Technical Note 23

Design Criteria for Precast Drainage Pits

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1 Purpose

This document outlines the department's design criteria for precast concrete drainage pits. It applies solely to pits, whether rectangular or round, connected to a stormwater drainage network. The maximum dimensions of pits under this document are:

a) internal plan dimension of 2500 mm (rectangular pits) or 1800 mm (round pits), and

b) internal depth of 5000 mm (inclusive of all risers and convertors).

For pits with dimensions outside this range, project-specific design criteria will need to be established.

Assessment of proprietary designs against this document is a requirement of MRTS72 *Manufacture of Precast Concrete Elements*.

2 Referenced documents

The table below lists referenced documents in this technical document.

Table 2 – Referenced documents

Reference	Title
AS 1597.1	*Precast reinforced concrete box culverts, Part 1: Small culverts (not exceeding 1200 mm span and 1200 mm height)*
AS 1597.2	*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 4198	*Precast concrete access chambers for sewerage applications*
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*
AS 5100.5	*Bridge design, Part 5: Concrete*
MRTS03	*Drainage Structures, Retaining Structures and Embankment Slope Protections*
MRTS04	*General Earthworks*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS72	*Manufacture of Precast Concrete Elements*
MRTS271	*Glass Fibre Reinforced Polymer (GFRP) Reinforcement*
MRTS273	*Fibre-reinforced Concrete*
SD1309	*Concrete Gully – Field Inlet Type 1*
SD1310	*Concrete Gully – Field Inlet Type 2*

Reference	Title
SD1443	*Concrete Gully – Roadway Type Precast Inlet Units on Grade*
SD1444	*Concrete Gully – Roadway Type Precast Inlet Units in Sag*

3 Proprietary precast pit designs

3.1 Design approval

Proprietary pit designs shall be submitted for review and approval by the Director (Systems and Governance). Submissions shall be made to tmr.techdocs@tmr.qld.gov.au and include sufficient evidence of compliance to this document (see Section 3.3).

Approved pit designs are listed in the *Proprietary Design Index for Bridges and Other Structures*, found on the Bridges and other structures Approved products and suppliers webpage and will also have a corresponding Transport and Main Roads Design Approval Letter.

3.2 Project-specific pit design

Pits with dimensions outside the ranges specified in this document (Section 1), or have additional project-specific design criteria, need to be assessed on a project-by-project basis. This will be managed through the project's design verification process.

3.3 Submission Requirements

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

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

The submission package shall include a statement of the applicability of the design (e.g., size range and exposure classification).

All drawings related to the design shall be included, with sufficient traceability between them. For example, the package may include general arrangement, reinforcement, and lifting drawings and tables for penetration detailing.

3.4 Design variation

Proprietary pit designs are by nature generic, in that the size and location of penetrations, and the depth of the pit, will be specific to an intended installation. Therefore, design approval is given to a design with a maximum number and maximum size of penetrations, and a range of depths, rather than individual pit details (such as those shown on a shop drawing). The size and number of penetrations on the shop drawing, and or the depth range of the pit, cannot exceed the approved design.

Designs may also be varied after approval to the extent that the structural and durability function is unchanged, for example minor edits / corrections to notes or title blocks.

4 Materials

4.1 General

Pits shall be manufactured from steel-reinforced concrete, fibre-reinforced concrete or concrete reinforced with Glass Fibre Reinforced Polymer (GFRP) reinforcing bars. Circular pits may be manufactured from machine-made concrete pipe segments. Unreinforced precast concrete drainage pits are not accepted.

Note: Circular pits may be manufactured by machine-made process or standard wet cast process as described in AS 4198.

4.2 Concrete

Concrete to be in accordance with MRTS70 *Concrete* and designated as Special Class.

The minimum concrete strength shall be 40 MPa.

Additionally, fibre-reinforced pits concrete to be in accordance with MRTS273 *Fibre-reinforced Concrete*.

For precast pit components manufactured from Steel-Reinforced Concrete Pipes (SRCP), concrete shall comply with MRTS25 *Steel Reinforced Precast Concrete Pipe*.

For precast pit components manufactured from fibre-reinforced concrete pipes, concrete shall comply with MRTS26 *Manufacture of Fibre Reinforced Concrete Drainage Pipes*.

4.3 Reinforcement

Reinforcing steel shall be in accordance with MRTS71 *Reinforcing Steel* and AS/NZS 4671.

Macro-synthetic and steel fibres shall be in accordance with MRTS273 *Fibre-reinforced Concrete*. Steel fibres shall not be used for pits with exposure classifications above B2.

GFRP reinforcing bars shall be in accordance with MRTS271 *Glass Fibre Reinforced Polymer (GFRP) Reinforcement*.

4.4 Covers and grates

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 itself shall be designed for AS 5100.2 loads as per this document.

5 Design life

Design life is specified such that 95% of the production can be expected to remain in a serviceable condition with negligible maintenance for the duration noted.

The design life shall be:

a) 50 years, for pits up to 3 m deep, or

b) 100 years, for pits from 3 m to 5 m deep.

6 General requirements for all precast drainage pits

6.1 General

Precast drainage 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 such as base pit unit, intermediate sections and top section. The minimum height of the intermediate sections shall be 1.2 m. Joints shall be bedded / sealed with cement mortar, proprietary cementitious or epoxy products to MRTS03 *Drainage Structures, Retaining Structures and Embankment Slope Protections*, or in accordance with the manufacturer's instructions to produce watertight joints.

b) Minimum wall and base thickness for rectangular pits shall be 100 mm. Minimum wall thickness for machine-made round pits shall be 60 mm. All other round pits shall have minimum wall thickness of 100 mm. Minimum base thickness for round pits shall be 100 mm.

> Note: The minimum 60 mm wall thickness requirement for machine-made round pit is derived based on AS 4198 with internal surfaces Exposure Classification to Mildly Aggressive, external surface Exposure Classification to Moderate, and reinforcement bar of 10 mm. Round pits shall be load tested as per AS 4198. If the reinforcement bar is greater than 10 mm, the minimum cover to reinforcement shall be as per the requirements for wet cast.

c) 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 7 of this document. The appropriate load factors and the load combinations as stated in Section 7 of this document shall be used.

d) 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.

e) Lifting points shall be designed and RPEQ certified in accordance with MRTS72 *Manufacture of Precast Concrete Elements*. The lifting points shall be shown in the design documentation.

f) The design and load test requirements for rectangular steel bar reinforced or fibre reinforced concrete pits shall be in accordance with Section 8 of this document.

g) The performance requirements for circular steel bar reinforced or fibre reinforced concrete pits shall be in accordance with Section 9 of this document.

h) The design and load test requirements for precast concrete pits reinforced with GFRP reinforcing bars shall be in accordance with Section 10 of this document.

6.2 Penetrations

The penetration for precast drainage pits shall meet following requirements:

a) All penetrations on pit walls for drainage pipes shall be 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) The edge of each penetration shall be at least 50 mm from the internal face of adjacent pit walls for rectangular pits.

c) 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.

d) 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. The diameter of the pre-formed holes shall not exceed the pipe external diameter by more than 100 mm.

e) The pit wall above the penetration shall be adequate to allow for the distribution of design loads around the penetration.

f) Connected pipes into circular pits shall not be larger than 750 mm nominal diameter.

6.3 Bearing Pressure

Load cases for full and empty pit with wheel loading on the roof as per Section 7 of this document shall be considered to determine the bearing pressure under the base slab. The design bearing pressure shall be calculated in accordance with AS 5100.3 and provided in the design documentation and drawings.

6.4 Access to Pit

Safe access to inside the pit for inspection and maintenance, including the method of access, shall be considered in the pit design. Permanent access if included, shall comply with AS 1657. Any step irons shall be proprietary products manufactured to AS 1657.

> Note: The need for permanent access will be determined by the individual project designer following a safety-in-design assessment.

6.5 Construction

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

7 Design loads

7.1 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 or internal diameter 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 (e.g., a Type 2 pit can be used where a Type 1 pit has been specified).

7.2 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.

7.3 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 7.2 of this document.

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

7.4 Horizontal pressure due to compaction

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

7.5 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.

7.6 Load combinations

Load combinations shall be in accordance with AS 5100.2.

8 Specific additional requirements for rectangular precast drainage pits

8.1 Design requirements for rectangular steel bar reinforced drainage pits

8.1.1 Serviceability and Ultimate Limit State design

The following criteria is applicable to rectangular steel bar reinforced drainage pits:

a) Exposure classifications and cover to reinforcement for pits up to 3.0 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.

b) Exposure classification for pits deeper than 3.0 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.

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

d) Ultimate and Serviceability Limit State design shall be in accordance with 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.

e) A reduced strength reduction factors to Table 2.2.2 of AS 3600 shall be applied if ductility Class L reinforcement is 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.

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

g) Load testing of prototypes 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. Refer to Section 8.3 of this document for the requirement of load testing.

8.1.2 Crack control for shrinkage and temperature effects

8.1.2.1 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 2, 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.

8.1.2.2 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.

8.2 Design requirements for rectangular fibre reinforced drainage 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. The maximum height for fibre reinforced concrete pits shall be less than or equal to 3.0 m.

The following requirements shall be met for fibre reinforced pits designed by structural analysis and capacity calculations:

a) Pits shall be uncracked for the Ultimate Limit State loading.

b) 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.

c) The design bending strength of the pit shall be calculated as ΦMuo, where Muo 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.

d) 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.

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

Note: This methodology requires the designer to specify the type and dosage of fibre.

For fibre reinforced concrete pits with reinforcement, cover to any steel bar reinforcement shall be in accordance with Section 8.1 of this document. 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.

8.3 Determine pits structural capacity by prototype testing

For rectangular concrete pits of size up to maximum plan internal dimension of 1500 mm by 1500 mm, 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 8.1 and 8.2. 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 7 of this document.

b) The test loads for the Serviceability Limit State shall be determined by multiplying the serviceability loading by 1.2 (refer to Clause B4.3 of AS 3600), and for the Ultimate Limit State by multiplying the ultimate 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 G 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) Pits shall be tested for vertical and horizontal loads derived in (a) and (b). Vertical loads should be applied to the top of the pit, and then the horizontal loads should be applied to the pit walls until the vertical and horizontal loads occur simultaneously. Load test shall be undertaken for both Serviceability Limit State and Ultimate Limit State.

h) 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.

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

9 Specific additional requirements for Precast circular concrete drainage pits

9.1 Performance requirements

Circular precast access and maintenance chambers to AS 4198 may be used where the size of these chambers is consistent with the pits shown on the drawings and where accepted by the Administrator. The performance requirements for precast circular concrete drainage pits shall be in accordance with AS 4198.

For circular pits manufactured from fibre reinforced concrete, the maximum plan internal diameter shall be 1500 mm and maximum height shall be 3000 mm.

9.2 Cover to reinforcement

For Exposure Classifications B2 or less to AS 3600 or AS 5100, the cover to reinforcement on the internal surfaces shall be consistent with a Mildly Aggressive exposure classification to AS 4198 and external cover to reinforcement shall be consistent with a Moderate exposure classification to AS 4198.

For Exposure Classifications C1 or C2 to AS 3600 or AS 5100, the cover to reinforcement on the internal surfaces (typically exposed to salt water) shall be consistent with a Moderately Aggressive exposure classification to AS 4198 and external cover to reinforcement shall be consistent with a Severe exposure classification to AS 4198.

9.3 Types of pits for vertical load test

The precast circular pits shall be load tested in accordance with AS 4198.

For the vertical test loads requirements, refer to Table 9 to correlate the concrete pit types specified in Section 7.1 of this document with the pit types specified in AS 4198.

Table 9 – Concrete pit types

Precast concrete pit types in this document (refer to Section 6.1)	Equivalent to AS 4198 pit types
1	Type B
2	Type C
3	Type D

9.4 Workmanship, finish, sampling and testing requirements

The dimensions, tolerances, classification of defects, sampling and testing of precast circular pits shall be in accordance with AS 4198.

10 Specific requirements for rectangular precast concrete pit manufactured with GFRP reinforcing bars

Rectangular precast concrete pits reinforced with GFRP rebars can only be used for Type 1 or Type 2 pits. The structural capacity of the pit shall be determined by prototype testing described in Section 8.3 of this document. The cover to reinforcement shall not be less than 1.5 times the maximum aggregate size, except for application in PASS / ASS where cover to reinforcement shall be the same as that for steel reinforcing bar. The minimum reinforcement for crack control and shrinkage shall be the same as those for steel reinforcing bars as described in Section 8.1.2 of this document. The requirements for bar spacings shall be the same as those for steel reinforcing bars.