

AS 4198:2022



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Precast concrete access and maintenance chambers for sewerage applications



AS 4198:2022

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- Australian Chamber of Commerce and Industry
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- Austroads
- Concrete Institute of Australia
- Concrete Pipe Association of Australasia
- Engineers Australia
- National Precast Concrete Association Australia
- University of New South Wales
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- Auckland Council
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Precast concrete access and maintenance chambers for sewerage applications

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Preface

This Standard was prepared by the Standards Australia Committee WS-006, Concrete Pipes, to supersede AS 4198:1994, *Precast concrete access chambers for sewerage applications*.

The objective of this Standard is to provide a performance-based document for precast concrete access and maintenance chambers.

The major changes in this edition are as follows:

- (a) Durability has been enhanced with additional requirements covering reinforcement and concrete materials, as well as production, placement and curing of concrete. This edition also introduces a new exposure classification for chambers in sewer applications.
- (b) Precast concrete maintenance chambers have been incorporated into this Standard.
- (c) An increase in the maximum depth of chambers and the maximum nominal diameter of chambers and an increase in the maximum diameter of connecting pipes. Additional testing requirements and test methods have been included that accompany these changes in diameter and depth.
- (d) Updates to the load testing requirements to accommodate larger diameter chambers and also changes in road traffic loading from AS 5100.2:2017.
- (e) A new informative appendix has been added to provide guidance on the installation of precast access and maintenance chamber systems.

Statements in alphabetical superscript footnotes in tables expressed in mandatory terms are deemed to be requirements of this document. Other notes are only for information and guidance.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

Contents

Preface	ii
Introduction	vi
Section 1 Scope and general	1
1.1 Scope	1
1.2 Normative references	1
1.3 Terms and definitions	3
Section 2 Component structure, manufacture and materials	11
2.1 General	11
2.2 Exposure classification	13
2.2.1 Exposure classification for internal environments	13
2.2.2 Exposure classification of the external environment	14
2.3 Concrete materials	15
2.3.1 Cementitious materials	15
2.3.2 Cementitious material for concrete	16
2.3.3 Aggregates	17
2.3.4 Water	17
2.3.5 Admixtures	17
2.3.6 Reinforcement	17
2.3.7 Synthetic fibres	17
2.3.8 Restrictions on chemical content	18
2.3.9 Minimum cementitious material content, maximum water / cementitious material ratio, and maximum water absorption value	18
2.3.10 Alternative concrete mixes	18
2.4 Cover to reinforcement	19
2.4.1 General	19
2.4.2 Cover to reinforcement for internal environment	19
2.4.3 Cover to reinforcement to the external environment	20
2.4.4 Cover to reinforcement for mating surfaces of joints between components	21
2.4.5 Additional concrete requirements for internal and external environments	21
2.5 Manufacturing processes, and concrete production, placement and curing	22
2.5.1 Manufacturing processes	22
2.5.2 Concrete batching	23
2.5.3 Concrete placing	23
2.5.4 Curing	24
2.6 Concrete quality control testing	25
2.6.1 Machine-made concrete testing	25
2.6.2 Wet cast concrete and automated SCC cast concrete testing	26
2.7 Elastomeric seals	27
2.7.1 General	27
2.7.2 Mastic sealants	27
2.7.3 Other materials	27
Section 3 Manufacture, workmanship and finish	28
3.1 General	28
3.2 Test loads for proof and ultimate load testing	28
3.2.1 General	28
3.2.2 Vertical load testing requirements	28
3.2.3 Horizontal load testing requirements (shaft components only)	29
3.3 Dimensions and tolerances	30
3.3.1 Internal diameter of shafts	30
3.3.2 Access cover clear opening sizes	30
3.4 Measurement of the dimensions	30
3.4.1 Straightness	30
3.4.2 Squareness of ends	30

3.4.3	Shaft diameter	31
3.4.4	Wall thickness	32
3.4.5	Effective length	32
3.4.6	Slab thickness	33
3.5	Workmanship and finish	33
3.5.1	General	33
3.5.2	Joints	33
3.5.3	Reinforcement	33
3.5.4	Cover	33
3.5.5	Classification of defects	34
3.6	Marking	35
3.7	Handling and storage	36
3.7.1	General	36
3.7.2	Lifting inserts	36
3.7.3	Unreinforced access and maintenance chamber components	36
Section 4	Step irons and ladders	37
4.1	General	37
4.2	Materials	37
4.3	Performance testing of installed step irons	38
4.4	Step-up and step-down limitations	38
4.4.1	Step-up	38
4.4.2	Step-down	38
Section 5	Access covers and frames	40
5.1	General	40
5.2	Surface finish	40
5.3	Design of lifting keyholes	40
Section 6	Sampling and testing of access and maintenance chamber components	41
6.1	General	41
6.1.1	Facilities for sampling and testing	41
6.1.2	Testing procedures	41
6.1.3	Testing	42
6.2	Type testing	45
6.2.1	General	45
6.2.2	Manufacture	45
6.2.3	Test specimens	45
6.3	Routine testing	45
6.3.1	General	45
6.3.2	Sampling	45
6.3.3	Testing	45
6.4	Test requirements	45
6.4.1	Ultimate load	45
6.4.2	Proof load	45
6.4.3	Cover to reinforcement	46
6.4.4	Water absorption	46
6.4.5	Hydrostatic testing of shafts and base units	46
6.4.6	Hydrostatic testing of joints	46
6.4.7	Vacuum testing of shafts and base units	46
6.4.8	Vacuum testing of joints	47
6.4.9	Hydrostatic testing of the base to pipe joints	47
6.4.10	Dimensional accuracy	47
6.4.11	Step irons	47
Appendix A	(normative) Product conformity	48
Appendix B	(informative) Information exchange between manufacturer and purchaser	53
Appendix C	(normative) Methods for load testing of access and maintenance chamber components	55

Appendix D (normative) Method for cover testing of reinforced precast concrete access and maintenance chamber components	72
Appendix E (normative) Method for water absorption testing.....	74
Appendix F (normative) Method for hydrostatic testing of a shaft section.....	78
Appendix G (normative) Method for hydrostatic testing of a shaft assembly joint.....	81
Appendix H (normative) Method for load testing of step irons and ladders.....	84
Appendix I (informative) Guide to determining exposure classification.....	86
Appendix J (normative) Method for vacuum testing of a shaft section	88
Appendix K (normative) Method for vacuum testing of a jointed shaft assembly.....	91
Appendix L (informative) Method for leak testing of a base to pipe joint seal.....	94
Appendix M (informative) Installation	98
Appendix N (normative) Accelerated curing of wet-cast concrete components.....	102
Bibliography	105

Introduction

This Standard was prepared by the Standards Australia Committee WS-006, Concrete Pipes, as a performance-based document for precast concrete access and maintenance chambers.

It was prepared to address advances in current practice, the age of the previous publication of AS 4198 and proposals from industry to move towards greater use of product performance testing. This Standard specifies product performance requirements and excludes normative installation procedures. However, this Standard provides an informative procedure for installation. For further guidelines on recommended installation procedures, reference should be made to the relevant published literature of access and maintenance chamber manufacturers, asset owners, asset owner industry associations and, where appropriate, regulatory authorities.

The in-service life of a precast concrete access or maintenance chamber is dependent on the manufacture, application and installation conditions. This Standard intends that for such installations, service life of 100 years could be expected when components are manufactured in accordance with and installed as recommended by this Standard in the environments defined in this Standard. Components subject to other environments should be assessed for suitability using appropriate engineering judgement. The Standard specifies requirements for concrete access cover assemblies and excludes requirements for metal and polymeric access cover assemblies. The use of some blended cement and chemical admixtures in concrete components is addressed by the Standard.

This document specifically addresses sewerage applications but may also be relevant to drainage, stormwater and other conveyance applications.

Australian Standard®

Precast concrete access and maintenance chambers for sewerage applications

Section 1 Scope and general

1.1 Scope

This Standard describes performance requirements for circular precast concrete access and maintenance chambers systems including chamber materials, component manufacture and quality control. It also describes methods of sampling and testing of precast concrete components manufactured in accordance with the Standard.

This Standard applies to precast concrete access and maintenance chamber components manufactured from steel reinforced, synthetic fibre reinforced or unreinforced concrete that are intended for use in buried sewerage systems. Access chambers conforming to the requirements of this Standard are suitable for a maximum depth to invert of 9 m and to a typical connected pipe diameter not larger than DN750. Similarly, maintenance chambers are suitable for a maximum depth of 6 m and a connecting pipe diameter of not more than DN300.

For other circumstances where depths are greater than 9 m, then specific design matters should be addressed between the designer and the manufacturer.

NOTE 1 Information on means for demonstrating conformity to this Standard is given in [Appendix A](#).

NOTE 2 Guidance on the information to be exchanged by purchaser and manufacturer at the time of an access or maintenance chamber product enquiry or order is given in [Appendix B](#).

NOTE 3 Special design considerations, including high water table, buoyancy uplift resistance, chamber depths greater than 9 m and connected pipes that exceed 750 mm in diameter should be addressed by negotiation between the parties.

NOTE 4 Guidance on the installation of precast access and maintenance chamber systems, including excavation, foundation preparation, placing of units, backfilling, compaction and *in situ* testing is provided in an informative [Appendix M](#).

This Standard does not provide for the following:

- (a) Requirements for cast *in situ* concrete components.
- (b) Ladders that are supplied and installed *in situ*.
- (c) Plastics maintenance shafts.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the requirements of this document.

NOTE Documents referenced for informative purposes are listed in the Bibliography.

AS 1012.1, *Methods of testing concrete, Method 1: Sampling of fresh concrete*

AS 1012.3.5, *Methods of testing concrete, Method 3.5: Determination of properties related to the consistency of concrete — Slump flow, T500 and J-ring test*

AS 1012.8.1, *Methods of testing concrete, Method 8.1: Method for making and curing concrete — Compression and indirect tensile test specimens*

AS 1012.9, *Methods of testing concrete, Method 9: Compressive strength tests — Concrete, mortar and grout specimens*

AS 1012.12.1, *Methods of testing concrete, Method 12.1: Determination of mass per unit volume of hardened concrete — Rapid measuring method*

AS 1012.20.1, *Methods of testing concrete, Method 20.1: Determination of chloride and sulfate in hardened concrete and aggregates — Nitric acid extraction method*

AS 1141.2, *Methods for sampling and testing aggregates, Method 2: Basic testing equipment*

AS 1141.5, *Methods for sampling and testing aggregates, Method 5: Particle density and water absorption of fine aggregate*

AS 1141.6.1, *Methods for sampling and testing aggregates, Method 6.1: Particle density and water absorption of coarse aggregate — Weighing-in-water method*

AS 1141.6.2, *Methods for sampling and testing aggregates, Method 6.2: Particle density and water absorption of coarse aggregate — Pycnometer method*

AS 1141.60.1, *Methods for sampling and testing aggregates, Method 60.1: Potential alkali-silica reactivity — Accelerated mortar bar method*

AS 1141.60.2, *Methods for sampling and testing aggregates, Method 60.2: Potential alkali-silica reactivity — Concrete prism method*

AS 1379, *Specification and supply of concrete*

AS 1478.1, *Chemical admixtures for concrete, mortar and grout, Part 1: Admixtures for concrete*

AS 1646, *Elastomeric seals for waterworks purposes*

AS 1657, *Fixed platforms, walkways, stairways and ladders — Design, construction and installation*

AS 2193, *Calibration and classification of force-measuring systems*

AS 2758.1, *Aggregates and rock for engineering purposes, Part 1: Concrete aggregates*

AS 3500.0, *Plumbing and drainage, Part 0: Glossary of terms*

AS 3582.2, *Supplementary cementitious materials, Part 2: Slag — Ground granulated blast-furnace*

AS 3799, *Liquid membrane-forming curing compounds for concrete*

AS 3850, *Prefabricated concrete elements (series)*

AS 3972, *General purpose and blended cements*

AS 3996, *Access covers and grates*

AS 4586, *Slip resistance classification of new pedestrian surface materials*

AS 4663, *Slip resistance measurement of existing pedestrian surfaces*

AS 5100.2, *Bridge design, Part 2: Design loads*

AS 5100.5, *Bridge design, Part 5: Concrete*

AS/NZS 1554.3, *Structural steel welding, Part 3: Welding of reinforcing steel*

AS/NZS 3582.1, *Supplementary cementitious materials, Part 1: Fly ash*

AS/NZS 3582.3, *Supplementary cementitious materials, Part 3: Amorphous silica*

AS/NZS 4058, *Precast concrete pipes (pressure and non-pressure)*

AS/NZS 4671, *Steel for the reinforcement of concrete*

AS/NZS 4680, *Hot-dip galvanized (zinc) coatings on fabricated ferrous articles*

EN 13101, *Steps for underground man entry chambers — Requirements, marking, testing and evaluation for conformity*

EN 14889-2, *Fibres for concrete — Part 2: Polymer fibres — Definitions, specifications and conformity*

ANSI/AWWA B100, *Granular Filter Material*

ASTM C805, *Standard Test Method for Rebound Number of Hardened Concrete*

ASTM C1116, *Standard Specification for Fiber-Reinforced Concrete*

ASTM C990 – 09, *Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants*

1.3 Terms and definitions

For the purposes of this document, the terms and definitions in AS 3500.0 and the following apply.

1.3.1

access chamber

assembly of precast concrete components which, when assembled, will provide a watertight chamber capable of supporting horizontal earth, road traffic and other imposed loads for the intended service life, and are used for a variety of purposes including personnel access

Note 1 to entry: See [Figure 2.1](#).

Note 2 to entry: Access chambers were once known as manholes (or maintenance holes) or maintenance structures but should not be confused with maintenance chambers that are typically, smaller, and are not designed for safe person entry.

Note 3 to entry: An access chamber is intended to provide for changes in pipeline horizontal and vertical alignment. It is also intended to provide for safe access to personnel and equipment for the purposes of inspection, testing, removal of obstructions, repair, maintenance and replacement work associated with the chamber and with connected pipelines. The minimum nominal diameter of an access chamber to provide safe access to personnel is typically DN1050. Access chambers can be installed with either a precast concrete or cast *in situ* concrete base component. Requirements for cast *in situ* base components are not within the scope of this document.

1.3.2

batch

group of components conforming with a design and produced, under uniform conditions during a given production period, by the same process

1.3.3

cementitious material

total mass of all of the cementitious material in the concrete mix including the mass of the GP Cement, GB Cement and any flyash, ground granulated blast furnace slag (GGBFS) or amorphous silica

1.3.4

clear opening

dimension of the unobstructed opening in the frame when the cover is removed or, the minimum distance between the topmost step iron and the opposite side of a straight back taper component

Note 1 to entry: See [Figure 1.3.4](#).

Note 2 to entry: This is synonymous with the “clear opening (CO)” definition in AS 3996.

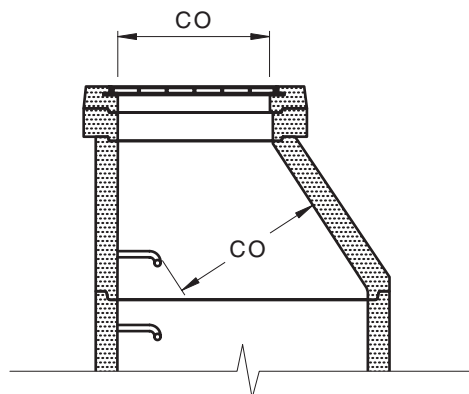


Figure 1.3.4 — Typical clear opening

1.3.5

concrete access cover

circular or rectangular precast concrete lid or lids that can be removed to provide access to the chamber

Note 1 to entry: Concrete covers are based on the W80 wheel load from AS 5100.2.

Note 2 to entry: See [Figure 2.2](#).

1.3.6

component

individual part of an access or maintenance chamber system that comprises multiple integral mating parts

1.3.7

component manufacturing processes

1.3.7.1

automated SCC cast precast concrete component

precast concrete component that is manufactured by an automated or semi-automated process in rigid metal moulds, using self-compacting concrete and process control for batching, casting and curing the concrete as detailed in this standard

1.3.7.2

machine-made precast concrete component

precast concrete component that is manufactured by an automated or semi-automated process, cast using zero slump concrete, which is placed and compacted by centrifugal forces, low frequency high amplitude vibration, or by direct mechanical compaction in rigid metal mould

1.3.7.3

wet cast precast concrete component

precast concrete component that is manufactured by semi-automated or manual processes in rigid metal moulds with concrete compacted by a combination of internal and external mould vibrators only, or by moulds attached to vibrating tables, or with self-compacting concrete placed without any additional compaction

1.3.8

conversion slab

flat slab reducers

concrete upper access or maintenance chamber component which is used to transition from the internal dimensions of the lower (or main) chamber shaft to dimensions approximating those of the chamber entry opening

Note 1 to entry: See [Figure 1.3.8](#).

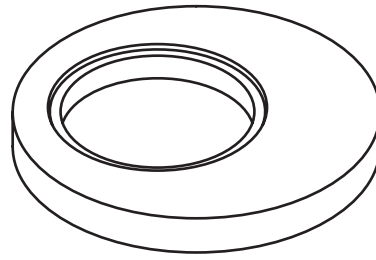


Figure 1.3.8 — Conversion slab

1.3.9 diameter

1.3.9.1 design diameter

internal diameter of the shaft and similar mating components as nominated by the manufacturer to which specified tolerances are applied

Note 1 to entry: Other mating components would be precast bases, conversion slabs, straight back tapers and squat cones.

1.3.9.2 internal diameter measured diameter

1.3.9.3 nominal diameter **DN**

alphanumeric designation of the size of shaft components which is used for reference purposes

Note 1 to entry: It comprises of the letters DN followed by a dimensionless number which is an approximate representation of the internal diameter of the shaft and mating components. It should not be used for measurement purposes.

1.3.10 ductile iron cover

circular or rectangular lid or lids that can be removed to provide access to the chamber

Note 1 to entry: Other types of metal covers are available as defined in AS 3996.

Note 2 to entry: [Figure 1.3.10](#) shows a typical circular cover; however rectangular covers are also commonly used for sewer access chambers.

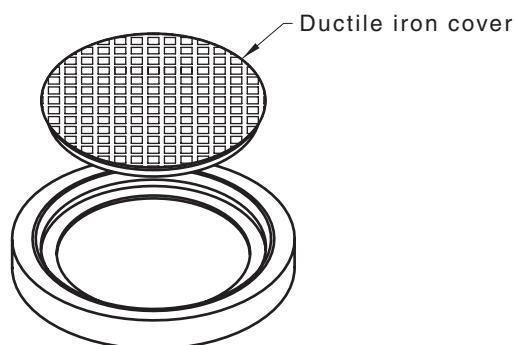


Figure 1.3.10 — Ductile iron frame

1.3.11

frame

fixed part of an access opening cover and frame unit or assembly that facilitates the receipt, location and provision of support all round for its mating removable access cover

Note 1 to entry: See [Figure 1.3.11](#). Typically, precast concrete covers do not require a frame. Precast concrete covers are configured differently to metal frames but, similarly, facilitate receipt, location and support all round for and removal of their mating concrete covers, i.e. the “part of gully top or manhole top which receives and supports a grating and/or a cover”, e.g. “An access chamber top frame” as defined in EN 124-1, and is the fixed part of an access opening cover and frame assembly/unit as referenced and shown in AS 3996 or equivalent terms.

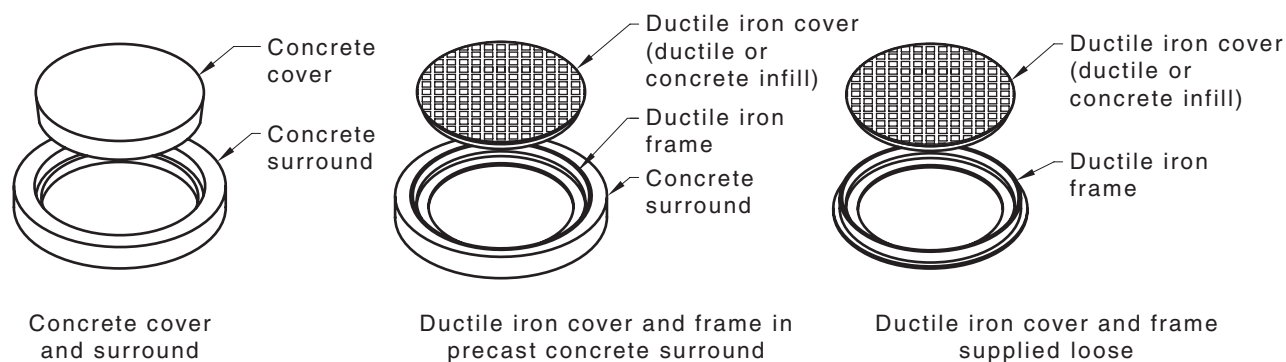


Figure 1.3.11 — Typical arrangement for different materials used as covers and frames

1.3.12

ladder

access climbing structure with treads, rungs and stiles with or without handrails, where installed

Note 1 to entry: Typically, ladders are supplied and installed *in situ* and are not covered by this document.

1.3.13

maintenance chamber

assembly of precast concrete components which, when assembled, will provide a watertight chamber capable of supporting horizontal earth, road traffic and other imposed loads for the intended service life, and are used primarily for maintenance and inspection purposes only using remotely operated equipment, when no personnel access is possible

Note 1 to entry: See [Figure 2.1](#).

Note 2 to entry: Maintenance chambers defined in this document should not be confused with plastics maintenance chambers or maintenance shafts. Requirements for plastics maintenance shafts are not within the scope of this document.

Note 3 to entry: A maintenance chamber is similar to an access chamber except that a maintenance chamber can only be used for minor changes in horizontal alignment and not a significant change of vertical alignment. The nominal diameter of a maintenance shaft is typically between 600 mm and 900 mm. They are typically provided with a precast concrete base unit.

1.3.14

major top component

transition between the larger main access shaft and the smaller access cover

Note 1 to entry: Examples include straight-back taper, squat cone or conversion slab.

1.3.15 make-up ring spacer

upper component that is placed above a major top component enabling the access cover, frame and concrete surround to be placed at the appropriate height and/or angle required to match the finished surface

Note 1 to entry: See [Figure 1.3.15](#). Make-up brickwork may be used in conjunction with a conversion slab in place of precast concrete make-up components, squat cone and straight-back taper components. Make-up components are generally required because shaft components are typically supplied in a limited number of height increments. A make-up component is also commonly known as a “spacer”.

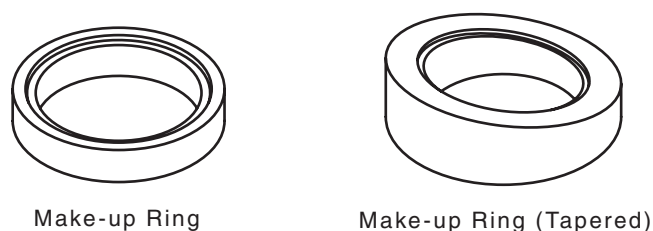


Figure 1.3.15 — Typical make up rings

1.3.16 precast base

concrete component which is positioned at the bottom of an access or maintenance chamber assembly which incorporates a section of shaft as well as an integrated precast base

Note 1 to entry: Precast base units may be supplied with or without concrete benching.

Note 2 to entry: Bases (excluding the shaft component) can also be cast *in situ*. Requirements for *in situ* bases are not within the scope of this document; however, they should be designed by an experienced person to satisfy the loading, water tightness and durability requirements of this document.

Note 3 to entry: It is common for precast base units to have cored or pre-formed holes and concrete benching to match the incoming pipes and outlet pipe to match various connected sewer pipe configuration designs.

Note 4 to entry: Precast base components often include an extension on the outside of the shaft diameter to prevent floatation of the access or maintenance chamber. This is commonly referred to as an anti-floatation ring, see [Figure 1.3.16](#). The exact shape of the extension may vary from what is depicted in [Figure 1.3.16](#).

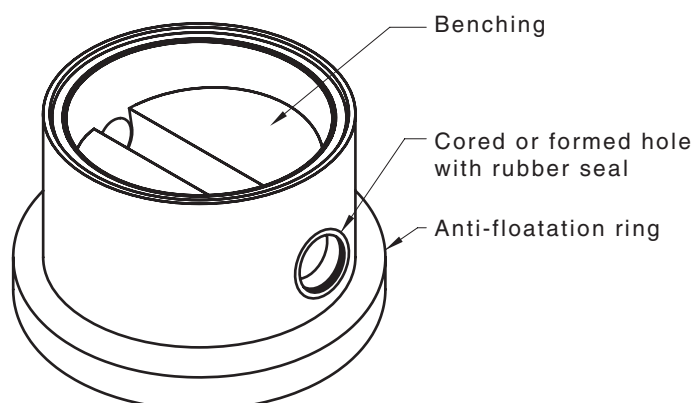


Figure 1.3.16 — Typical arrangement for a precast base unit

1.3.17**self-compacting concrete****SCC**

concrete that can flow and consolidate under its own weight to completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity without the need for additional compaction

Note 1 to entry: SCC is also known as “self-consolidating concrete” or “super workable concrete”.

1.3.18**shaft****riser**

concrete access chamber or maintenance chamber components which form the main part of the chamber between the precast (or in-situ) base and the upper entry transition component

Note 1 to entry: Shaft sections are supplied in various standard lengths to facilitate various chamber installation depths, see [Figure 1.3.18](#).

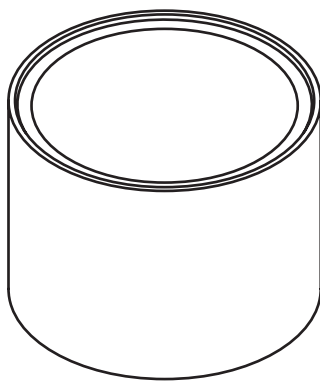


Figure 1.3.18 — Shaft section

1.3.19**shall**

indicates that a statement is mandatory

1.3.20**should**

indicates a recommendation

1.3.21**squat cone**

precast concrete upper access chamber entry component which is concentrically tapered to transition from the internal dimensions of the lower (or main) access chamber shaft to dimensions approximating those of the chamber entry opening

Note 1 to entry: Squat cone components are typically used for shallow access chambers that do not require step irons or ladders, see [Figure 1.3.21](#).

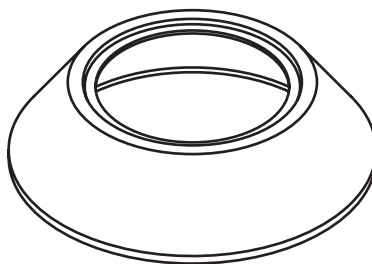


Figure 1.3.21 — Squat Cone used for change of DN

1.3.22

step-down

distance from the top of the cover/frame assembly from the topmost step iron or rung of a ladder

Note 1 to entry: See [Figure 4.4](#).

1.3.23

step irons

ladder without stiles, each rung of which is individually attached to an access chamber structure

1.3.24

step-up

distance from the top of the benching to the lowermost step iron or rung of a ladder

Note 1 to entry: See [Figure 4.4](#).

1.3.25

straight-back taper

precast concrete upper access chamber entry component which is eccentrically tapered to transition from the internal dimensions of the lower (or main) access chamber shaft to dimensions approximating those of the chamber entry opening

Note 1 to entry: Straight back taper components allow for step irons or ladders to be used on the vertical face which continues down into the shaft components, see [Figure 1.3.25](#).

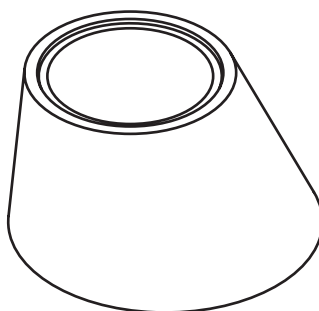


Figure 1.3.25 — Straight back taper used for change in DN

1.3.26

surround

concrete slab, into which a recess is formed to accept a mating concrete or ductile iron removable access cover

Note 1 to entry: For ductile iron covers, a mating ductile iron frame is cast into the concrete surround.

1.3.27**water cementitious material ratio****W/C ratio**

ratio of the total mass of the water in the concrete mix including any free moisture on the surface of the aggregates to the mass of the cementitious material in the concrete mix

Note 1 to entry: Free moisture on the surface of the aggregates is the total water in the aggregates less the water absorbed by the aggregate. For further information on determining free moisture on surface of aggregates refer to Vicroads Test Method RC253.01, *Determination of Aggregate Moisture Content and Estimated Free Water* (using microwave or hot plate).

1.3.28**wet cast concrete**

concrete with slump varying from 80 to 250 mm or SCC

1.3.29**zero slump concrete**

concrete with low water to cementitious material ratio (achieved with or without the addition of water-reducing admixtures), which is unable to be compacted using conventional tamping or mechanical vibration such as used in standard wet cast precast concrete production processes

Section 2 Component structure, manufacture and materials

2.1 General

This section sets out the durability requirements, material specification and properties for precast concrete components used in access and maintenance chambers. Typical component arrangements are illustrated in [Figure 2.1](#).

NOTE The shapes depicted in the arrangements detailed in [Figure 2.1](#) are informative only and not intended to restrict the design of the components.

Dimensions in millimetres

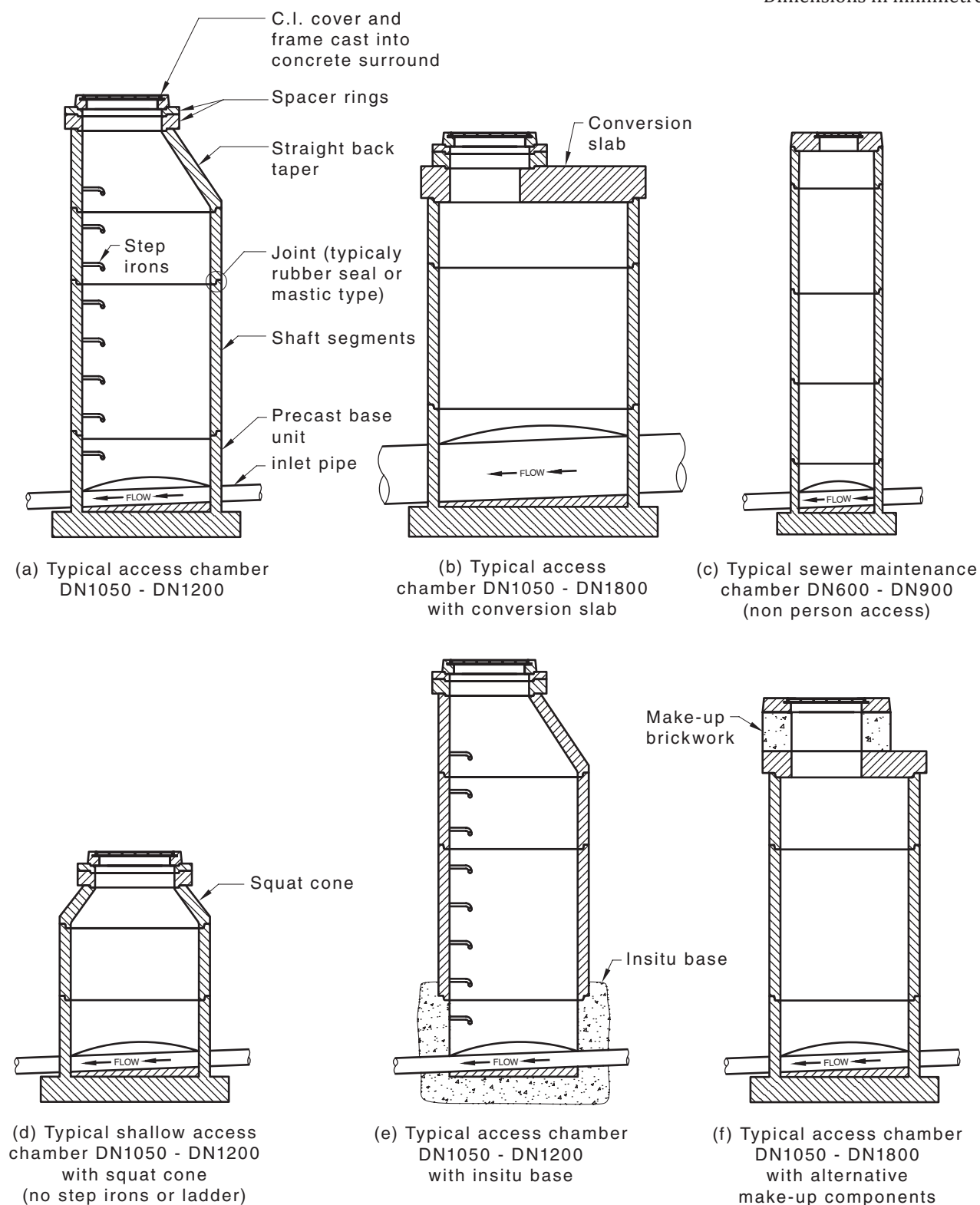


Figure 2.1 — Typical arrangements (components used in various configurations)

NOTE The shapes depicted in [Figure 2.2](#) are informative and not intended to restrict the design of components. For example, while only one-piece circular access covers are shown, covers may be rectangular or of a multi-part design.

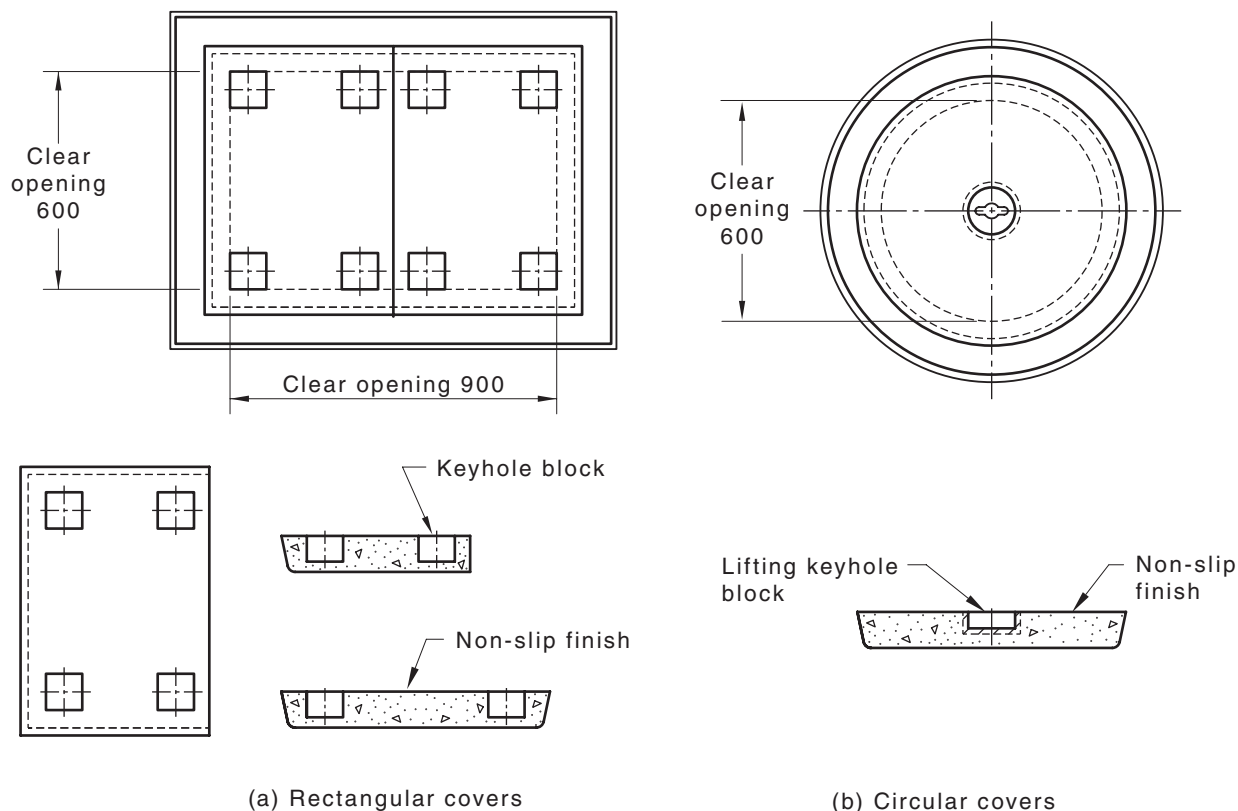


Figure 2.2 — Typical access covers and frames

2.2 Exposure classification

2.2.1 Exposure classification for internal environments

Exposure classifications for internal environments for precast concrete components supplied in accordance with this standard shall be defined as either non-aggressive, mildly aggressive, moderately aggressive or highly aggressive. These definitions are based on the expected rate of biogenic H_2S corrosion of the internal surface of the concrete component. See [Table 2.2.1](#) below. [Appendix I](#) provides information to assist in determining the exposure classifications.

Table 2.2.1 — Internal surface exposure classifications

Exposure classification ^f	Additional durability requirements ⁱ	
	Aggregate material	Sacrificial concrete thickness ^a (mm)
Non-aggressive ^g	Siliceous ^b	Nil
Mildly aggressive	Siliceous	10 ^{c,d}
Moderately aggressive ⁱ	Calcareous ^{c,h}	35 ^{c,d}
Highly aggressive	Siliceous + cast in liner ^e	Nil

^a This is a layer of concrete on the inside surface of all components that are exposed to the interior environment that is intended to be lost during the service life. At the end of the service life, the performance requirements of this Standard shall still be met. As such all type testing of all components (including unreinforced components) with sacrificial concrete layer shall be tested without this sacrificial layer.

^b For the purpose of this Standard, siliceous shall be any aggregate that conforms to the requirements of [Clause 2.3.3](#).

Table 2.2.1 (continued)

Exposure classification ^f	Additional durability requirements ⁱ	
	Aggregate material	Sacrificial concrete thickness ^a (mm)
^c There is no universally accepted model for the evaluation of the levels of biogenic corrosion to which sewerage system pipelines or access/maintenance chambers are exposed, although various models do exist for sewerage pipelines. The US EPA Process Design Manual for Sulphide Control in Sanitary Sewage Systems was used to define the additional durability requirement for the moderately (as compared with mildly) aggressive exposure classification, based on the EPA formulae for pipe corrosion. Durability requirements shall be as detailed in this table, except where other thicknesses of the sacrificial layer and/or aggregate materials have proven durable for specific environments, and have been otherwise agreed or specified. ^d Where step irons are used, the concrete embedment depth shall allow for loss of the total thickness of the sacrificial concrete layer. ^e Cast in (keyed) protective linings are designed to create a permanent barrier between access and maintenance chamber concrete and its internal corrosion environment. Linings materials (PVC and PE for example) shall have proven long term resistance to corrosion in sewerage environments. These should not be confused with painted and/or sprayed-on linings which have a poor corrosion resistance performance history in highly corrosive sewerage environments due to primarily hydrostatic pressure effect from external water infiltration are generally not considered equivalent in terms of corrosion protection effectiveness and longevity. High build sprayed or applied linings with a proven and measurable bond strength to the concrete sufficient to overcome external hydrostatic pressure may be a suitable alternative, but these are generally not suitable for precast concrete systems which allow some movement at joints between some components. ^f Guidance on the classification of the internal environment is contained in Appendix I. ^g This exposure category is also applicable to stormwater applications not subject to infiltration by brackish or saltwater. Stormwater pipe networks are not constrained by pipe diameter (can be larger than DN300), provided they are categorised as non-aggressive. ^h Calcareous aggregate refers to 100 % of the fine and coarse aggregate used in the concrete conforming to a ≥ 90 % Acid Solubility by ANSI/AWWA B100. ⁱ Siliceous aggregate or combinations of calcareous and siliceous aggregate concrete mixes manufactured to moderate exposure classification in accordance with Table 2.3.1(b) may be accepted as an alternative solution subject to the agreement of the purchaser where local conditions and experience indicate that siliceous or a siliceous calcareous blend of aggregates provide the required service life of this Standard. Models^c for concrete pipes indicate that concretes with calcareous aggregates can provide up to 4 times the service life of the same concrete with siliceous aggregates, and concretes with only partial substitutions of calcareous aggregates will provide a service life performance relative to the Calcium Carbonate equivalence of the aggregate combination used. ^j Durability requirements for more aggressive environments can be applied to cases with lower durability requirements. NOTE Statements in alphabetical superscript footnotes in tables expressed in mandatory terms are deemed to be requirements of this document. Other notes are only for information and guidance.		

2.2.2 Exposure classification of the external environment

Exposure classifications for external environments for precast concrete components supplied in accordance with this Standard shall be as defined in the following clauses as mild, moderate or severe exposure conditions as defined in [Table 2.2.2](#) which provides exposure classifications for external environment for chloride, potential acid sulfate soils (PASS) or acid sulfate soil (ASS) environments.

Table 2.2.2 — Exposure classifications for external environments for chloride, PASS and ASS ground conditions

Below ground exposure conditions				Exposure classification	
Sulfates (expressed as SO ₄)		pH	Chlorides in groundwater ^a (ppm)	High permeability soils (e.g. sands, gravel)	Low permeability soils (e.g. silt, clay)
In soil (ppm)	In groundwater (ppm)				
≤ 1 000	≤ 400	≥ 5.5	≤ 2000	Mild	Mild
> 1 000, ≤ 3 000	> 400, ≤ 1 500	< 5.5, ≥ 4.5	> 2 000, ≤ 8 000	Moderate	Mild
> 3 000, ≤ 20 000	> 1 500, ≤ 10 000	< 4.5, ≥ 4.0	> 8 000, ≤ 20 000	Severe	Moderate
> 20 000	> 10 000	< 4.0 ⁸	> 20 000	Severe	Severe
^a The following definitions also apply to chlorides in ground water: (a) Freshwater ≤ 2000 ppm. (b) Brackish water > 2 000, ≤ 8 000 ppm. (c) Saltwater > 8 000, ≤ 20 000 ppm. (d) Brine > 20 000 ppm. NOTE 1 This is a simplified approach to the complex response of concrete to a range of severe soil conditions. It is common to find more than one chemical in the service environment and the effect of these chemicals may be modified in the presence of others. For example, sulfate ions become severe at levels of 600 to 1 000 ppm when combined with magnesium or ammonium ions. In the presence of chloride ions; however, attack by sulfate ions generally exhibits little disruptive expansion except for conditions of wetting and extreme drying where crystallization can cause surface fretting of concrete. NOTE 2 If magnesium ions exceed 1 000 mg/l together with sulfate ions (SO₄) more than 1 000 ppm in soil or 400 ppm in groundwater, and an aggressivity or exposure classification of one higher class should be adopted, additional protective measures should be considered, and expert advice should be sought. NOTE 3 Corrosion damage by chlorides is only relevant to the steel reinforcement and steel inclusions in concrete. If there is no steel reinforcement or the reinforcement is otherwise adequately protected (for example, by a waterproof coating or cathodic protection), the chloride content is not relevant to the exposure classification. NOTE 4 Chemical concentrations relate only to the proportion of chemical present that is water-soluble. NOTE 5 Acidic ground conditions can be caused by dissolved “severe” carbon dioxide, pure and very soft waters, organic and mineral acids, and bacterial activity. Care is needed in the assessment of pH under concrete element installation and lifetime conditions since pH can change over the lifetime of the concrete element. Therefore, the pH should not be assessed only based on a present-day test result, rather the ground chemistry should be considered over the design life of the concrete element. Testing for pH should be carried out either <i>in situ</i> or immediately after sampling as there is otherwise a risk of oxidation with time, leading to apparent acidity, which does not correctly represent <i>in situ</i> conditions. NOTE 6 Testing for pH should be in accordance with AS 1289.4.3.1. NOTE 7 Testing for sulfate should be in accordance with BS 1377 Parts 1 and 3. NOTE 8 For pH levels < 3 additional protective measures should be provided comprising the application of suitable coatings and/or other physical barriers and/or replacement of surrounding soil with controlled fill.					

2.3 Concrete materials

2.3.1 Cementitious materials

2.3.1.1 Cement

GP Cement shall conform to AS 3972.

2.3.1.2 Supplementary cementitious materials

Supplementary cementitious materials shall conform to AS/NZS 3582.1, AS 3582.2 and AS/NZS 3582.3 as appropriate.

2.3.2 Cementitious material for concrete

The cementitious material for concrete in accordance with this Standard shall be a either GP Cement, GB Blend conforming with AS 3972 and this Standard, or a blend of GP cement and a supplementary cementitious materials (SCM) in accordance with this standard as permitted in [Table 2.3.1\(a\)](#) and [Table 2.3.1\(b\)](#) for the internal and external surfaces of the product with the most onerous combination being applicable.

Table 2.3.1(a) — Concrete cementitious blends internal exposure

Exposure classification of the internal environment (i.e. biogenic H ₂ S corrosion)	Acceptable cementitious blends
Non-aggressive	GP cement or binary blends or ternary blends
Mildly aggressive	
Moderately aggressive	
Highly aggressive	
NOTE The concretes resistance to microbial induced corrosion from an actively corrosive moderately aggressive internal sewerage environment with concrete mixes based primarily on Ordinary Portland Cement (GP Cement) is primarily determined by the type of aggregate used rather than the cement blend; however some blended types of cement may give better performance and are typically required to ensure resistance to alkali-aggregate reactivity. Where a cast in liner is used, this protects the concrete surface from attack from highly aggressive internal sewerage environments.	

Table 2.3.1(b) — Concrete cementitious blends for components exposed to various external environments

Exposure classification of the external environment	Acceptable cementitious blends
Mild	GP cement, or binary blends, or ternary blends
Moderate	Binary or ternary blends
Severe	Ternary blends or ≥ 60 % slag or binary blends with a protective coating (see Note)
NOTE For binary blends with protective coatings, consideration should be given to the design life of the coating and its ability to provide, in combination with the existing concrete and cover to reinforcement, a product with the ability to provide a design life in accordance with this standard. For PASS/ASS soil applications the coating would need to be acid-resistant.	

Acceptable cementitious blends constitute —

- (a) Binary blends of —
 - (i) 60 % to 75 % GP cement, 25 % to 40 % fly ash;
 - (ii) 90 % to 96 % GP cement, 4 % to 10 % amorphous silica; and
 - (iii) 30 % to 70 % GP cement, 30 % to 70 % ground granulated blast furnace slag
 and
- (b) Ternary blends of —
 - (i) 35 to 55 % GP cement, 20 to 35 % ground granulated blast furnace slag, and 25 to 30 % fly ash;

- (ii) 55 to 71 % GP cement, 4 to 10 % amorphous silica, and 25 to 35 % fly ash; and
- (iii) 30 to 46 % GP cement, 4 to 10 % amorphous silica, and 50 to 65 % ground granulated blast furnace slag.

In accordance with AS 3972, all special-purpose types of cement (Types HE, LH, SR, SL) shall be accepted as Type GP or Type GB. Where Type SR cement is specified or required, the requirement shall be deemed to be satisfied if a blended cement option conforming to this section is used.

NOTE [Clause 2.3.3](#) has additional requirements for use of blended types of cement with respect to alkali-aggregate reactivity.

2.3.3 Aggregates

Aggregates shall conform to AS 2758.1 with the following variations to the requirements:

- (a) Aggregates sourced from sedimentary rocks (for example, sandstone, siltstone, mudstone, arenite, and chert) and duricrust rocks (for example, silcrete, ferricrete, and calcrete) shall not be used.
- (b) Water absorption of aggregate, determined in accordance with AS 1141.5 (fine aggregate) and AS 1141.6.1, AS 1141.6.2 (coarse aggregate), shall be limited to a maximum of 2.5 %.
- (c) Lightweight aggregates and non-ferrous metallurgical slag aggregates shall not be used.
- (d) Where calcareous aggregates (sedimentary rock which is formed from or contains a high proportion of calcium carbonate and or magnesium carbonate) are used, the aggregate shall have ≥ 90 % Acid Solubility when tested to ANSI/AWWA B100.

All aggregate shall conform to AS 2758.1 for B2 exposure classification except for the external conditions classified as “severe” exposure classifications. These shall conform to AS 2758.1 for C exposure classification.

Aggregates shall be tested in accordance with AS 1141.60.1 to determine the aggregate reactivity classification. An aggregate may additionally be tested in accordance with AS 1141.60.2 to determine the aggregate reactivity classification. Aggregates that are deemed non-reactive by either AS 1141.60.1 or AS 1141.60.2 can be used with a GP Cement only blend.

In all other cases, as a minimum, a blended cement containing a minimum of 25 % fly ash or a minimum of 60 % slag shall be used. The recommendations in SA HB 79 may be followed, where the internal or external exposure classification requirements of this standard [Table 2.3.1](#) (a) and 2.3.1(b) are less onerous than SA HB 79.

2.3.4 Water

Water shall conform to the requirements of AS 1379.

2.3.5 Admixtures

Chemical admixtures shall conform to AS 1478.1.

2.3.6 Reinforcement

Reinforcement shall be steel bars, steel wire, or welded-wire fabric conforming to AS/NZS 4671. Any welding of the reinforcement, including splice welding, shall be in accordance with AS/NZS 1554.3.

2.3.7 Synthetic fibres

Synthetic fibres if used to reinforce the concrete shall conform to either EN 14889-2 or ASTM C1116.

2.3.8 Restrictions on chemical content

All materials used in the production of concrete shall neither contain acid-soluble chloride nor sulfate salts in excess of the values given in [Table 2.3.8](#) for the complete concrete mix.

NOTE 1 Components that do not contain any steel reinforcing are exempt from exposure classification requirements brought about by chloride ion exposure.

NOTE 2 Acid-soluble chloride and sulfate ion content should be determined by testing in accordance with AS 1012.20.1 in hardened concrete.

Table 2.3.8 — Maximum values of acid-soluble chloride and sulfate ion content in concrete as cast

Condition	Mass of maximum acid-soluble chloride ion content kg/m ³ of concrete	Mass of maximum acid-soluble sulfate ion content % by mass of cementitious material
Concrete with steel reinforcing and cured at ambient temperatures	0.8	5.0
Concrete with steel reinforcing and accelerated cured	0.6	4.0
Concrete containing no steel reinforcing and cured at ambient temperatures	No limit	5.0
Concrete containing no steel reinforcing and accelerated cured	No limit	4.0
Concrete with steel reinforcing with any curing regime and product is subject to severe external exposure classification	0.4	4.0

2.3.9 Minimum cementitious material content, maximum water / cementitious material ratio, and maximum water absorption value

The minimum cementitious material content, maximum water-cement ratio, and maximum water absorption value shall be as specified in [Clause 2.4.5](#) depending on the exposure classification, cover to reinforcement and manufacturing method.

NOTE Cementitious material content includes the GP cement component and any supplementary cementitious materials or an appropriately blended GB cement. Refer to AS 1379 for more information.

2.3.10 Alternative concrete mixes

An alternative concrete mix outside the scope of this document may be used by agreement with the purchaser if testing demonstrates that the alternative concrete can provide similar or improved performance and durability. Examples of alternative concrete mixes include geopolymer concrete with a high fly ash content, concretes made with high alumina cement and concrete containing admixtures which significantly decrease permeability or significantly increase the microbially induced corrosion resistance of the concrete.

NOTE Mineral acid resistance testing is insufficient to determine microbial induced corrosion resistance in a sewer environment. The most accurate laboratory testing methods use simulated exposure solutions containing well-controlled bacterial strains that are grown in the laboratory such as ASTM C1904. However, the most accurate performance determinations for long-term testing of alternative concrete mixes involves placing concrete samples in known highly aggressive sewerage environments for several years to determine the actual rate of loss of wall thickness which would then need to be extrapolated for the duration of the required service life of this Standard.

2.4 Cover to reinforcement

2.4.1 General

Cover to reinforcement is shown in [Table 2.4.2](#) and [Table 2.4.3](#) for both machine-made and automated SCC cast, based on a maximum nominal reinforcement bar or wire diameter of 10mm. Where nominal reinforcement bar or wire diameter is greater than 10 mm for these processes, the minimum cover to reinforcement shall be for wet cast. All covers to reinforcement require the use of rigid metal moulds for all forms of manufacture and concrete placement and compaction in accordance with [Clause 2.5.3](#). The concrete cover to reinforcement excludes radial nibs to circumferential reinforcement, end spacers, and longitudinal reinforcement ends.

2.4.2 Cover to reinforcement for internal environment

For reinforced concrete components exposed to the internal environment with concretes also conforming to the requirements of [Table 2.4.5](#), the cover to reinforcement shall not be less than the appropriate value of total cover detailed in [Table 2.4.2](#). For unreinforced concrete components, or concrete components reinforced only with synthetic fibres, sacrificial cover shall still be considered to ensure minimum wall thickness is achieved at the end of the design life.

Values in [Table 2.4.2](#) are minimum values and hence there is no negative tolerance allowed.

Table 2.4.2 — Minimum cover to reinforcements for internal environment

Exposure classification (see Note 2)	Machine made components			Automated SCC cast components			Standard wet cast components			Additional durability requirements
	Min. cover ^c mm	Sacrificial cover ^a mm	Total cover mm	Min. cover ^c mm	Sacrificial cover ^a mm	Total cover mm	Min. cover ^c mm	Sacrificial cover ^a mm	Total cover mm	
Non-aggressive (see Note 3)	10	0	10	10	0	10	25	0	25	Siliceous Aggregate ^b
Mildly aggressive	10	10	20	10	10	20	25	10	35	Siliceous Aggregate ^b
Moderately aggressive	10	35	45	10	35	45	25	35	60	Calcareous Aggregate (see Notes 4 and 5) ^d
Highly aggressive (see Note 1)	20	0	20	20	0	20	25	0	25	Siliceous Aggregate ^b + liner

Automated SCC cast and standard wet cast concrete maximum nominal aggregates size shall not exceed the minimum cover to reinforcement, and the maximum aggregate size not exceed 20 mm for all processes.

^a This is a layer of concrete on the inside surface of all components that are exposed to the interior environment that is intended to be lost during the service life. At the end of the service life, the performance requirements of this Standard shall still be met. As such all type testing of all components with sacrificial layer concrete shall be tested without this sacrificial layer.

^b For the purpose of this Standard, siliceous shall be any aggregate that conforms to the requirements of [Clause 2.3.3](#).

^c This will be the thickness of the remaining sound concrete that provides cover to reinforcement at the end of the expected service life. All type testing shall be carried out on components manufactured with this minimum cover.

Table 2.4.2 (continued)

Exposure classification (see Note 2)	Machine made components			Automated SCC cast components			Standard wet cast components			Additional durability requirements
	Min. cover ^c mm	Sacri-ficial cover ^a mm	Total cover mm	Min. cover ^c mm	Sacri-ficial cover ^a mm	Total cover mm	Min. cover ^c mm	Sacri-ficial cover ^a mm	Total cover mm	
^d Calcareous aggregate refers to 100 % of fine and coarse aggregate used in the concrete conforming to a ≥ 90 % acid solubility by ANSI/AWWA B100. NOTE 1 Components in a highly aggressive environment are protected by a liner for the duration of the intended service life. Minimum cover is governed by the anchor embedment of the liner. NOTE 2 Guidance on the classification of the internal environment is contained in Appendix I. NOTE 3 This exposure category is also applicable to stormwater applications not subject to infiltration by brackish or saltwater. Stormwater pipe networks are not constrained by pipe diameter (can be larger than DN300), provided they are categorised as non-aggressive. NOTE 4 Siliceous aggregate or combinations of calcareous and siliceous aggregate concrete mixes manufactured to moderate exposure classification as per Table 2.3.1(b) may be accepted as an alternative solution subject to the agreement of the purchaser where local conditions and experience indicate that siliceous or a siliceous calcareous blend of aggregates provide the required design life of this Standard Also refer note i of Table 2.2.1. NOTE 5 Durability requirements for more aggressive environments can be applied to cases with lower durability requirements. NOTE 6 Statements in alphabetical superscript footnotes in tables expressed in mandatory terms are deemed to be requirements of this document. Other notes are only for information and guidance. NOTE 7 If calcareous aggregate is specified in the concrete mix then calcareous aggregate should also be used in the benching concrete.										

2.4.3 Cover to reinforcement to the external environment

For reinforced concrete components exposed to the external environment with concretes also conforming to the requirements of [Table 2.4.5](#), the cover shall not be less than the appropriate value detailed in [Table 2.4.3](#).

Values in [Table 2.4.3](#) are minimum values and hence there is no negative tolerance allowed.

Table 2.4.3 — Minimum cover to reinforcements for the external environment

Exposure classification	Machine-made components	Automated SCC cast components ^a	Standard wet cast components ^a
	Cover mm	Cover mm	Cover mm
Mild	10 (0)	10 (0)	25 (0)
Moderate	20 (10)	20 ^b (10)	35 (10)
Severe	20 ^b (10)	30 (20)	45 ^c (20)
For unreinforced concrete or concrete reinforced only with synthetic fibres, a sacrificial layer of thickness shown in brackets in Table 2.4.3 is required for exposure to acid sulfate soil environments, or acid-resistant coating forming a physical barrier can be applied. No sacrificial concrete cover is required for concrete components that do not contain steel reinforcement in environments only exposed to chlorides. ^a An automated SCC cast and standard wet cast concrete maximum nominal aggregates size shall not exceed the minimum cover to reinforcement.			

Table 2.4.3 (continued)

Exposure classification	Machine-made components	Automated SCC cast components ^a	Standard wet cast components ^a
	Cover mm	Cover mm	Cover mm
^b For the cover to the reinforcement of 20 mm a ternary blend, or high slag binary blend (greater than 60 %) cementitious material blend is required, alternatively a cover to the reinforcement of 30mm, or a suitable chloride resistance or acid-resistant protective coating forming a physical barrier can be used. ^c When severe exposure is specified due to acidic ground conditions and a minimum cover to the reinforcement of 45mm is not practical, the cover to reinforcement may be reduced to 35mm in conjunction with the use of additional protective measures comprising the application of suitable acid-resistant coatings and/or other physical barriers and/or replacement of acidic soils with non-acidic controlled backfill.			

2.4.4 Cover to reinforcement for mating surfaces of joints between components

The cover to reinforcement to the mating surfaces of joints between components shall conform to [Table 2.4.4](#).

Table 2.4.4 — Cover to reinforcement for spigot and socket

Method of manufacture	Minimum cover to mating surface of the socket			Minimum cover for the mating surface of the spigot		
	Exposure classification					
	Mild / non-aggressive / mildly aggressive	Moderate / moderately Aggressive	Severe	Mild / non-aggressive / mildly aggressive	Moderate/ moderately aggressive	Severe
Machine-made	10	20	20	6	10	20
Automated SCC cast	10	20	20	6	10	20
Standard wet cast	25	35	45 (see Note 2)	25	35	45 (see Note 2)

NOTE 1 For internal highly aggressive exposure classification the minimum cover is governed by the anchor embedment of the liner.

NOTE 2 See footnote c in [Table 2.4.3](#).

2.4.5 Additional concrete requirements for internal and external environments

The additional concrete requirements for internal and external environments shall be in accordance with [Table 2.4.5](#)

Table 2.4.5 — Additional concrete requirements for the internal and external environment

Exposure classification (external / internal)	Machine-made components minimum f'c 50 MPa ^{b,c}			Automated SCC cast components minimum f'c 60 MPa ^a			Standard wet cast components ^a minimum f'c 50 MPa	
	Minimum cementitious material content (kg/ m ³)	Maximum water/ cementitious material ratio (W/C) ^c	Maximum water absorption % ^b	Minimum cementitious material content (kg/ m ³)	Maximum water/ cementitious material ratio (W/C)	Maximum water absorption % ^b	Minimum cementitious material content (kg/ m3)	Maximum water/ cementitious material ratio (W/C)
Mild/non-aggressive	330	0.40	6.0 (5.5)	500	0.35	5.0 (4.5)	400	0.45
Moderate/ mildly aggressive, moderately aggressive, or highly aggressive	350	0.40	5.5 (5.0)					
Severe / -	420	0.36	5.0 (4.5)				450	0.40

^a In addition to the requirements of this table, SCC concrete shall conform to the requirements of [Table 2.6.2.2](#).

^b Bracketed values are for net water absorption, see [Appendix E](#).

^c Some machine-made processes expel water from the concrete during the manufacturing process and therefore the recorded W/C ratio and the compressive strength of the batched concrete (pre moulding) is not representative of the final W/C and compressive strength of the final concrete product. When this is the case a method of validating the W/C shall be by agreement between the manufacturer and the purchaser. Compressive strength shall be determined on concrete samples taken post-manufacture if concrete samples taken pre-manufacture are unable to demonstrate conformity by rebound hammer testing.

NOTE 1 Rebound hammer test as per ASTM C805 is acceptable as an alternative to testing concrete cylinders

NOTE 2 Water/cementitious material(W/C) ratio.

NOTE 3 Statements in alphabetical superscript footnotes in tables expressed in mandatory terms are deemed to be requirements of this document. Other notes are only for information and guidance.

2.5 Manufacturing processes, and concrete production, placement and curing

2.5.1 Manufacturing processes

2.5.1.1 Machine-made process

A machine-made process is an automated or semi-automated process where the concrete is cast and compacted in a machine with rigid metal moulds using zero slump concrete and shall be placed and compacted by centrifugal forces, low frequency-high amplitude vibration or by direct mechanical compaction. The concrete used by machine-made processes is zero slump concrete as defined in this Standard.

NOTE 1 Typical machine-made processes include spinning, roller compaction and vertical dry casting.

NOTE 2 Some machine-made processes are known to expel water from the concrete during the compaction process.

NOTE 3 A typical automated machine-made manufacturing process involves the following:

- Concrete batching within the facility for the relevant component.
- A casting machine that is located in a weatherproof building.
- Automatic control of casting and compaction cycle times for the component being manufactured.
- An automatically controlled curing cycle in accordance with this standard.
- Maintenance of process records for each of the stages of manufacture.

NOTE 4 A semi-automated process is similar to an automated process except that the casting cycle time may be visually inspected and manually controlled by a trained process operator or by an alternative auditable and traceable quality assurance control.

2.5.1.2 Standard wet cast process

A standard wet cast process is a semi-automated or manual process using rigid metal moulds using a wet cast concrete mix which is compacted by a combination of internal and external mould vibrators, external mould vibrators only, or by moulds attached to vibrating tables or with SCC concrete placed without any additional compaction.

NOTE A typical wet cast process involves the following:

- (a) Concrete batched within the facility or supplied from a premix concrete plant in agitator trucks.
- (b) Curing methods in accordance with this Standard.
- (c) Maintenance of process records for each of the stages of manufacture.

2.5.1.3 Automated SCC cast process

An automated SCC cast process is an automated or semi-automated process using self-compacting concrete conforming to the requirements of [Clause 2.6.2.2](#) of this Standard placed in rigid metal moulds.

NOTE 1 A typical automated SCC cast process involves the following:

- (a) Concrete batching with advanced integrated consistency control systems, within the production facility.
- (b) The entire production and curing process is located in a weatherproof building.
- (c) automated concrete delivery and mould filling system with accurate dispensing by volume or weight.
- (d) Controlled casting and cycle times for each component manufactured.
- (e) Automated curing cycle (single stage or double stage) in dedicated curing chambers with accurately controlled temperature and relative humidity in accordance with this standard.
- (f) Maintenance process records for each stage of manufacture.

NOTE 2 A semi-automated process is similar to an automated process except that the casting cycle curing may be manually controlled by a trained process operator or by an alternative auditable and traceable quality assurance control.

2.5.2 Concrete batching

Concrete shall be control batched and mechanically mixed to conform to AS 1379 and the requirements of this standard. The batching and mixing shall be controlled to produce fresh concrete of uniform quality throughout each production run. The manufacturer shall maintain a batch recording system which includes control and measurement of added mix water, and records details and quantities of all batch constituents for each batch for all concrete mixes. These records shall be available for inspection at the manufacturer's plant by the purchaser on request. Where premix concrete supplied in agitator trucks is used, an identification certificate (delivery docket) conforming to AS 1379 including the information required for concrete specified by the water-cement ratio (total water in the concrete mix) shall be retained which provides traceability to the premixed concrete suppliers batch recording system with records being provided on request.

2.5.3 Concrete placing

The fresh concrete in all manufacturing processes shall be placed and compacted as required by the manufacturing process and concrete type to achieve the equivalent of full compaction to produce

a homogeneous dense mass free from defects that would impair the strength, serviceability and durability of the unit.

Concrete shall be compacted as follows:

- (a) Machine made product using centrifugal force, low frequency-high amplitude vibration or direct mechanical compaction.
- (b) For standard wet cast product using vibration by a combination of internal and external mould vibrators; external mould vibrators alone, or moulds attached to vibrating tables.
- (c) For automated SCC cast product with self-compacting concrete poured in a continuous process with no interruption, no vibration is required.

NOTE Where there is an interruption in pouring a component with self-compacting concrete, some vibration may be needed to prevent the formation of a cold joint.

2.5.4 Curing

2.5.4.1 General

Concrete shall be cured using at least one of the methods described in [Clauses 2.5.4.2 to 2.5.4.4](#). The concrete shall be protected from moisture loss until curing commences. Curing shall continue until the concrete reaches the minimum compressive strength of concrete curing in [Table 2.5.4.1](#) column 3 or the minimum concrete curing requirement in columns 4, 5 or 6. Where a partial accelerated curing cycle is used followed by moist or membrane curing, the requirements of the moist or membrane curing method in accordance with [Table 2.5.4.1](#) shall apply. Where curing is interrupted for more than 30 min, the unit shall be protected from moisture loss. Testing to confirm the minimum compressive strength of concrete a curing is required in accordance with [Clause 2.6](#).

No lifting of the product shall occur either as part of the formwork removal process or off the base form after formwork removal until at least 15 MPa is reached. Lifting of the unit while in the formwork, before the release of the formwork, is permitted before at least 15 MPa is reached, provided no damage to the product occurs as part of this process.

NOTE The minimum concrete compressive strength for lifting and handling a component, using cast-in lifting anchors or other methods, may be greater than 15 MPa for some products.

Table 2.5.4.1 — Concrete curing requirements

Exposure classification for external surfaces	Exposure classification for internal surfaces	Minimum compressive strength of concrete at completion of curing	Minimum concrete curing (i.e. either age or maturity at completion of curing, whichever occurs first)		
			Moist curing	Membrane curing	Accelerated curing
		MPa	Age (days)	Age (days)	Maturity (°C hrs)
Mild	Non-aggressive/ mildly aggressive	15	3	3	220

Table 2.5.4.1 (continued)

Exposure classification for external surfaces	Exposure classification for internal surfaces	Minimum compressive strength of concrete at completion of curing	Minimum concrete curing (i.e. either age or maturity at completion of curing, whichever occurs first)		
			Moist curing	Membrane curing	Accelerated curing
		MPa	Age (days)	Age (days)	Maturity (°C hrs)
Moderate	Moderately/highly aggressive	25	7	7	350
Severe	N/A	32		Not permitted	420

NOTE 1 Maturity values in this table are defined as the concrete’s curing enclosure temperature multiplied by the time in hours. For machine made components, curing cycles can be validated by determining the compressive strength by a rebound hammer test as per ASTM C805 as an alternative to testing concrete test cylinders.

NOTE 2 It is recommended that no component goes into service in less than 7 days from manufacture.

NOTE 3 Compressive strength testing is not required at the completion of moist, membrane or accelerated curing if the minimum concrete compressive strength for lifting and handling has already been achieved.

NOTE 4 Ambient curing of precast concrete in its mould until the minimum compressive strength of concrete at completion of curing is achieved is acceptable provided on site processes maintain saturation of all concrete surfaces at all times.

2.5.4.2 Moist curing

Concrete shall be kept continuously moist, with the concrete being maintained at a temperature above 5 °C. All surfaces of the product shall remain fully saturated.

2.5.4.3 Membrane curing

Curing compounds conforming to the requirements of AS 3799 may be used in accordance with [Table 2.5.4.1](#) for all exposure classifications except for components with a severe external exposure classification. Curing compounds shall be applied in a minimum of two coats at the minimum application rate to all exposed concrete surfaces. The concrete shall be maintained at a temperature above 5 °C. As an alternative to proprietary curing compounds, membrane curing may be carried out using close-fitting tarps, plastic wrapping or other covers or enclosures which prevent moisture loss from the concrete surface.

2.5.4.4 Accelerated curing

Accelerated curing shall be carried out in accordance with [Appendix N](#).

2.6 Concrete quality control testing

2.6.1 Machine-made concrete testing

Concrete shall be produced with properties that provide durability consistent with the water absorption limits, compressive strengths and composition specified in [Table 2.5.4.1](#) and quality appropriate to the

nominated loading and hydrostatic performance requirements. The test method for water absorption is detailed in [Appendix E](#) and its frequency of testing is detailed in [Table A.1](#)

Compressive strength determinations for lifting, curing and determination of 28-day design strength shall be conducted daily per mix design and manufacturing method or machine by either compressive strength cylinder testing or as an alternative for machine-made precast products only, by rebound hammer testing to ASTM C805. Daily water absorption testing can be conducted instead of daily compressive strength determinations in the event of 28-day strength failures to satisfy durability requirements only for a machine-made product. Where compressive strength cylinders are used for strength determination the method shall conform to [Clause 2.6.2](#).

As an alternative for test cylinders for machine-made components, concrete strength at the end of curing and for design strength conformity can be determined by a rebound hammer test as per ASTM C805.

NOTE 1 To achieve reliable and consistent results, some preparation of the concrete surface by grinding the surface to achieve a flat defect-free may be required.

NOTE 2 Relationships between rebound number and concrete strength that are provided by instrument manufacturers should be used only to provide indications of relative concrete strength at different locations.

2.6.2 Wet cast concrete and automated SCC cast concrete testing

2.6.2.1 General

The concrete compression testing cylinders shall be made in accordance with AS 1012.1 and AS 1012.8.1 and subsequently tested in accordance with AS 1012.9 and AS 1012.12.1.

Curing of concrete compression cylinders shall be carried out in accordance with AS 1012.8.1 with the exception that for the initial curing period the cylinders shall be cured with the product until the completion of the accelerated curing process, or a concrete strength of 15 MPa is reached whichever is the longest. Where the product is accelerated cured the cylinders shall undergo accelerated curing with the product as required in [Appendix N](#). After completion of the initial curing or accelerated curing 28-day compressive strength cylinders shall be cured in accordance with AS 1012.8.1

A minimum of one cylinder shall be tested for lifting and/or to determine completion of curing. Two cylinders shall be tested for strength at 28 days for characteristic strength determination in accordance with AS 1379. Testing for compressive strength shall be tested at a minimum of every 25 m³ or daily (maximum 10 h of continuous manufacture) regardless of concrete production or manufacturing method.

NOTE The required minimum concrete compressive strength for lifting and handling some components, using cast-in lifting anchors, may be greater than the minimum compressive strength required for durability purposes.

2.6.2.2 Self-compacting concrete for automated SCC cast

Self-compacting concrete for automated SCC cast shall conform to [Table 2.4.5](#) and [Table 2.6.2.2](#).

Table 2.6.2.2 — Tolerances for consistency

Nominated slump flow ^a (mm)	Slump flow tolerance (mm)	Visual stability index ^b	Nominated T ₅₀₀ (s)	T ₅₀₀ tolerance (s)
Self-compacting concrete (SCC) ^c 650-750mm	±50	0-1	2-5	±2

^a Slump flow and T₅₀₀ test to AS 1012.3.5. Testing shall to the same methodology as AS 1012.3.5; however, the time recorded is the time when the concrete has stopped flowing.

^b Visual Stability Index to ASTM C1611.

Table 2.6.2.2 (continued)

^c Self-compacting concrete shall also be tested for J Ring passability to AS 1012.3.5 during the type testing phase, or mix design development with a maximum permitted value of 10mm. The concrete shall not exhibit signs of segregation. J Ring passability is not required during routine production.

NOTE 1 In addition to the minimum requirements of this table some additional testing by the relevant authority may be required. This testing may include but is not limited to mix design validation by such tests as the volume of permeable voids, concrete sorptivity and measurements of chloride diffusion or permeability. For chloride permeability to ASTM C1202 typical values for SCC for automated SCC cast are less than 1 000 coulombs at 56 days.

NOTE 2 T_{500} measurements can be highly subjective and therefore rejection of delivered concrete should not be contingent on T_{500} conformity to this table. T_{500} measurements should be used in combination with another testing, batch and visual indicators to inform users of concrete quality and consistency.

NOTE 3 Statements in alphabetical superscript footnotes in tables expressed in mandatory terms are deemed to be requirements of this document. Other notes are only for information and guidance.

2.7 Elastomeric seals

2.7.1 General

Elastomeric seals intended for use for providing a watertight connection between precast concrete components or precast concrete components and connecting pipes shall conform to AS 1646 and be supplied with the components.

The seals may incorporate an approved tree root inhibitor or alternate method of preventing tree root ingress.

NOTE The use of tree root inhibitors incorporated into joint seals should be agreed upon between the parties. Some chemicals used for such applications are known to be toxic and appropriate safety precautions may be required which are beyond the scope of this document.

2.7.2 Mastic sealants

Mastic sealants intended for use for providing a watertight connection between precast concrete components shall conform to ASTM C990 and shall be supplied with the components.

2.7.3 Other materials

Materials used for jointing shall be flexible to accommodate the expected settlement or movement due to ground conditions. For this reason, rigid joints made using materials such as cementitious or epoxy mortars between shaft components and/or shaft and base components shall not be used for sewerage applications. If the joint is designed as rigid and is restrained from movement then this condition may be relaxed. Epoxy mortars or similar materials may also be used for connection of pipes to base units provided they are subject to testing requirements contained in [Clause 6.4.9](#).

NOTE 1 Rigid jointing materials may be suitable for stormwater applications where a watertight chamber may not be required.

NOTE 2 Rigid jointing materials to connect makeup rings and frames to other components within 500 mm of the ground surface are acceptable.