Technical Note 23

Design Criteria for Precast Drainage Pits

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Queensland Government

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1 Purpose

The purpose of this Technical Note is to address the design criteria for precast drainage pits to departmental requirements.

2 Referenced documents

The table below lists referenced documents in this technical document.

Table 2 – Referenced documents

Reference	Title
AS 1597.1 (2010)	*Precast reinforced concrete box culverts, Part 1: Small culverts (not exceeding 1200 mm span and 1200 mm height)*
AS 1597.2 (2013)	*Precast reinforced concrete box culverts, Part 2: Large culverts (exceeding 1200 mm span or 1200 mm height and up to and including 4200 mm span and 4200 mm height)*
AS 1657	*Fixed platforms, walkways, stairways and ladders - Design, construction and installation*
AS 3600	*Concrete structures*
AS 3996	*Access cover and grates*
AS/NZS 4058	*Precast concrete pipes (pressure and non-pressure)*
AS/NZS 4671	*Steel for the reinforcement of concrete*
AS 5100	*Bridge design*
AS 5100.2	*Bridge design, Part 2: Design loads*
AS 5100.3	*Bridge design, Part 3: Foundation and soil-supporting structures*
MRTS03	*Drainage Structures, Retaining Structures and Embankment Slope Protections*
MRTS04	*General Earthworks*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS72	*Manufacture of Precast Concrete Elements*
MRTS273	*Fibre-reinforced Concrete*
SD1309	*Concrete Gully - Field Inlet Type 1*
SD1310	*Concrete Gully - Field Inlet Type 2*
SD1443	*Concrete Gully - Roadway Type Precast Inlet Units on Grade*
SD1444	*Concrete Gully - Roadway Type Precast Inlet Units in Sag*

3 Design life

The design life means that 95% of the production shall remain in a serviceable condition with negligible maintenance for the specified design life.

a) For pits up to 5.0 m deep – 50 years.

b) For pits deeper than 5.0 m – 100 years.

4 Design loads

4.1 Vertical traffic loads

Precast concrete pits shall be designated by Types 1, 2 and 3 according to the design vertical load of the pit. The pit supplier shall mark the appropriate pit Type Number on the inside face of one pit wall. The pit type shall be written on the construction drawings.

a) Type 1 – Pits use for field inlets

   For precast pits that are used for field inlets (loaded only by a 10 tonne maintenance vehicle as per SD1309 and SD1310), the vertical traffic wheel load shall be 30 kN with a dynamic factor of 1.1 and Serviceability Limit State and Ultimate Limit state load factors of 1.0 and 2.0 respectively.

b) Type 2 – Pits under precast gully inlet

   For pits with a maximum plan internal dimension less than 1500 mm, that are used under roadside gullies (at the kerb) and not directly exposed to wheel loads (e.g. pits under precast inlet units to SD1443 or 1444), the vertical traffic wheel load shall be 50 kN with a dynamic factor of 1.4 and Serviceability Limit State and Ultimate Limit state load factors of 1.0 and 1.8 respectively. Pits with plan inner dimension greater than 1500 mm, or an alternative inlet structure other than that of the type shown in SD1443 or 1444 shall be designed as a Type 3 pit.

   Generally precast gully inlets units are designed to span over a maximum pit size of 930 mm. Therefore, pits with a maximum plan inner dimension greater than 930 mm may require the use of a 'Converter Slab' to ensure that the gully pit span is 930 mm or less.

c) Type 3 – Pits directly under road traffic

   Pits that are exposed to direct traffic roads, shall be designed for the worst effect of W80, A160, SM1600 and HLP400 in accordance with AS 5100.2. Traffic load factors and dynamic load allowance shall be as defined in AS 5100.2.

   Pits designed for higher traffic loads can be used for locations where the actual traffic load is less than its design loads. For example, a Type 2 pit can be used where a Type 1 pit has been specified.

4.2 Horizontal earth pressure

Horizontal earth pressure due to compacted fill shall be calculated to Clause 3.3.3 of AS 1597.2 with K_0 equal to 0.5. ULS load factor for earth pressure is 1.5.

4.3 Surcharge loads from road traffic loads

Live load surcharge shall be determined in accordance with Clause 14.2 of AS 5100.2. Earth pressure coefficients shall be calculated similar to Section 4.2 of this document.

The traffic surcharge loads for field inlets (Type 1 Pits) shall be 10 kPa.

4.4 Horizontal pressure due to compaction

Horizontal pressure due to compaction shall be determined in accordance with AS 1597.2 Clause 3.3.4, with a Serviceability Limit State and Ultimate Limit state load factors of 1.0 and 1.4 respectively.

4.5 Water pressure on pit walls

All pits shall be designed for external hydrostatic pressure on pit walls for minimum water level 1.0 m below the finished surface of the fill and pit in its empty condition.

4.6 Access covers and grates

Access covers and grates shall be in accordance with AS 3996. Covers and grates shall be designed for load classification in accordance with AS 3996 and appropriate for the application. The minimum load classification for pits under road traffic shall be Class D.

4.7 Load combinations

Load combinations shall be in accordance with AS 5100.2.

5 Materials

5.1 Steel bar reinforced concrete pits

a) Concrete to be in accordance with MRTS70 *Concrete.* All concrete to be Special Class to MRTS70.

The minimum concrete strength shall be 40 MPa and in accordance with the required cover to reinforcement and exposure classifications.

Exposure classifications and cover to reinforcement for pits up to 5.0 m deep (50 years design life) shall be as defined in AS 3600. The minimum exposure classification shall be B1. Cover to reinforcement is as defined in AS 3600.

Exposure classification for pits deeper than 5.0 m (100 year design life), shall be in accordance with AS 5100.5 with a minimum exposure classification of B2. Cover to reinforcement is as defined in AS 5100.5.

Higher exposure classifications to be determined in accordance with AS 5100.5 or AS 3600 as appropriate.

5.1.1 Reinforcement

Reinforcement shall be in accordance with MRTS71 *Reinforcing Steel* and AS/NZS 4671. If ductility Class L reinforcement is used, reduced strength reduction factors to Table 2.2.2 of AS 3600 shall be used. If Class L reinforcement together with Class N reinforcement is used, the maximum value for capacity reduction factor for member design strength calculation shall be taken as 0.64.

5.2 Fibre reinforced concrete pits

This clause describes the requirements for concrete pits that are predominantly manufactured from fibre reinforced concrete, but may have some additional or supplementary steel bar reinforcement.

The maximum plan internal dimension of a fibre reinforced concrete pit shall be 1500 mm by 1500 mm, or for round pits or round access chambers maximum internal diameter of 1500 mm. The maximum height for fibre reinforced concrete pits shall be less than or equal to 5.0 m.

The minimum concrete strength shall be 40 MPa.

5.2.1 Fibres

Fibres shall comply with MRTS273 *Fibre-reinforced Concrete* and be either steel fibres or macro synthetic. Steel fibres shall not be used in salt or brackish water applications with a chloride content above 2000 ppm. The minimum fibre dosage shall be in accordance with MRTS273. Specification of fibres and dose rate shall also be performance based in accordance with MRTS273.

5.2.2 Concrete

Concrete to be special Class concrete in accordance with MRTS70 *Concrete* and additional requirements of MRTS273 *Fibre-reinforced Concrete*. Minimum performance measures of MRTS273 apply. Additional concrete testing to MRTS273 with the exception that toughness testing is not required at trial mix.

Cover to any steel bar reinforcement shall be in accordance with Clause 5.1 of this Technical Note. For fibre reinforced concrete pits with no steel bar reinforcement exposed to Potential Acid Sulphate Soils or Acid Sulphate Soils (PASS/ASS) or other acidic soil environments, a sacrificial concrete thickness equal to the cover to steel bar reinforcement shall be provided, or alternatively an acid resistant epoxy coating shall be applied to exposed surfaces of the pit.

6 Structural design

Structural design of pits shall be in accordance with this section and the process is further summarised in Appendix A – *Design process for precast drainage pits*.

6.1 General

Precast pits shall be designed to meet following requirements:

a) Wherever possible, pits shall be designed and cast monolithically in a single piece to a site-specific height as per the Design Drawings. If not possible, pits can be designed and cast in multiple sections with individual sections (except for the final top section) a minimum of 1.2 m in height. Joints shall be bedded / sealed with cement mortar to MRTS03 *Drainage Structures, Retaining Structures and Embankment Slope Protections* or cementitious proprietary products in accordance with the manufacturer's instructions to produce watertight joints.

b) Minimum wall and base thickness for all types of pits shall be 100 mm.

c) Drawing notes shall include all design criteria, relevant Australian Standards, Transport and Main Roads Technical Specifications, material standards and manufacturing requirements.

d) Structural analysis shall be carried out using relevant structural analysis software or other appropriate methods to determine the necessary structural actions.

e) Load testing of prototypes (refer Section 6.2) to confirm the structural performance can be used as an alternative method of design for size of pits up to maximum internal pit plan dimension of 1500 mm by 1500 mm, or 1500 mm diameter for round pits or access chambers can be undertaken.

f) The design shall be certified by a Registered Professional Engineer of Queensland (RPEQ) (Structural).

6.2 Serviceability and ultimate limit state design

6.2.1 General requirements for drainage pits

The following criteria is applicable for all drainage pits:

a) For steel bar reinforced concrete pits, Ultimate and Serviceability Limit State design shall be to Clause 9 of AS 3600 for pits up to 3.0 m depth and to Clause 9 of AS 5100.5 for pits of depth over 3.0 m. For design of fibre reinforced concrete pits, refer Clause 6.2.3(a).

b) Pit walls and the base shall be designed for the worst load effect of vertical traffic loads and horizontal loads on the pit walls as stated in Section 4 of this document. The appropriate load factors and the load combinations as stated in Section 4 of this document shall be used.

c) Load cases where the traffic wheel load distributed to all walls shall be considered to obtain the maximum design base pressure and structural actions (bending moment and shear force) on the base.

d) Where there is a cover or grate associated with the pit, covers and grates shall be designed for the load classification appropriate for the application in accordance with AS 3996. The minimum load classification for pits under road traffic shall be Class D. The cover and grate design loads are only for cover and grate design. The pit structure shall be designed for AS 5100.2 loads referred to in Section 4 of this document.

6.2.2 Steel bar reinforced concrete pits

For steel bar reinforced concrete pits of size up to maximum plan internal dimension of 1500 mm by 1500 mm or circular pits up to a maximum 1500 mm internal diameter, the pit structural capacity at Serviceability and Ultimate Limit State may be determined by prototype load testing as an alternative to design by calculations stated in Section 6.2.1. The following requirements shall be met for prototype testing:

a) The test load shall be determined from a structural model prepared for the applicable design loads specified in Section 4 of this Technical Note.

b) The test loads for the serviceability limit state shall be determined by multiplying the Serviceability Loading by 1.2 (refer AS 3600 Clause B4.3), and for the Ultimate Limit State by multiplying the Ultimate Design Load Design load by an additional factor as per Table B4.3 of AS 3600 assuming an expected coefficient of variation of 10%.

c) A single pit size or component which represents the worst case for the design may be used as a prototype test for multiple less critical sizes (e.g. for a pit design with the same wall and base thickness for multiple sizes, the largest size pit only needs to be tested).

d) The maximum number and size of pipe penetrations permitted by the design shall be used in the test pit.

e) The prototype load testing, acceptance criteria and reporting of test results shall generally in accordance with Appendix G1 of AS 1597.1 with test loads being derived as per item (b) of this clause. The maximum crack width at the Serviceability Limit State Load shall be equivalent to the 'proving test load applied' in Table G1 of AS 1597.1 and after unloading from the Serviceability Limit State Load equivalent to 'proving test load removed' in Table G1 of AS 1597.1. Crack widths for intermediate cover to reinforcement in Table G1 of AS 1597.1 can be interpolated. Crack widths for cover to reinforcement greater than 50 mm shall be the

value for 50 mm. For pits with fibre reinforcement only, the crack widths equivalent to a cover to reinforcement of 25 mm shall be used.

f) All crack widths shall be measured during testing at the concrete surface by crack gauge card or ruler. As an option, a feeler gauge as per AS 1597.1 may be used.

g) Vertical downwards loading applied to the pit in the normal orientation. The vertical load shall be applied uniformly to the four walls of the pit. The pit base shall be supported on a thick rubber pad or thick polystyrene foam pad of adequate stiffness and thickness to simulate the ground support conditions of the base of the pit. This pad shall be supported on a concrete slab or similar surface. Test loads shall be determined as per Section 6.2.2 (a) and (b). Vertical load test shall be undertaken for both Serviceability Limit State and Ultimate Limit State.

   Test method, loadings, test results, statement of compliance including photographs in accordance with Appendix G of AS 1597.1 and this Technical Note shall be prepared and submitted by the pit supplier for acceptance by the Director (Structures Design, Review and Standards). The department may elect to witness the prototype load testing.

6.2.3 Fibre reinforced concrete pits

For fibre reinforced pits, the pit shall be designed to meet following requirements:

a) Following requirements shall be met for pit designed by structural analysis and capacity calculations:

   i. Pits shall be uncracked for the Ultimate Limit State Loading.

   ii. Fibre reinforced pits are not required to be designed for Serviceability Limit State due to requirement to be uncracked at the Ultimate Limit State Loading.

   iii. The design bending strength of the pit shall be calculated as ϕM_{uo}, where M_{uo} shall be calculated using the characteristic flexural tensile strength ($f'_{ct,f}$) determined by testing in accordance with MRTS273 *Fibre-reinforced Concrete*. The strength reduction factor (ϕ) for bending shall be taken as 0.65.

   iv. Shear strength of the fibre reinforced concrete members shall be calculated considering plain concrete section in accordance with AS 3600 Clause 20.4.3. The strength reduction factor (ϕ) for shear shall be taken 0.65.

b) When pit structural capacity is determined by prototype testing as an alternative to design by calculations, prototype testing shall be as per reinforced concrete pit test method provided in Section 6.2.2 of this Technical Note. Both Ultimate and Serviceability Limit State performance shall be tested.

6.3 Crack control for shrinkage and temperature effects

6.3.1 Steel bar reinforced pits

6.3.1.1 Base slab

Primary Direction reinforcement shall be as per Clause 9.5.3.2 of AS 3600.

Secondary Direction:

a) For square slabs, the slab shall be considered as a partially restrained slab to Clause 9.5.3.5 of AS 3600 but reinforcement shall not be greater than the reinforcement provided in primary direction.

b) For rectangular slabs where length / width ratio is equal or greater than two, slabs shall be considered as a partially restrained slab to Clause 9.5.3.5. Average of reinforcement area required for Clause 9.5.3.3 and Clause 9.5.3.4(c) of AS 3600 shall be provided.

6.3.1.2 Pit walls

Primary Direction reinforcement shall be as per Clause 9.5.3.2 of AS 3600.

Secondary Direction minimum reinforcement to Clause 9.5.3.3 of AS 3600 considering an unrestrained slab to full height shall be provided.

6.3.2 Fibre reinforced concrete pits

Crack control for shrinkage and temperature shall be deemed to be controlled provided the minimum fibre content as per MRTS273 *Fibre-reinforced Concrete* is provided.

6.4 Penetrations for drainage pipes

The penetration for precast drainage pits shall meet following requirements:

a) All penetrations on pit walls for drainage pipes are preferably above the base slab. The lowest outlet penetration shall be placed on the top of the base slab. The depth of base slab shall be increased to match the invert level of the lowest outlet pipe to achieve a smooth flow inside the pit. Alternatively, the invert level of the lowest pipe penetration may be kept within the minimum required base slab thickness provided the designer has calculated the structural adequacy of the reduced base slab thickness at the penetration, using a Finite Element analysis or other appropriate methods.

b) Local stresses at penetrations for drainage pipes shall be taken into consideration in structural design. Adequate trimmer bars shall be provided at the penetration to control cracking around the periphery of the penetration.

c) All penetrations through pit walls for drainage pipes are to be pre-formed (blockout) during casting, or core drilled by the pit manufacturer at the precasting yard. 'Knockout' pits are not permitted.

6.5 Bearing pressure under base

Load cases for full and empty pit with wheel loading on the roof as per Section 4.1 of this Technical Note shall be considered to determine the bearing pressure under the base slab. The design bearing pressure shall be calculated in accordance with AS 5100.6 and provided in the design documentation and drawings.

7 Manufacturing requirements

Manufacture of precast drainage pits shall meet following requirements:

a) Manufacture of precast concrete pits shall be in accordance with MRTS72 *Manufacture of Precast Concrete Elements*.

b) Lifting points shall be designed and RPEQ certified in accordance with MRTS72. The lifting points shall be shown in the design documentation.

c) Additional requirements of MRTS273 *Fibre-reinforced Concrete* to apply for fibre reinforced concrete pits.

8 Access to pit

Safe access to inside the pit for inspection and maintenance shall be considered in the pit design. Permanent access if specified shall comply with AS 1657.

9 Construction

Backfilling shall be undertaken in accordance with MRTS04 *General Earthworks*.

10 Proprietary precast pit designs

Proprietary pit designs shall be in accordance with this Technical Note and shall be submitted to the following email for review and approval by the Director (Structural Design, Review and Standards):

Email: tmr.techdocs@tmr.qld.gov.au

If the submission is not suitable for emailing, please mail to Director (Structural Design, Review and Standards) for review and approval:

Department of Transport and Main Roads
Engineering and Technology
Director, (Structural Design, Review and Standards)
GPO Box 1412
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Appendix A – Design process for precast drainage pits