance with AS 1597.2 and AS 5100 with the following additional requirements:

- a) The design life of large culverts shall be 100 years. The design life means that 95% of the production shall remain in a serviceable condition with negligible maintenance for 100 years;
- b) AS 1597.2 Clause 4 – Load Testing for Design is not permitted;
- c) The tolerances in Clause 2.12.2.3 of AS 1597.2 of are amended to +10 mm and -5 mm;
- d) Clauses 3.2.2 and 3.2.3 of AS 1597.2 are deleted;
- e) Culverts must be designed for a range of fills from zero to the maximum design height. The minimum design height of fill shall be 2 metres;
- f) Table 2.4 of AS 1597.2 is deleted and replaced by Tables 4.10.3(A) and 4.10.3(B) of AS 5100.5;
- g) Minimum transverse distribution reinforcement in the bottom face of the crown of culverts and of link slabs shall be the greater of 25% of the main bending reinforcement and 333 mm²/m with a bar spacing not exceeding 300 mm;
- h) Design loads are W80, A160, SM1600 and HLP 400 in accordance with AS 5100;
- i) Distribution of live loads shall be in accordance with AS 5100;
- j) Tables 3.2 and 3.3 of AS 1597.2 are amended that "2" for W_{LV} is replaced by "1.8", and 1.0 for W_{DC} is replaced by "1.2"; and
- k) Structural design shall be based on a maximum concrete grade of 50 MPa;
- l) Dynamic load allowance shall be in accordance with AS 5100.2;
- m) Live load surcharge shall be in accordance with AS 5100.2; and
- n) Minimum clear bar spacing shall be in accordance with AS 5100.5.

9.4 Precast Culvert Bases

Precast culvert bases shall be designed such that –

- a) for in-service loads, the ultimate capacity of the precast slab shall be at least equal to or greater than the capacity of the cast-in-situ slab in Main Roads standard drawings; and
- b) for handling and transporting loads, the self weight of the slab with a dynamic load allowance equivalent to 50 percent of self weight is supported during handling of the slabs and the steel stress in the reinforcing shall be less than 0.6 f_y .

9.5 Segmental Culverts

Culverts of segmental construction shall be designed by calculation in accordance with Clauses 9.1 to 9.3 and the AS 5100, except that horizontal earth pressure for live load shall be taken as the coefficient of earth pressure for live load times the vertical earth pressure.

The earth pressure surcharge shall be applied concurrently with or without SM1600 and HLP400 loadings to create the worst effect.

9.6 Small Culverts

Design of small box culverts will be accepted if they comply with the requirements of Clause 13.4.

10 HANDLING, STORING, TRANSPORTING

10.1 Provision for Lifting

Each culvert component shall be provided with an approved means for the attachment of lifting equipment. If holes are provided for this purpose, the Manufacturer shall supply snugly fitting concrete or plastic plugs with each consignment.

10.2 Marking

The following information shall be clearly marked on each component at the time of manufacture —

- a) the date of manufacture and identification number;
- b) the manufacturer's name or registered mark;
- c) the size of the culvert;
- d) the maximum mass of the culvert; and
- e) the specification number and version to which the culvert has been manufactured.

10.3 Handling

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

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

10.4 Transporting

The legs of all culverts shall be adequately braced to prevent whipping and bending.

The precast invert base slabs and link slabs to be transported shall be loaded in the as-laid position.

Components shall not be transported from the precast yard until the greater of 7 days or the time when concrete has attained 70% of the specified 28 day characteristic strength.

10.5 Storing

Components to be stored shall be placed on a plane surface, stacked and supported in a manner that will avoid damage. Link slabs and bases may be stored in more than one layer. Timber supports separating each layer shall be placed near the ends of the slab and directly above the supports of any lower layer.

10.6 Loading

Culverts shall not be backfilled or loaded with construction traffic prior to the time that the concrete has attained the specified 28 day characteristic strength unless otherwise approved by the Superintendent. Where culverts are to be loaded prior to 28 days, the Contractor shall advise the manufacturer of the requirements and the manufacturer shall make any necessary adjustments to the manufacturing process and certify the time when backfilling can occur.

11 MODIFICATIONS TO MRS11.70

11.1 General

Notwithstanding any requirements to the contrary in MRS11.70 *Concrete*, Clauses 11.2 to 11.7 shall apply to the manufacture of precast concrete culverts.

11.2 Placing Concrete

Placing of concrete shall be a mandatory hold point in the manufacturer's quality assurance system.

11.3 Stripping and Curing

Formwork shall not be stripped prior to concrete having reached a strength of 15MPa.

Notwithstanding any requirements of AS1597.2 curing shall continue until the lesser of 7 days or the time when the concrete has attained 70% of the specified 28 day characteristic strength. Where concrete is steam cured for a lesser time than the above curing requirements, the concrete shall be kept covered and saturated until the concrete cools to not more than 20°C above ambient temperature and alternative curing is commenced to achieve the above requirements.

11.4 Finish

11.4.1 Surface Condition

The concrete shall be dense and hard and substantially free from chipped edges, fins, protrusions and surface roughness.

Culverts shall not be coated with cement wash or any other preparation not specified or otherwise approved by the Superintendent.

11.4.2 Defects, Dents and Bulges

Culverts shall be free from fractures and cracks wider than 0.15 mm and residual test cracks wider than 0.08 mm. Dents not exceeding 3 mm in depth and bulges not exceeding 3 mm in height shall be permitted provided they do not extend over the surface for a distance greater than twice the thickness of concrete where they occur.

11.4.3 Air Holes

Air holes exceeding 12 mm in lateral dimension and having a depth greater than 3 mm shall be filled in accordance with Clause 25 of MRS11.70 *Concrete*.

11.5 Tolerance

11.5.1 Large Culvert

Large culverts shall comply with the requirements of AS1597.2 for tolerance.

11.5.2 Small Culverts

11.5.2.1 General

Small culverts shall comply with the tolerances specified in Clause 11.5.2.

11.5.2.2 Internal Dimensions

The actual internal dimensions shall not differ from the dimensions as shown on the manufacturer's drawings by more than ± 5 mm.

11.5.2.3 Thickness

The actual thickness of a culvert wall, link slab or base slab shall not differ from the dimensions as shown on the manufacturer's drawings by more than + 5 mm or - 3 mm.

11.5.2.4 Length

The actual length of a culvert shall not differ from the length as shown on the manufacturer's drawings by more than ± 10 mm.

11.5.2.5 Straightness

When the inner surface of a culvert is tested with a 1 metre long straight-edge, the deviation from straightness at any point shall not exceed 6 mm.

11.5.2.6 Ends

When tested with a tri-square, the end faces of the culvert unit, link slab or base slab at any location shall be square within ± 4 mm when measured across the unit section thickness.

11.5.2.7 Verticality

With the base of the culvert unit horizontal, the vertical side faces of the legs and the end faces shall not deviate from the vertical at any location by more than ± 20 mm for the entire height of the culvert unit.

11.6 Fillets

The internal corners of culverts shall be finished with curved or straight fillets appropriate to the size of the culverts.

11.7 Concrete Strength

Culverts shall be manufactured from concrete with characteristic 28 day strength not less than –

- a) normal service conditions 50 MPa;
- b) saltwater conditions 50 MPa

12 MODIFICATIONS TO MRS11.71

12.1 General

Notwithstanding any requirements to the contrary in MRS11.71 *Reinforcing Steel*, Clauses 12.2 to 12.5 shall apply to the manufacture of precast concrete culverts.

12.2 Cover

The tolerance for small culverts shall be + 10 mm, - 0 mm where a positive value indicates the amount of clearance cover to reinforcement may increase and a negative value indicates the amount that cover may decrease.

The tolerance for cover for large culverts shall be in accordance with AS 1597.2.

12.3 Placing of Reinforcement

The placing of the primary reinforcement shall be such as not to interfere with the location of lifting holes or dowel bars.

The reinforcement may be displaced locally to obtain the required cover.

12.4 Substitution of Reinforcement

Substitution of reinforcement in large box culverts shall not be made without the approval of Main Roads. Application for such approval shall be made at least one week prior to the date on which the reinforcement is required to be placed. No additional payment will be made on account of any approved substitution.

12.5 Bar Chairs

Steel spacers or approved plastic bar chairs shall be used to maintain cover to the reinforcement except where culverts are to be placed in a saltwater environment in which case stainless steel spacers or approved plastic bar chairs shall be used.

For normal service conditions, steel spacers shall not be used to maintain cover unless the culvert is manufactured using rigid formwork and intense vibration.

13 ACCEPTANCE

13.1 General

Culverts shall remain available for inspection for a minimum of 3 days.

13.2 Large Box Culverts

Large box culverts shall be accepted on the basis of culvert design, visual inspection, geometric measurement, measurement of clear cover to reinforcement, reinforcement spacing and location and concrete strength.

13.3 Small Culverts

Small culverts shall be inspected on the basis of visual inspection, geometric measurement, measurement of clear cover to reinforcement, concrete strength and proof load testing.

Load testing shall be carried out in accordance with Clause 13.4.

13.4 Load Testing (Small Culverts Only)

13.4.1 General

Clause 13.4 shall apply to small box culverts only as shown in Table 1.

For small culvert units with a nominal length of 2.4 metres and 3.6 metres, the design shall have the same concrete thickness and distribution of reinforcement as a 1.2 metres long unit.

13.4.1.1 Ultimate Load Test

The ultimate test load shall be 205 kN for a 1.2 metres long unit. The ultimate load testing shall be in accordance AS 1597.1. The number of units to be tested to ultimate shall be as set out in Table 2.

Table 2 - Number of Ultimate Load Tests

Total Lot Size	Number of Ultimate Load Tests
< 10	0
11 – 99	1
> 100	1%

An entire lot is rejected if the ultimate load test is not satisfied.

13.4.1.2 Proof Load Testing

Proof load testing shall be conducted in accordance with AS 1597.1. The test load shall be 130 kN for a 1.2 metres wide unit.

Proof load testing involves the selection of a sample of culverts from a lot and subjecting the sample of culverts to a test load.

13.4.2 Proof Load Testing Sampling

13.4.2.1 A Lot and a Sample

For the purpose of this specification, a lot and a sample are as defined below.

A lot is a number of culverts made under similar conditions. A lot may consist of culverts of more than one size. In relation to culvert size, there are three types of lot which apply in relation to this specification, as follows –

Lot type A All culverts of a single size.

Lot type B The culverts may be of two or more sizes where at least two-thirds are of a single size. The size consisting of the two-thirds portion shall be termed the predominant size.

Lot type C The culverts may be of two or more sizes where no single size consists of at least two-thirds of the total number.

A sample shall consist of a number of culverts selected from a lot. The number of culverts shall be determined from Table 3. The method of selection will depend on the lot type, as follows –

Lot type A A number of culverts shall be selected at random from the entire lot.

Lot type B A number of culverts shall be selected at random from the predominant size in the lot.

Lot type C A number of culverts shall be selected at random from the largest size in the lot, the number of which is sufficient to obtain the total cumulative sample.

Table 3 - Sampling Plan

Total Lot Size	Normal Sampling Level				Reduced Sampling Level			
	Sample Size	Cum. Size	Accept No.	Reject No.	Sample Size	Cum. Size	Accept No.	Reject No.
2 to 8	First 2	2	0	2	First 2	2	0	2
	Second 2	4	1	2	Second 2	4	0	4
9 to 15	First 2	2	0	2	First 2	2	0	2
	Second 2	4	1	2	Second 2	4	0	4
16 to 25	First 3	3	0	2	First 2	2	0	2
	Second 3	6	1	2	Second 2	4	0	4
26 to 50	First 5	5	0	3	First 2	2	0	2
	Second 5	10	3	4	Second 2	4	0	4
51 to 90	First 8	8	1	4	First 3	3	0	3
	Second 8	16	4	5	Second 3	6	1	5
91 to 150	First 13	13	2	5	First 5	5	0	4
	Second 13	26	6	7	Second 5	10	3	6

Note: If a sample size is equal to or greater than a lot size, adopt 100% inspection.

13.4.2.2 Normal and Reduced Sampling Levels

In the sampling plan in Table 3 there is a normal sampling level and a reduced sampling level. The sampling level to be used shall be determined as follows –

- a) The normal sampling level shall continue for at least 12 months after the commencement of operations of a new manufacturer and also for any new culvert size(s) or new culvert design(s) for at least 12 months after their introduction.
- b) The reduced sampling level shall commence after the period specified above, if there have been no rejections on original inspections from any of the 10 preceding lots proof load tested under the normal sampling level.

The normal sampling level shall be reintroduced if a lot subject to the reduced sampling level is rejected or if the reduced sampling plan terminates without either the acceptance or rejection number being met. The reduced sampling level may be reintroduced provided there have been no rejections on original inspections from any of the 10 preceding lots proof load tested under the normal sampling level.

13.4.2.3 Proof Load Testing Procedure

The proof load testing procedure shall be as follows –

- a) The number of culverts tested shall be equal to the first sample size number given in the sampling plan in Table 3. If the number of culverts which do not pass the test load in the sample is equal to or less than the first acceptance number, the lot shall be accepted.
- b) If the number of failed culverts is equal to or greater than the first rejection number, the lot shall be rejected.
- c) If the number of failed culverts is between the first acceptance and rejection number, a second group of culverts shall be tested. The number of culverts tested in the second group shall be equal to the second sample size number. The number of failed culverts in the first and second sample shall be added. If the total number of failed culverts is equal to or less than the second acceptance number, the lot shall be accepted.

If the total number of failed culverts is equal to or greater than the second rejection number, the lot shall be rejected.

If the reduced sampling level is being used and the number of failed culverts is between the second acceptance and rejection number, the normal sampling level shall be re-introduced.

- d) If a lot consisting of culverts of a single size is rejected, the Contractor may request that every culvert in a lot be subjected to the load test. Each culvert which passes the load test shall be accepted.
- e) If a lot consisting of culverts of more than one size is rejected, the Contractor may request that every culvert from the size used for testing be subjected to the load test. Each culvert which passes the load test will be accepted.

Where other sizes within the lot are to be considered for acceptance, they shall be divided into individual sub-lots according to their size. Individual sub-lots shall then be sampled at random for load testing in accordance with the resubmitted lot sampling plan given in Table 4. The operation of the testing procedure shall be in accordance with sub-paragraphs (a), (b) and (c) above.

Table 4 - Resubmitted Lot Sampling Plan

Total Sub-lot Size	Sample Size	Cumulative Size	Accept Number	Reject Number
2 to 8	First 2	2	0	2
	Second 2	4	1	2
9 to 15	First 3	3	0	2
	Second 3	6	1	2
16 to 25	First 5	5	0	3
	Second 5	10	3	4
26 to 50	First 8	8	1	4
	Second 8	16	4	5
51 to 90	First 13	13	2	5
	Second 13	26	6	7

Note: If a sample size is equal to or greater than a lot size, 100% inspection shall be adopted.