CPAA GUIDANCE NOTE (NZ)

LOADS ON CIRCULAR STEEL REINFORCED PRECAST CONCRETE MANHOLES AND ACCESS CHAMBERS

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Concrete Pipe Association of Australasia

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Scope

This document provides guidance on Industry best practices for the design and specification of circular steel-reinforced precast concrete manholes in NZ to meet the performance expectations of asset owners. It applies to manholes with diameters ranging from 600 mm to 2,100 mm. Manholes exceeding 2,100 mm in diameter are outside the scope of this document, as multiple wheel loads may act on the same lid.

This guidance note is developed for circular precast concrete access chambers manufactured from concrete with circumferential steel reinforcement and installed in Normal Environments as defined by Appendix E of AS/NZS 4058:2007. This typically includes gravity drainage, non-aggressive sewerage, water supply, or service duct applications. The principles outlined in this document may be extended to other installation conditions, provided that durability and water-tightness considerations are addressed.

This document does not cover cast in situ access chambers, box chambers, unreinforced circular concrete manholes, fiber-reinforced circular concrete manholes or manholes of other materials.

Note: The term 'Access Chamber' is used in some regions. However, the term 'Manhole' is more commonly used in NZ. As this document is intended for a New Zealand audience, the term 'Manhole' is used throughout.

Introduction

Design loads applied to structures, specifically Manholes in this case, need to be clearly defined and well understood; as such, the purpose of this document is as follows:

1. To allow Asset Owners/Consulting Engineers to specify consistently and accurately one of the three main loading conditions found in New Zealand; namely LD20, HD60 or HN-HO-72 for Manhole lids. This Guidance Note will provide clarity on the meaning of these terms including Load Factors, Impact Factors, and detailing allowable crack widths.
2. Provide Asset Owners/Consulting engineers with clear guidance on the Standards applicable for design and manufacture of the various concrete components comprising the manhole system.
3. Provide specifiers with an easy method of specifying Manhole lids/conversion slabs by reference to this document.
4. Provide Manufacturers with clarity around performance expectations from Asset Owners.
5. Identify additional consideration for Designers & Specifiers.

Note: the term 'manhole lid' is the concrete component shown in figure 1; as distinct from the metal component referred to as 'streetware'.

The adequacy of manhole components can be validated; either by design calculation or by load testing.

Traditionally, steel reinforced circular precast manholes have been designed and manufactured with reference to a number of Standards including the following:

• AS/NZS 4058: 2007	• NZS 3109: 1997
• NZS 3101: Part 1: 2006	• NZS 3114: 1987
• AS/NZS 1170.0: 2002 Section 4 for LD20 and HD60	• NZS 4404: 2010
• NZTA, Bridge Manual (SP/M/022) for HN-HO-72	• ASTM C857-14

Commonly used components and terminology are shown in Figure 1.

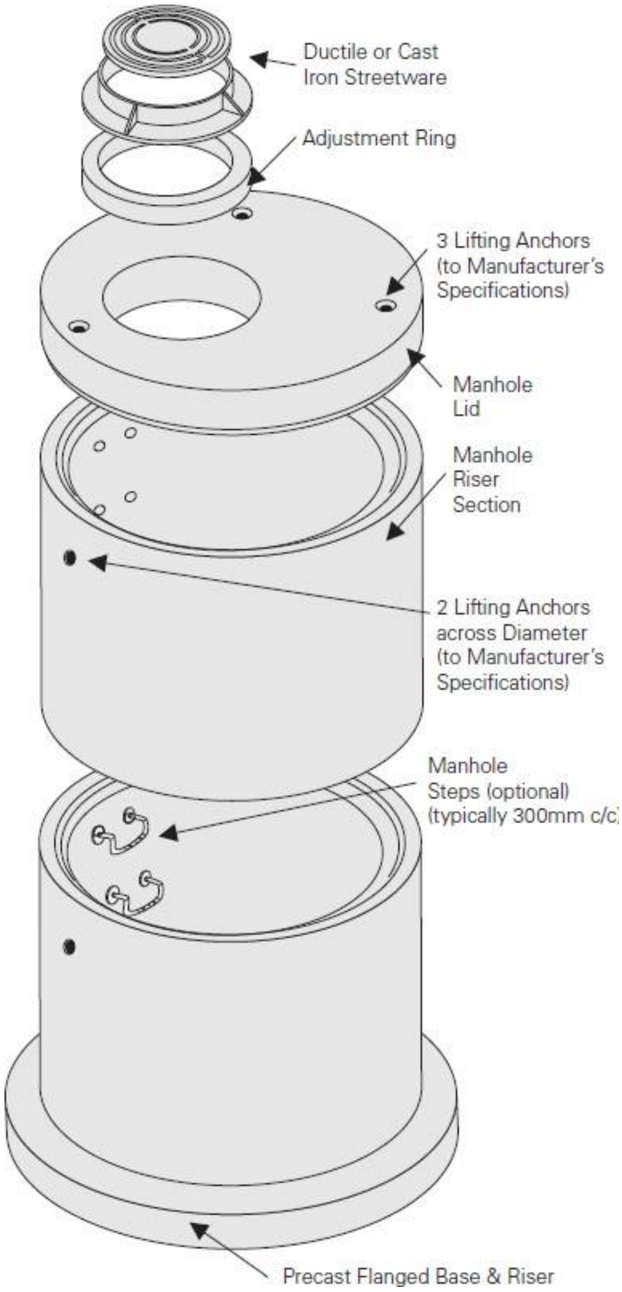

Figure 1 Schematic Diagram of Precast Manhole General arrangement

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Load Specification

Loading type

When specifying or ordering manhole components, one of the following live load types should be specified:

1. Light Duty LD20
2. Heavy Duty HD60
3. Bridge Manual HN-HO-72
4. Specific design, when the above categories are not considered appropriate.

Live Load Definition

A summary of the first three load types are defined in Table 1.

Table 1: Loading type and design methodology *

Criteria	LD20 [1]	HD60 [1]	HN-HO 72 [2]
Application	Lightly trafficked	Majority of roading environments	Used when compatibility with bridge design required
Single Wheel Load	20 kN (4 T axle)	60 kN (conservative)	60 kN (HN) and 120 kN (HO) (12 T and 24 T axles respectively)
Ultimate Strength	E_d = [1.5Q, 1.2G]		Combination 1A [2.25Q, 1.35G]
Serviceability limit states	[Ψ_sQ, G] = [0.7Q, G]		Combination 1A [Ψ_sQ, G] = [1.35Q, G]
Impact factor for lid	1.3		
Impact factor for riser/base	N/A		
Lid Design	NZS 3101		
Lid Serviceability considerations	crack widths		

* Further detail is provided in Appendix 1.

[1] The components are designed by the Manufacturer for combinations of action defined in AS/NZS 1170.0:2002 Section 4:

[2] The components are designed by the Manufacturer for combinations of action defined in NZTA Bridge Manual for HN-HO-72, Clause 3.5, "Combination of load effects".

Durability

Typically a manhole comprises three components; lid, riser and base. For a number of reasons, including the method of manufacture, there are differing Standards relating to the design and manufacture of the specific component. These are summarised in Table 2 below:

Table 2: Durability issues and criteria

Component	Relevant Standard	Exposure classification
Lids	NZS 3101	'B1' as defined in Table 3.1 of NZS 3101: Part 1:2006 for the inside and B2 for outside surfaces.
Risers	AS/NZS 4058	'Normal' - AS/NZS 4058:2007. Table E1 of that document gives guidance on exposure conditions and concentration limits.
Bases	NZS 3101	'B2/B1' as defined in Table 3.1 of NZS 3101: Part 1:2006 for the inside/outside surfaces.

The in-service life of the installation is dependent on the component's manufacture, application and installation conditions. Based on past experience of installations, a service life of 100 years could be expected when components are manufactured in accordance with the Standards referenced above. Components subject to other environments i.e. more aggressive, should be assessed for suitability using appropriate engineering judgement. Appendix E of AS/NZS 4058, for example, gives some guidance on this. Unless specified otherwise, Manufacturers generally detail components for a service life of 100 years when subjected to Normal exposure conditions.

Note: The principles of this guideline can be extended to more aggressive sewer environments. This is typically achieved by providing an additional sacrificial cover beyond the requirements of AS/NZS 4058:2007 or by incorporating a cast-in protective liner.

Water Absorption Testing

Water absorption testing of manhole risers shall be carried out in accordance with Appendix F of AS/NZS 4058:2007 at a minimum frequency of one test per 6 months for each concrete mix design at each manufacturing facility. The water absorption is not to exceed 6.0%.

Sustainable Infrastructure

The CPAA & its members are committed to supporting NZ's sustainable infrastructure journey by providing the information that customers need to make informed, sustainable procurement decisions. The best way to achieve this is for Manufacturers to perform a Life Cycle Analysis (LCA) of their products and to make this information available to customers. To allow for comparison between Manufacturers, all LCAs shall be third party reviewed by a reputable LCA practitioner (in good standing with LCANZ) to be in accordance with ISO14025:2006 and EN15804+A2:2019 (or the latest versions of these documents). The results of these LCAs can be published in an Environmental Product Declarations (EPD) or similar document that details the LCA standards to which the calculations comply, the LCA practitioner and which life cycle modules the calculations cover.

Design

Method of Analysis

The structural analysis used to determine action effect from loads is in accordance with the principles of structural mechanics. Design moments, shears, and thrusts are determined using elastic method and design is based on maximum stress resultants at critical sections caused by the most severe combination of design loads.

Refer to Appendix 1 for more detailed design criteria.

Additional Considerations for Designers

Depth of manhole

Design of the base involves consideration of transferring the self-weight actions and wheel loads on the lid to the ground below the base. In most instances the bearing pressures from these load cases determine the thickness and reinforcement required in the base. Standard products are typically satisfactory for a maximum installation depth of 10 m. For deeper manhole installations, engineering assessment by the purchaser may be required.

Watertightness

Standard manholes typically have a mastic/mortar joint. Such joints have a proven in-service history of satisfactory watertightness performance. However, as the performance of these joint is highly dependent on onsite workmanship such joints are typically not pressure rated by the Manufacturer. For projects where the manhole will be installed into the water table or ensuring a high level of watertightness of the manhole is critical, Specifiers/Designers are recommended to check with Manufacturers on the availability of rubber ring jointed manholes or consider alternate sealing details.

Buoyancy

Manufacturers make no allowance for buoyancy other than providing the standard 150 mm wide flange on the manhole base. Engineering assessment should be done by the Purchaser/Designer if required.

Bedding

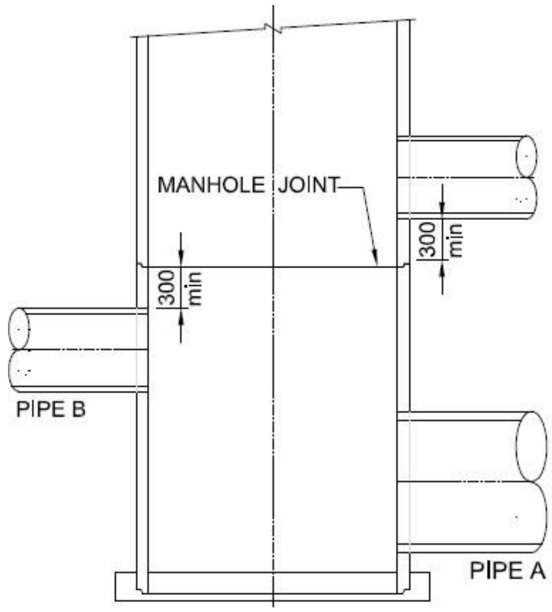
Bedding below the base of any structure is important; manholes are no different. As with many civil assets, bedding shall be a uniform pre-prepared layer of suitable granular material on natural firm ground. For the base, the safe bearing capacity (SBC) should be a minimum of 150 kPa for manhole depths in excess of 5 m, and 100 kPa for manhole depths of less than 5 m. The bedding base shall be levelled and compacted under the wall of the manhole. This shall be extended for a minimum of 150 mm each side of the wall centre-line to form a uniform support to the wall, without creating a central high spot.

Other Considerations for the Project Designer

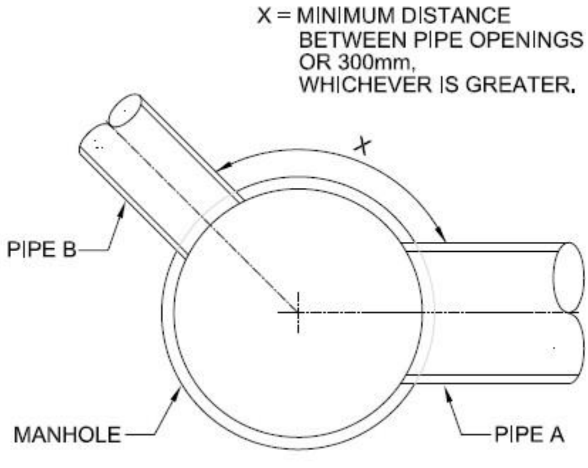
The structural capacity of the installation is affected by a number of other design considerations. For example; pipes entering and exiting the wall and benching within the chamber. The effect of pipe entries and benching on the structural capacity of a steel reinforced flanged base is considered negligible if installed in accordance with the following guidelines:

1. For manhole risers with single entry/exit pipework, the riser internal diameter (ID) should be typically 1.5 to 2 times the entry/exit pipe outside diameter (OD).
2. The maximum opening in the wall of the manhole riser shall be 0.65 x MH ID.
3. The minimum clear distance along the perimeter of the riser between equal sized entry/exit pipes shall be 0.75 x entry/exit pipe OD, or 300 mm, whichever is greater.
4. The minimum distance along the perimeter of the riser between un-equal sized pipes shall be 0.65 x pipe OD of the larger pipe, or 300 mm, whichever is greater.
5. The minimum distance from the top of a pipe entering into a riser on a base shall be at least 300 mm to the nearest riser joint above.
6. Pipe entries into a riser without a base shall have a minimum clearance of 300 mm above and below the pipe to any riser joint.

Multiple entries in riser sections above the flanged base require engineering assessment by the Purchaser/Designer.



Sectional Elevation



Plan

Manufacture

For a number of reasons, including the method of manufacture, there are differing Standards relating to the design and manufacture of the specific components.

Lids and Bases

Lids and bases are manufactured and assessed in accordance with NZS 3109:1997

Risers

Risers are manufactured and assessed in accordance with AS/NZS 4058:2007 and load rated to a nominal Class 1 (Half of load requirements for Class 2 pipe as listed in Table 4.2 of AS/NZS 4058:2007).

Precast stormwater risers are manufactured with circular reinforcement.

Appendix 1 – Design Criteria

This appendix expands on the summary Table 1 earlier in this document and how these loads are applied to the lids, risers and bases.

Light Duty LD20

This is considered suitable for installation in lightly trafficked areas consistent with a single wheel load of 20 kN (4 tons axle). The components are designed by the Manufacturer for combinations of action:

1. Ultimate strength E_d = [1.5Q, 1.2G]
2. Serviceability limit states = [Ψ_sQ, G] = [0.7Q, G] (Table 4.1)

Definitions from AS/NZS 1170.0:2002 Section 4

Heavy Duty HD60

This is considered suitable for the majority of roading environments. The legal maximum axle weight on NZ roads is 9.5 tons (47.5 kN per wheel) (NZTA Land Transport Rule Vehicle Dimensions and Mass 2016). However, measurements would suggest that these limits are occasionally exceeded. The diameter of manhole lids are such that only one wheel load will be carried as the spacing of tandem axles (1.25 m) precludes two axles being on the lid at the same time. A conservative assumption is made for future increases in axle loads and a design of wheel load for the lid of 60 kN is recommended (12 tons single axle). Note that the inclusion of a 1.3 impact factor means that even greater axle loads could be accepted in future with limitations placed on the speed of the vehicle.

The components are designed for combinations of action

1. Ultimate strength E_d = [1.5Q, 1.2G]
2. Serviceability limit states = [Ψ_sQ, G] = [0.7Q, G] (Table 4.1)

Definitions from AS/NZS 1170.0:2002 Section 4

Heavy Duty HD60: 60kN wheel load of "Single Axle Double Tyre" shall be applied on an effective area of 200 mm X 500 mm on top of the manhole lid.

Bridge Manual "BM"; HN-HO-72

The NZTA Bridge Manual, SP/M/022, defines an HN and HO vehicle used in the design of bridges. These design vehicles were originally developed to simplify the design of medium to long span bridges. With axle weights of 12 tons and 24 tons the vehicles are not specifically meant to represent a NZ heavy vehicle. These design actions do, however, provide a pragmatic design methodology for estimating design moments and shears for medium to long span bridges. For short span structures the use of HN-HO design vehicle actions can lead to very conservative structures. However, given the shortness of the span, this conservatism is achieved at a modest cost premium.

Combination of actions used in design is based on:

1. Ultimate limit state, Table 3.2, combination 1A = [2.25Q, 1.35G]
2. Serviceability limit state, Table 3.1, combination 1A = [Ψ_sQ, G] = [1.35Q, G]

Definitions from NZTA Bridge Manual for HN-HO-72, Clause 3.5, "Combination of load effects"

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Impact Factor for LD20, HD60 and HN-HO-72 Lid Loads

For the lid only, both serviceability and ultimate limit state shall include an Impact Factor of 1.3 applied to the wheel load. The Impact Factor shall not be considered when designing the riser or base. Design of the lids shall be in accordance with the Concrete Design Standard NZS3101, including consideration of crack widths for the serviceability limit state.

Lateral Earth Pressure Design for Risers

Lateral earth pressure from earth adjacent to the manhole walls is considered to be k_0 = 0.5 acting uniformly around the full circumference. Uniform radial forces acting on a circular cross section result in only compressive forces on the section.

Manholes can be subjected to non-uniform lateral loads (such as traffic acting on one side of the manhole). These non-uniform loads will subject the manhole riser to bending moment and shear stresses that need to be considered by the Specifier.

Standard manhole risers shall be manufactured and tested as per AS/NZS 4058:2007, with a nominal Class 1 strength rating. This load rating is to accommodate loads during storage, handling, transport, installation and common in service traffic loads.

Alternate Load Conditions/High Strength Manholes

For loads greater than HN-HO-72, or specific conditions, specific engineering assessment and design by the Purchaser is required. Examples include:

- No pavement,
- No side support,
- Wharf structures and rail yards,
- Liquefaction or dynamic loads such as heavy compaction or,
- Loading adjacent to the manhole such as that from pile driving.

This information must be communicated to the Manufacturer. The Purchaser or Designer should determine the appropriate riser load class based on the anticipated non-uniform lateral loads. Bespoke manholes with higher load class ratings can be designed upon request. Specifiers are encouraged to collaborate with Manufacturers to identify the most economical, practical, and readily available solution.