Technical Specification

Transport and Main Roads Specifications
MRTS24 Manufacture of Precast Concrete Culverts

January 2015

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1 Introduction

This Technical Specification applies to the manufacture of small and large precast reinforced concrete rectangular box culverts and other associated culvert components for the conveyance of stormwater, which does not place the culvert under internal pressure.

Culverts beyond 4200 mm in height or span are not within the scope of this specification. Culverts classified as Railway load class by AS 1597.1 and AS 1597.2 are not within the scope of this specification.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

The requirements for the manufacture of precast concrete culverts and other associated culvert components include the use of suppliers and products for the items listed in Table 1 that are either registered or approved by the department.

Table 1 – Items requiring use of registered suppliers and approved products

Clause	Category of Work
9.3	Precast Concrete Manufacturer
6.4	Cementitious Repair Grout
12	Proprietary Cast-in Items

For information regarding registered suppliers and approved products for the above items, refer to the TMR website or:

Queensland Department of Transport and Main Roads (TMR)

Bridge Construction Maintenance and Asset Management (BCMAM)

GPO Box 1412

Brisbane Qld 4001

2 Definition of terms

The terms used in this Technical Specification shall be as defined in Clause 2 of MRTS01 *Introduction to Technical Standards*.

In addition, terms listed in Table 2 are applicable to this Technical Specification.

Table 2 – Definition of terms applicable to MRTS24

Term	Definition
Applied Load per Anchor	The dead weight of the precast concrete culvert multiplied by the sling angle factor and the dynamic factor and divided by the number of effective lifting points used in the lift.
Culvert Component	Culvert, link slab, or precast base slab
Day	Calendar day

Term	Definition
Designer	Registered Professional Engineer Queensland (RPEQ) responsible for the design of the precast concrete culvert component.
Design Approval Certificate	Certificate issued by the Director (Bridge and Marine Engineering) stating that the design of the culvert is in accordance with this Technical Specification.
Dynamic Factor	A multiplying factor to account for dynamic effects during lifting.
Factor of Safety	The ultimate capacity (lower characteristic strength) of the lifting anchor divided by the applied load per anchor.
f_{sy}	Yield strength of reinforcing steel, as per AS 5100.5
Height	As per AS 1597.1 and AS 1597.2
Large Box Culvert	Rectangular culvert exceeding 1200 mm span, or 1200 mm height, with span and height less than or equal to 4200 mm as per AS 1597.2.
Length	Size of culvert in the direction of water flow
Lifting Anchor	A cast-in, bolted-on or otherwise attached device anchored to the precast culvert component at the lifting point, which is provided exclusively for lifting the precast concrete culvert.
Lifting Attachment	Lifting device used to attach a lifting anchor to the hoisting equipment.
Lifting Point	The designed location of a lifting device to be used for lifting a precast concrete culvert.
Link Slab	A single slab supported by adjacent culverts or structures.
Precast Base Slab	Precast concrete slab used for the base of the culverts.
Rigging Diagram	Diagram showing the method for attaching hoisting equipment to the precast concrete culvert, the required sling angles and load sharing requirements.
Small Box Culvert	Culverts with maximum 1200 mm span and maximum 1200 mm height as per AS 1597.1.
Span	As per AS 1597.1 and AS 1597.2
Sling Angle Factor	The factor by which the tension in a sling increases according to the included angle between the slings.
Super-workable Concrete (SWC)	Concrete that is able to flow and consolidate under its own weight, completely filling the formwork or bore hole even in the presence of dense reinforcement while maintaining homogeneity and generally without the need for additional compaction.
Working Load Limit	The maximum load which may be applied to a lifting anchor, device or attachment.

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 1012.20 (1992)	Methods of testing concrete method 20: Determination of chloride and sulfate in hardened concrete and concrete aggregates
AS 1379 (2007)	Specification and supply of concrete
AS 1597.1 (2010)	Precast reinforced concrete box culverts: Part 1 small box culverts
AS 1597.2 (2013)	Precast reinforced concrete box culverts: Part 2 large box culverts
AS 3600 (2009)	Concrete structures
AS/NZS 4680 (2006)	Hot dip galvanized (zinc) coatings on fabricated ferrous articles
AS 5100.2 (2004)	Bridge design Part 2 Design loads
AS 5100.5 (2004)	Bridge design Part 5 Concrete
AS/NZS ISO 9001 (2008)	Quality management system requirements
Design Criteria	Design Criteria for Bridges and Other Structures (TMR document)
MRTS01	*Introduction to Technical Standards*
MRTS03	*Drainage, Retaining Structures and Protective Treatments*
MRTS04	*General Earthworks*
MRTS50	*Specific Quality System Requirements*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS71A	*Stainless Steel Reinforcing*
MRTS78	*Fabrication of Structural Steelwork*
SMP-PC01 (BCM-P-016)	Procedures Manual: Register of Approved Suppliers of Precast Concrete Products

4 Quality system requirements

4.1 Hold Points, Witness Points and Milestones

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Specification are summarised in Table 4.1.

Milestones are defined in terms of calendar days.

Table 4.1 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Milestone	Witness Point
5.1.2	1. Approval to use precast base slabs	Submission of details for precast base slabs (21 days)	
5.3	2. Approval of alternative dimensions	Submission of alternative dimensions (21 days)	
8.8	3. Design approval	Submission of design information (14 days)	
9.3	4. Approval of manufacture of precast concrete culvert components	Submission of information (7 days)	
9.4	5. Approval of a new manufacturing procedure	Submission of details of process of manufacture (28 days)	
11.5		Substitution of reinforcement (7 days)	
13.2			Placement of concrete
15.1			Inspection of products
15.3	6. Acceptance of Culverts		

4.2 Conformance requirements

The conformance requirements which apply to culvert components covered by this Specification are summarised in Table 4.2.

Table 4.2 – Conformance requirements

Clause	Item
13	MRTS70 *Concrete*
13.10	Tolerances
15	Acceptance

4.3 Testing frequency

The minimum testing frequencies for work covered by this Technical Specification are described in Clause 15 and MRTS70. Culverts are accepted or rejected on an individual basis.

5 Culverts – Types and dimensions

5.1 Types of culvert, link slabs and base slabs

Culverts shall consist of:

a) a monolithic inverted U-shaped section forming the deck slab and the two walls and a separate base slab

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

c) an integral hollow rectangle section forming the top slab, the two walls and the base slab.

5.1.1 Link slab

Link slabs shall be simply supported on mortar seatings on the top of the culverts. Four bar anchors per 1.2 m long slab section shall be provided to locate the assembly. The bar anchors shall pass through holes in the link slab and be grouted into holes provided in the legs of the culvert crowns. For Exposure Classification C2 (see Clause 6.3), these bars shall be stainless steel to MRTS71A. For all other Exposure Classifications, these bars shall be carbon steel to MRTS71 and hot-dipped galvanised to the requirements of AS/NZS 4680.

5.1.2 Precast base slab

Precast concrete base slabs shall not be substituted for cast-in-situ base slabs unless otherwise approved by the Administrator.

If the contractor wishes to use precast concrete base slabs, then the contractor shall submit a proposal including all design (refer Clause 8.7) and installation details to the Administrator, not less than 21 days before manufacture of the culvert components is due to commence **Milestone**

Manufacture shall not commence until written approval is given by the Administrator. **Hold Point 1**

The practicality of manufacturing, transporting and installation of larger slabs should be considered.

5.2 Sizes

The standard dimensions of box culverts components covered by this Technical Specification are as per AS 1597.1 Clause 2.8 and AS 1597.2 Clause 2.8, unless specified otherwise in the Contract documents.

Non-standard sizes may be available upon request from the manufacturer – this should be confirmed before finalising requirements. Availability of culverts components with a span of 450 mm or less should also be confirmed.

5.3 Design water way area

The effective internal dimensions and total cross section of the water way area in the culvert shall not be less than 95% of the nominal internal dimensions specified on the drawings for all culverts. Where this requirement is not met, alternative dimensions may be submitted to the Administrator for approval. Drawings or tabulations showing the alternative dimensions shall be submitted not less than 21 days before supply of culverts is due to commence **Milestone** No culverts of alternative dimensions shall be supplied until written approval is granted by the Administrator **Hold Point 2**

The internal dimensions and effective cross sectional area of the water way determines the hydraulic performance of the culverts. Consideration of alternative smaller effective cross sectional area of the water way for culverts will need to take into consideration the reduction in hydraulic performance and is to be referred to the designer. Compatibility with existing infrastructure and other services may also need to be considered.

6 Design requirements – general

The design of precast concrete culvert components shall comply with the following requirements and shall apply to small and large box culverts.

6.1 Structural design

Structural design of precast concrete culvert components shall be in accordance with the following requirements:

a) small box culverts and link slabs in accordance with Clause 7 by type testing (maximum height of fill being 2 m)

b) small box culvert with height of fill above 2 m in accordance with Clause 8 by design calculations

c) large box culverts and link slabs in accordance with Clause 8 by design calculations

d) where permitted (refer Clause 5.1.2), precast concrete base slabs shall be designed in accordance with Clause 8.7.

6.2 Design life

The design life of all precast concrete box culvert components shall be 100 years.

> This means that 95% of the culvert components shall remain in a serviceable condition with negligible maintenance for 100 years.

6.3 Exposure classifications and cover to reinforcement

6.3.1 Exposure classifications

The minimum exposure classification for all precast concrete culvert components shall be B2 in accordance with AS 1597.1 and AS 1597.2. Exposure classifications shall be in accordance with AS 1597.1 and AS 1597.2, with the exception of the following environments:

a) brackish, saltwater and marine applications in accordance with Table 6.3.1 (a)

b) potential acid sulphate soil (PASS) and acid sulphate soil (ASS) environments in accordance with Table 6.3.1 (b).

Table 6.3.1 (a) – Concrete exposure classifications for precast culvert components in brackish, saltwater and marine applications

Location	Chloride content of water	Exposure classification
Brackish water permanently submerged or zones subject to repeated wetting or drying	2000 ppm to 8000 ppm	B2
Permanently submerged in marine or saltwater	Above 8000 ppm	C
Spray zones in marine or saltwater	Above 8000 ppm	C
Tidal splash zones or zones subject to repeated wetting and drying in marine or saltwater	Above 8000 ppm	C2

Notes:
1. Tidal splash zone is the zone 1.0 m below lowest astronomical tide (LAT) to 1.0 m above highest astronomical tide (HAT).
2. Spray zone is the zone from 1.0 m above HAT where the structure is exposed permanently to salt spray or built over the sea.
3. Culverts which are in occasional contact (more than six times per year) with saltwater shall be Exposure Classification C.

Table 6.3.1 (b) – Concrete exposure classifications for precast culvert elements in PASS/ASS

SO_4 in groundwater (mg/l or ppm)	Acidity (pH)			
	< 3.5	≥ 3.5 to < 4.5	≥ 4.5 to < 5.5	≥ 5.5
< 1500	C2	C1	C	B2
≥ 1500 to < 3000	C2	C1	C	B2
≥ 3000 to < 6000	C2	C1	C	B2
≥ 6000	C2	C1	C2	C

Notes:
1. Full isolation of the concrete surface exposed to the environment by either protective coating, membrane or use of controlled backfill is also required for Exposure Classification C2.

Additional information is provided in this section as AS 5100.5, AS 1597.1 and AS 1597.2 do not adequately address exposure classifications for aggressive environments, including salt water environments, acid sulphate soils (ASS) and potential acid sulphate soils (PASS).

Exposure Classifications C1 and C2 are used in anticipation of a revised AS 5100.5.

6.3.2 Cover to reinforcement

Cover to reinforcement shall be as defined in AS 1597.1 and AS 1597.2 with the following exceptions:

a) Exposure Classification C2 as defined in Tables 6.3.1 (a) or 6.3.1 (b) – 70 mm with rigid forms and intense vibration
b) Exposure Classifications C and C1 as per Exposure Classification C in AS 1597.1 and AS 1597.2 with rigid forms and intense vibration.

In the case where superworkable concrete is used, intense vibration is not mandatory.

Tolerances for cover are given in Clause 11.2.

6.4 Provision for lifting

Each precast concrete culvert component shall be provided with approved lifting points and these lifting points shall be shown on the Drawing. Approved lifting points shall comply with the following:

a) The designer shall be responsible for certification of the lifting points. A rigging diagram shall be shown on the drawing. The rigging diagram shall include details of the required load sharing to equalise loads between lifting points and the included angle between the slings.

b) The minimum factor of safety for the design of the lifting points for both lifting anchor and concrete pull out capacity shall be 4.0.

c) The minimum allowance for dynamic effects (dynamic factor) shall be 1.5. Higher values shall be used in the following cases:

- Lifting with a crawler crane travelling on an even surface with the load suspended (1.7)
- Lifting with a rubber tyred mobile crane either stationary or travelling on an even surface with the load suspended (2.0)
- Lifting while travelling over very rough ground with the load suspended (5.0).

d) Cast-in lifting anchors shall comply with Clause 12 and shall fail in a ductile manner as evidenced by visible distortion prior to failure.

e) If holes are provided instead of cast-in lifting anchors, the manufacturer shall supply tight-fitting concrete or plastic plugs with each consignment to seal the holes. Alternatively, the holes can be filled with an approved cementitious repair grout (refer Clause 1).

f) Cover to reinforcement at the lifting anchor recess is required and shall be maintained in accordance with this Technical Specification.

g) Cover to the lifting anchor is not required, provided any recess is filled with an approved cementitious repair grout, and:

- stainless steel lifting anchors are used for Exposure Classification C2
- lifting anchors are hot dip galvanised to AS 4680 for all other exposure classifications.

h) All lifting anchors shall be permanently marked or tagged by the manufacturer with the working load limit, which shall be clearly visible when installed and in use.

i) The number of lifting points and the location of these points shall be designed to provide stability at all stages of lifting, handling and installation, including the requirement to place the product at the required level during installation.

j) With the exception of small box culvert components with a mass less than 300 kg, a minimum of four lifting points shall be provided, and no product shall be lifted with less than two points. Lifting of culvert components shall be in accordance with the rigging diagram.

k) Lifting anchors which are damaged shall not be used without inspection and certification by an RPEQ Engineer.

In addition to the requirements of MRTS24, the following should also be considered:

a) Details of any temporary bracing or support requirements during transport or erection should also be detailed by the designer.

b) For some products a generic lifting design may cover a range of variations to a product where there are only small variations in design such as minor changes which decrease product mass or inclusion of additional ferrules or cast-in items.

c) For design purposes, it should be assumed that products are lifted 20 times.

d) It should also be noted that the Working Load Limit shown on the lifting anchor may not correspond to a Factor of Safety of 4.0 as required by MRTS24. The manufacturer's specifications and the certified lifting design should always be consulted before installation of lifting anchors.

e) Even surface is defined as a paved or prepared surface suitable for regular traverse of cranes or other heavy equipment.

f) Very rough ground is defined as ground conditions typical of a construction site or off-road conditions.

7 Design of small box culverts and link slabs by type testing

Design of box culverts by type testing is limited to small box culverts and link slabs, with a maximum height of fill of 2 m (refer to AS 1597.1 Clause 1.2).

Design of precast concrete small box culverts, and associated link slabs, will be accepted subject to testing of 1.2 m long units (in accordance with Appendix G of AS 1597.1), demonstrating compliance with Clause 3.3 of AS 1597.1 and the following requirements:

a) for culverts with a cover to reinforcement greater than 50 mm, the crack widths shall be as for culverts with 50 mm cover

b) for ultimate load testing the co-efficient of variation of the five recorded results shall not be greater than 0.15

c) testing of units shall occur at 28 days from the date of manufacture

d) manufacture of the test units shall be in accordance with this Technical Specification, including all materials

e) for small culvert units with a nominal length of 2.4 m the design shall have the same concrete thickness and distribution of reinforcement as a 1.2 m long unit.

The testing shall be witnessed and the results certified and reported by an RPEQ Engineer.

Changes to the maximum nominal aggregate size in the concrete mix shall require re-testing.

Routine load testing of small box culverts and associated link slabs shall be in accordance with Clause 15.2.

8 Design of large box culverts and link slabs, and precast base slabs by calculation

Large precast concrete box culverts, associated link slabs, all precast base slabs and small box culverts with a height of fill above 2 m shall be designed in accordance with AS 1597.2 and the following additional requirements.

8.1 Height of fill

Precast concrete culvert components shall be designed for the worst combination of loads for the corresponding load cases for fill heights from zero to the maximum fill height stated in the Annexure to MRTS03. For fill heights of less than 2 metres, precast concrete box culvert components shall be designed for the worst combination of loads for corresponding load cases for fill heights from zero to 2 metres.

8.2 General design requirements

General design requirements for large box culverts and link slabs shall be as follows:

a) load testing to design or verify the design of large box culverts or link slabs is not permitted.

b) culverts shall be designed to act in all of the following cases, as illustrated in Figure 3.1 of AS 1597.2:

- single cell units designed for vertical and horizontal load effects on both legs
- multi-cell units placed side-by-side or in a link slab arrangement with the interior units designed for vertical load effects only and the exterior units designed for vertical load effects and the horizontal load effects as applicable on one leg only.

c) culverts shall be designed as portal frame structures pinned at the base, with horizontal movement prevented at the base of the culvert leg.

d) skewed culvert units and skewed link slabs are not accepted.

e) sidesway shall be considered for culvert units on a skewed alignment where the culvert has less than 0.5 m of support (1.2 m long units) from an adjacent culvert unit. Similarly, for 2.4 m long culvert units with less than be 1 m of support are to be designed for sidesway. For all other conditions, sidesway may be considered prevented, provided the culverts are installed in accordance with AS 1597.2 Section 5.

f) link slabs shall be designed as a simply supported slab with the effective span being the clear span plus the thickness of the link slab.

g) design of 2.4 m long culvert units shall be as for a 1.2 m long culvert unit with the reinforcement being the appropriate multiple of the 1.2 m long culvert design.

8.3 Installation and fill height design requirements

a) Culverts shall be designed to be installed either in the embankment installation or trench installation condition.

b) Culverts shall be designed for a range of fills from zero to the maximum design fill height as defined in Clause 8.1.

It is expected that the embankment installation case will be the most critical.

8.4 Traffic and construction loading design requirements

a) The traffic loading shall be as follows. All traffic loadings are as defined in AS 1597.2, but with the wheel contact lengths for all loadings as defined in AS 5100.2.

- W80 wheel loading and A160 axle loading
- single lane of the M1600 loading
- two lanes of the M1600 loading with reduction for multiple lanes in accordance with A 5100.2
- HLP400.

b) Dynamic load allowance shall be in accordance with AS 1597.2.

c) Braking loads are not required to be considered.

d) Fatigue loading shall be considered in accordance with AS 5100.2 and AS 1597.2 for culverts with less than 1.0 m of fill on principal interstate and intrastate freeways and highways.

e) Additional construction vehicle loadings shall be as specified in the annexure MRTS24.1 or as nominated by the Contractor. The dynamic load allowance for these construction vehicle loadings shall be 0.4 as per AS 1597.2.

f) The distribution of road and construction traffic wheel loadings through fill shall be in accordance with AS 5100.2.

Wheel contact lengths are defined in accordance with AS 5100 rather than AS 1597.2 to be consistent with all other departmental infrastructure.

Fatigue loading requirements are consistent with AS 1597.2 Clause 3.3.5.6.

Distribution of traffic wheel loadings through fill are as defined in accordance with AS 5100 rather than AS 1597.2 to be consistent with all other departmental infrastructure. Note also that this is a permitted option in AS 1597.2.

8.5 Design for strength and detailing requirements

a) Structural design shall be based on a maximum concrete strength of 50 MPa.

b) Density of concrete shall be assumed to be 2500 kg/m³.

c) Consideration of the effect of reinforcement ductility class on capacity reduction factors shall be in accordance with AS 1597.2 and AS 3600.

d) For design due to bending moment, the effect of the W80 wheel loading located at the edge of the culvert or link slab shall be considered. The effective width shall be determined in accordance with Clause 9.6(b) of AS 5100.5.

e) The shear capacity of recessed link slabs shall be calculated a distance ‘d’ (where ‘d’ is the effective depth of the recessed section) from the face of the support using ‘d’ in calculating the shear capacity.

f) Calculation of shear strength shall be in accordance with AS 3600 Clause 8.2.7. The critical shear section shall be taken as shown in Figure 3.2 of AS 1597.2, with the load positioned in such a way that the maximum shear is produced at the critical sections.

g) The minimum flexural reinforcement shall be in accordance with AS 1597.2 Clause 3.7.2.

h) 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. This requirement shall also apply to precast concrete base slabs (refer Clause 5.1.2).

The requirements of this sub-clause are necessitated by uncertainty as to whether culverts are installed across or along the road.

i) Shrinkage reinforcement shall be a minimum of 150 mm²/m, with a maximum bar spacing of 300 mm.

j) Anchorage of positive moment reinforcement to be in accordance with Clause 8.1.8.3(c) of AS 5100.5.

k) The location of maximum negative moment is in accordance with Clause 7.2.10(a) of AS 5100.5.

l) Reinforcement shall be positioned on all faces of the culvert at cover for large box culverts. Reinforcing may be placed centrally in small box culverts. Haunches must be reinforced.

m) Minimum clear bar spacing shall be in accordance with AS 5100.5.

Calculation of shear strength to AS 3600 Clause 8.2.7 is a permitted option in AS 1597.2 Clause 3.6.1.2.

8.6 Transport and handling design requirements

a) In addition to the self-weight, all culverts and link slabs shall be designed for a vertical dynamic load of 50% of the weight of the culvert or link slab at any stage of the lifting operation.

b) All culvert units shall be designed to be transported either legs down, legs up, or on edge, with this noted on the drawings.

c) Culverts and link slabs shall be designed to resist handling loads without producing a stress in the reinforcement in excess of 0.6 f_{sy}.

Where transport modes are limited by design, this should be indicated on the product.

Design of lifting points is covered in Clause 6.4.

8.7 Precast concrete base slabs

In addition to the requirements of Clauses 8.1 to 8.6, precast culvert bases shall be designed such that:

a) for in-service loads, the ultimate capacity of the precast base slab shall be at least equal to, or greater than, the structural capacity of the cast-in-situ slab Standard Drawings

b) for handling and transporting loads, the self-weight of the slab with a dynamic load allowance equivalent to 50 per cent of the self-weight is supported during handling of the slabs and the steel stress in the reinforcing shall be less than 0.6 f_{sy}.

c) joints between precast concrete culvert base slabs shall be designed to be filled with in-situ concrete and be reinforced such that the joint is capable of resisting:

   i. 25% of the main bending capacity of the slab in the water flow direction, and

   ii. 100% of the main bending capacity of the slab in the span direction.

The joint shall also be designed to be durable with a design life of 100 years.

d) the length or width of the precast base slab shall not be more than 3.6 m.

8.8 Design approval

Manufacture of precast base slabs and large box culvert components shall not commence until a Design Approval Certificate has been issued. **Hold Point 3**

Submission of precast culvert component designs for approval shall be provided to the Director (Bridge and Marine Engineering) at the following address no later than 14 days (two weeks) before the proposed date of manufacture. **Milestone**

Director (Bridge and Marine Engineering)

Bridge and Marine Engineering (BAME)

Queensland Department of Transport and Main Roads (TMR)

GPO Box 1412

Brisbane Qld 4001

8.8.1 Drawings

Drawings for culvert components shall contain the following information as a minimum:

a) concrete strength and aggregate size

b) exposure classification and cover to reinforcement in accordance with Clause 6.3

c) fill height – zero and maximum height of fill

d) grade of reinforcing steel and steel schedule

e) number and nominal spacing of reinforcing bars and details of other reinforcement

f) tolerances on dimensions, cover and steel reinforcement

g) design of standard culverts for Transport and Main Roads projects must conform to MRTS24, MRTS70 and MRTS71

h) design loads in accordance with this Technical Specification Clause 8.4

i) formwork and compaction type (e.g. rigid formwork and intense vibration)

j) lifting details, including all details as defined in Clause 6.4 of this Technical Specification

k) dimensions of haunch

l) calculated mass of individual units

m) unique drawing identification (e.g. plan number and revision number).

All drawings are to be certified by an RPEQ Engineer.

9 Conditions for manufacture of precast concrete culverts

9.1 Specification

All precast concrete culvert components shall be manufactured in accordance with the details shown on the Drawings and in accordance with this Specification.

9.2 Manufacture by registered suppliers

Precast concrete culvert components shall be manufactured only by a Registered Supplier. The requirements for registration are outlined in SMP-PC01. For a copy of this document, refer to contact details in Clause 1 of this specification.

To be eligible for registration as a Registered Supplier, a manufacturer shall:

a) operate a quality management system certified to a minimum of AS/NZS ISO 9001. Certification shall be by a JAS/ANZ accredited certifier

b) establish procedures for manufacture of precast concrete culvert components, and

c) have an inspection and test plan, including Hold Points acceptable to the department for manufacturing precast concrete culvert components which demonstrates compliance with this Technical Specification. The inspection and test plan shall address supply of materials.

Registration as a Registered Supplier of precast concrete culvert components shall be reviewed by the department at intervals varying from six months to three years, depending on registration level or earlier if unsatisfactory performance is noted.

9.2.1 Registration status

Information regarding registration status can be obtained from the department. Refer to Clause 1.

9.3 Manufacture of precast concrete culverts

At least seven days before manufacture is due to commence, the Contractor shall provide to the Administrator the following information: **Milestone**

a) copy of the precast concrete culvert component's Design Approval Certificate and Drawings (refer Clause 8.8)

b) the calculated mass of the culvert components

c) the identity and address of the proposed supplier

d) an outline of the procedure of manufacture, Quality Plan and casting program.

Manufacture of precast concrete culvert components shall not commence until approval has been granted by the Administrator. **Hold Point 4**

Where drawings for culverts have been previously approved by the department, evidenced by a copy of the precast culvert component Design Approval Certificate in accordance with Section 8.8 of this Technical Specification, reinforcement details do not need to be included on the drawings for submission under this item. However, drawings indicating reinforcement details must be available at the place of manufacture for inspection purposes.

9.3.1 Stock items

Where small box culvert components have been manufactured in accordance with this Technical Specification, and to a design which has a precast concrete culvert component Design Approval Certificate, small box culvert components which have been already been manufactured by a Registered Supplier may be accepted at the sole discretion of the Administrator subject to:

a) submission and approval of full production records and all other information in accordance with this Technical Specification, demonstrating that the product is compliant with this Technical Specification prior to the product being delivered to site, and

b) inspection of the product before delivery to site in accordance with the requirements of Clause 15 of this Technical Specification.

9.4 Manufacturing procedure

Procedures for manufacturing precast concrete culverts must be included in the supplier's registration (refer Clause 5.2). Proposed new or innovated procedures must be submitted for inclusion in registration scope not less than 28 days prior to establishment of the process. Significant changes to procedures must be likewise submitted. **Milestone**

Manufacture shall not occur until approval and registration of the new procedure has been granted. **Hold Point 5**

Where innovative manufacturing processes are proposed, it should be noted that the department has a strategy document on engineering innovation which can be found on the department's website.

With respect to intellectual property, the department has and always will respect manufacturer's intellectual property. However, it is considered necessary for all details of products and processes purchased by the department to be provided. These details shall not be provided to any third party. Note that any confidentiality document or formal agreement required may need to be negotiated between Transport and Main Roads Legal Services and the manufacturer.

Dry casting is considered an innovative procedure.

10 Materials

Steel reinforcing shall comply with the requirements of MRTS71, except as amended by this Technical Specification (refer Clause 11).

Cast-in items shall comply with Clause 12 of this Technical Specification.

Concrete shall comply with the requirements of MRTS70, except as amended by this Technical Specification (refer Clause 13).

11 Modifications to MRTS71 Reinforcing Steel

11.1 General

Notwithstanding any requirements to the contrary in MRTS71 *Reinforcing Steel*, Clauses 11.2 to 11.5 shall apply to the manufacture of precast concrete culvert components.

11.2 Cover

The tolerance for cover to steel reinforcing in all elements shall be -5 mm, +10 mm.

> Note that excessive cover on one face may cause insufficient cover on the other – see also Clause 8.5 (m).

11.3 Bar chairs

Bar chairs and spacers between the formwork and reinforcement shall comply with MRTS70. Steel spacers can be used for internal spacing of individual reinforcing mats where the spacer does not intrude on the cover zone in any way.

11.4 Placing of reinforcement

The placing of the reinforcement shall be such as not to interfere with the location of lifting holes, lifting anchors, dowel bars or any other cast-in items. The reinforcement may be displaced locally to obtain the required cover. Cutting or omission of reinforcement is not permitted.

11.5 Substitution of reinforcement

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

Class L reinforcement shall not be substituted for Class N reinforcement unless the culvert, link or base slab has been specifically designed with Class L reinforcement.

12 Cast-in items

Cast-in items including, but not limited to, ferrules, formwork anchors, lifting devices, cast-in bolts, anchor points, lintels, and drainage grate surrounds shall be either:

a) fabricated by an approved steel fabricator in accordance with MRTS78, or

b) proprietary items as specified in the Drawings or approved equivalent. Proprietary cast-in items shall be an approved product (refer to Clause 1).

13 Modifications to MRTS70 Concrete

13.1 General

In addition to the requirements of MRTS70, clauses 13.2 to 13.10 shall apply to the manufacture of precast concrete culvert components.

13.2 Placing concrete

Placing of concrete shall be a mandatory hold point in the manufacturer's Quality Management System. The manufacturer shall also advise the Administrator of the intention to place concrete. **Witness Point** For small box culverts, refer to alternative requirements in Clause 5.4.

13.3 Concrete strength grade and additional concrete mix design requirements

The nominal specified maximum aggregate size shall be 20 mm unless shown otherwise on the Drawings.

MRTS24 requires that 'The nominal specified maximum aggregate size shall be 20 mm unless shown otherwise on the Drawings'. Changing to smaller maximum aggregate size concrete mixes is not permitted unless approved by the designer. There has been some history with increased shrinkage and cracking of product with 10 mm maximum aggregate mixes, particularly in larger products. Smaller aggregate sizes also lead to lower concrete shear strengths.

Note that for small box culverts, changes to aggregate size require the culverts to be retested – refer Clause 7.

13.3.1 Exposure classifications B2

For exposure classification B2 to AS 1597.1 and AS 1597.2, the following requirements are in addition to MRTS70:

a) minimum strength grade to be 40 MPa

b) cementitious material to be a blend compliant with either of the following criteria, with the combined total adding to 100%. Blend tolerances to be as per AS 1379:

- 65% to 75% GP cement, 25% to 35% fly ash
- 50% to 55% GP cement, 20% to 25% ground granulated blast furnace slag and 25% to 30% fly ash, or
- 65% to 71% GP cement, 4% to 8% amorphous silica, and 25% to 31% fly ash.

c) maximum chloride ion content of hardened concrete to be 0.80 kg/m³.

13.3.2 Exposure classifications C, C1 and C2

For Exposure Classifications C, C1, C2 to AS 1597.1 and AS 1597.2 or this Technical Specification, the following requirements are in addition to MRTS70:

a) minimum strength grade to be 50 MPa

b) cementitious material to be a blend compliant with either of the following criteria, with the combined total adding to 100%. Blend tolerances to be as per AS 1379:

- 50% to 55% GP cement, 20% to 25% ground granulated blast furnace slag and 25% to 30% fly ash, or
- 65% to 71% GP cement, 4% to 8% amorphous silica and 25% to 31% fly ash.

c) maximum chloride ion content of hardened concrete to be 0.40 kg/m³

d) For Exposure Classifications C1 and C2, minimum total cementitious content to be 500 kg/m³ and maximum water cementitious ratio to be 0.4.

There is a strong evidence to demonstrate that concrete mixes containing a ternary blend of cementitious materials provide significantly enhanced durability. This is particularly critical in aggressive environments. Use of supplementary cementitious materials, such as fly ash and ground granulated blast furnace slag, also significantly decreases the environmental impacts associated with cement production and also controls Alkalia Silica Reaction (ASR).

Under no circumstances in any environment will the use of only GP cement be considered due to the risk of ASR. Thus, a blended cement is specified in all applications.

The minimum cementitious content for Exposure Classification C mixes is 450 kg/m³ as per MRTS70.

13.3.3 Determination of chloride content of hardened concrete

The following method shall be used to determine the chloride ion content by testing ground samples of hardened concrete in accordance with AS 1012.20.

Take the samples from a minimum 1.2 kg portion of the hardened concrete. Crush and grind the 1.2 kg of hardened concrete to a maximum size of 150 microns, and then oven dry at 110ºC ± 5 ºC for a minimum of one hour before taking the samples for analysis.

Analyse five (5) randomly selected samples of 20 ± 0.1 grams of the ground concrete for chloride ion content.

Use the Volhard titration method calibrated against a concrete with known chloride content for the tests. Modify the procedure of AS 1012.20 and use standard solutions for the analysis that bracket the expected chloride ion concentration. Alternatively, use the AS 1012.20 XRF (X-Ray Fluorescence) Method in accordance with AS 1012.20.

Report the following:

a) chloride ion content of each of the five samples

b) the average chloride content

c) standard deviation of the five samples.

The average mass of acid soluble chloride ion per unit volume of hardened concrete as placed must not exceed the values given in Clause 10.3.2 (c) or 10.3.3 (a) as appropriate.

Tests are to be undertaken by a National Association of Testing Authorities (NATA) accredited laboratory, and be submitted with the mix design. Test is to be repeated annually.

13.4 Formwork

Culverts shall be cast legs down or on end.

Unless specified otherwise on the Drawings, the joints between adjacent culverts shall be plain butt joints.

Formwork shall be constructed from metal – timber forms are not acceptable. Where rigid forms and intense vibration is specified, external formwork vibrators shall be used. Where a hole or void in the

concrete is shown on the Drawings, the formwork or void former shall be removed after casting. Permanent hole formers are not accepted unless shown on the drawing.

13.5 Fillets and chamfers

Internal corners and external edges of all precast concrete culverts shall be finished with curved or straight fillets appropriate to the application.

Specified cover also includes cover to fillets and chamfers.

13.6 Installation of lifting devices

Lifting anchors shall be fixed securely in place before placement and compaction of concrete.

Puddling in of lifting anchors into wet concrete is not permitted. Regarding cover to anchors, see Clause 6.4.

13.7 Removal of formwork

Formwork shall not be removed from the concrete, nor the product lifted until the concrete has attained a strength not less than 40% of the concrete's specified 28-day strength. Curing in accordance with Clause 13.8 of this Technical Specification shall continue as soon as practical, but no later than one hour after removal of formwork.

Where a minimum concrete lifting strength is shown on the Drawings which is higher than these requirements, the Drawing requirements shall apply.

13.8 Curing

13.8.1 General

Curing shall conform to the requirements listed in Clause 13.8.2 and 13.8.3. Combinations of curing methods are permitted.

Combinations of curing may involve steam curing until at least the specified concrete strength for removal of formwork and lifting of the product has been achieved followed by water or membrane curing. This allows maximum utilisation of formwork in precast applications. The requirements of this Technical Specification must be followed in the transition between steam, and water or membrane curing. Care must be taken to avoid damage or cracking to the product due to thermal shock and to ensure that the product has cooled before application of a curing compound if this curing method is used.

13.8.2 Water or membrane curing

Curing shall continue until the lesser of seven days and the time when the concrete has attained 70% of the specified 28 day characteristic strength. Acceptable curing methods are described in MRTS70.

13.8.3 Steam curing

Steam curing processes shall be as per MRTS70. Curing shall be deemed to be complete if 70% of the specified concrete strength and a minimum of 420ºC hours in the enclosure has been achieved.

Where concrete is steam cured for a lesser time than these curing requirements, or 70% of the specified strength has not been achieved, the concrete shall be kept covered and saturated until the concrete surface cools to not more than 20ºC above ambient temperature and alternative curing is commenced to achieve the standard curing requirements defined in Clause 13.8.2 of this Technical Specification.

13.9 Finish

13.9.1 Surface condition

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

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

13.9.2 Cracks, dents and bulges

Precast culvert components shall have:

- no crack or fissure wider than 0.15 mm
- no individual crack longer than 300 mm
- a cumulative crack length of no more than 500 mm.

Dents not exceeding 3 mm in depth and bulges not exceeding 3 mm in height shall be permitted, provided these do not extend over the surface for a distance of more than 180 mm and the specified cover is maintained.

Crack width shall be measured at the surface of the crack and not with the feeler gauge method.

> The intention of MRTS24 is that precast units are produced crack free.
>
> The use of feeler gauges to measure crack width (see AS 1597) is not considered accurate enough due to variability in crack shape and operator technique.

13.9.3 Air holes

Air holes exceeding 12 mm in lateral dimension, or having a depth greater than 3 mm, shall be filled in accordance with MRTS70 *Concrete*.

> The intention of this specification is that precast units are produced with very few air holes. Excessive air holes are a strong indication that suitable manufacturing processes are not being observed in the production process and are not acceptable.

13.10 Tolerances

Tolerances on measured dimensions for both small and large box culverts and associated link slabs shall comply with AS 1597.1 and AS 1597.2 as appropriate and the following requirements.

13.10.1 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.

13.10.2 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.

13.10.3 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.

13.10.4 Fillets

The internal corners of culverts shall be finished with curved or straight fillets appropriate to the size of the culverts. Fillets shall not reduce the waterway area beyond the requirements outlined in Clause 5.3.

14 Handling, storage, and transportation

14.1 Marking

The following information shall be clearly and permanently marked on each culvert component from time of manufacture:

a) the date of manufacture and unique identification number

b) the manufacturer's name or registered mark

c) the size of the culvert component

d) the maximum mass of the culvert component

e) the Technical Specification number and version to which the culvert component has been manufactured.

14.2 Handling

Culvert components shall be handled in a manner which will avoid damage to the components and shall be lifted using the lifting points provided as shown on the Drawings and Rigging Diagram (refer Clause 6.4).

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

14.3 Transportation

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

Precast base slabs and link slabs shall be transported in the as-laid position.

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

14.4 Storage

Culvert components to be stored shall be placed on an even surface, stacked and supported in a manner that will avoid damage. Culvert components may be stored in more than one layer. Timber or other suitable material which does not damage, mark or stain the culverts shall be used as supports between the ground and the culvert components and separating each layer. For culvert components,

stack height shall be no greater than either six metres or six culverts. The manufacturer shall be responsible for any damage that occurs during storage.

For precast base slabs and link slabs, supports shall be placed near the ends of the slab and directly above the supports of any lower layer and the maximum number of slabs in any one stack shall be six components.

15 Acceptance

15.1 General

Precast culvert components shall remain available for inspection for a minimum of seven days from the date of manufacture **Witness Point**. Precast culvert components shall be rejected if the components fail to meet any of the requirements of this Technical Specification.

Any damage to the product during handling or transportation to site shall be assessed in accordance with Clause 13.9 of this Technical Specification.

Culvert components shall be accepted on the basis of compliance with the acceptance criteria as listed in Table 15.1.

Table 15.1 – Applicability of acceptance criteria

Acceptance criteria	Small box culverts1	Large box culverts2
Type testing	Applicable	Not applicable
Component design	Base slabs only	Applicable
Visual inspection	Applicable	Applicable
Geometric measurement	Applicable	Applicable
Cover to reinforcement	Applicable	Applicable
Reinforcement spacing and location	Applicable	Applicable
Concrete strength	Applicable	Applicable
Proof load testing	Applicable	Not applicable
Ultimate load testing	Applicable	Not applicable

Notes:
1. Maximum height of fill of 2 m.
2. Also small box culverts with height of fill over 2 m.

This Technical Specification states that ‘Precast concrete culvert components may be rejected should the components fail to meet any of the requirements of this Technical Specification’. It should be noted that manufacture of defect-free product in accordance with MRTS24 is always the preferred outcome. However, where issues exist, early submission of non-conformances in accordance with the contract to the Administrator may assist with resolving issues. Acceptance of non-conforming or defective product is always at the discretion of the Administrator.

15.2 Routine testing

Routine testing of box culverts shall be conducted in accordance with Appendix F of AS 1597.1 or Appendix F of AS 1597.2, as appropriate, and the following requirements.

For this purpose:

a) the definition of 'design' shall include exposure classification and cover to reinforcement

b) culverts and link slabs shall be treated as separate lots

c) months shall be considered as calendar months.

Testing and acceptance of reinforcement materials shall be in accordance with MRTS71.

Testing and acceptance of concrete shall be in accordance with MRTS70.

For the purposes of defining a lot and selecting a sample (see AS 1597.1 F2, AS 1597.2 F2), sampling shall be planned such that during the course of a calendar year, each size and design of culvert should be sampled for testing, with the exception of ultimate load tests for small box culverts.

This requirement may necessitate the testing of non-prominent sizes/designs, in the case of Clause F2 (ii) and non-largest sizes/designs, in the case of Clause F2 (iii).

This requirement is included to ensure that smaller or less common sizes and designs are tested on a semi-regular basis.

15.2.1 Proof load testing

The frequency of testing and the basis of acceptance of the testing for proof load shall be as defined in Clause F6.1 of AS 1597.1 or monthly – which ever gives the greater number of tests.

Based on these requirements, generally proof load testing will occur either monthly or two per 50 culvert components – which ever gives the most number of tests.

15.2.2 Ultimate load testing

The frequency of testing and the basis of acceptance of the testing for ultimate load shall be as defined in Clause F6.2 of AS 1597.1.

Clause F6.2 requires an ultimate load test every 150 components or per three months of production – whichever gives the most tests.

15.3 Information to be supplied at delivery

With each batch of culverts delivered to the site, a delivery docket shall be supplied that provides traceability to a conformance report for the batch. The delivery docket shall also state that the culverts supplied conform to the requirements of this Technical Specification.

At no less than monthly intervals, the Contractor shall provide a conformance report, issued by the manufacturer, confirming that the culverts supplied conform to the requirements of this Technical Specification and providing the conformance information as listed in Clause 15.1.

In addition for small box culverts, this conformance report shall include reports on the load testing of small box culverts and link slabs in accordance with AS 1597.1 Clause G9.2.

Final acceptance of culvert components shall be subject to receipt and acceptance of these reports by the Administrator. **Hold Point 6**

16 Installation

Culverts shall be installed in accordance with MRTS03 and MRTS04. Culverts shall not be backfilled or loaded with construction traffic prior to 28 days from date of manufacture, unless otherwise approved by the Administrator.

Backfilling of culverts is a Hold Point: MRTS04 Clause 19.3.3.