Concrete pipe jacking is a method of installing pipelines using “trenchless technology” – installation without disrupting existing surface facilities or activities. Pipe jacking has been used to install concrete pipelines for drainage and sewerage projects throughout Australia and New Zealand since the late 1960s.

The major applications for concrete pipe jacking and “micro-tunnelling” include new sewerage and drainage construction, sewer replacement, and culverts. Special applications include the concrete pipe sleeves being jacked into an existing pipe as a liner to add strength and durability.

With increasing growth in Australian and New Zealand cities and towns and the consequent need to refurbish, renew and upgrade existing facilities, the need for trenchless technology is ever growing. The technique can be used without disrupting major infrastructure such as buildings, roads and railways, as well as being able to install pipeline under natural made obstacles. It means the contractor can minimise the surface disruption that is associated with traditional trench (open cut) methods in applications where it would be difficult, unnecessary or a safety concern. Concrete pipe jacking is considered an economic alternative to traditional trenching, particularly where pipelines are laid at depths greater than 5 metres for lengths longer than 50 metres.

Many thousands of kilometres of concrete pipelines have been installed throughout Australia and New Zealand using trenchless technology. A number of these have been highlighted in the CPAA Pipeline newsletter in recent years such as:

- Rail Infrastructure Corporation – Hunter Valley railway maintenance (February 2006 issue): Over 300 metres of DN 750, DN 1200 and DN 1500 Class 4 jacking pipe.
- North Shore City Council (Auckland) – CARE programme (March 2007): 1 kilometre of 2100DN pipe, all PVC lined, for wastewater network improvement.
- Tauranga City Council – Pillans Tunnel (March 2008): 400 metres of 2250DN stormwater pipe installed 20 metres below the surface.
- Northern Network Alliance (South East Queensland) – Northern Pipeline Interconnector (August 2011): More than 1 kilometre of 2100DN with height difference of 60 metres from start to end.
- Christchurch Western Interceptor – Phase 2b (August 2011 and Winter 2012): 4 kilometres of lined 1350DN over 19 months interrupted due to the seismic events at the time.

The benefits associated with concrete pipe jacking that were all evident in these case studies include:

- Resistance to internal and external corrosion
- High strength of the pipe material
- Smooth internal finish giving good flow characteristics
- Ability to withstand static and dynamic loads
- Capacity to withstand internal and external pressure
- Prevention of ground water ingress by use of pipes with sealed flexible joints
- Less risk of settlement
- Minimal surface disruption
- Reduced requirement for utilities diversions in urban areas.

Concrete pipeline systems using trenchless technology require a quality pipe material made to a recognised Standard, a detailed design process to ensure that the right pipe material is selected, and an appropriate installation specification to match the requirements. This issue of Pipeline looks at concrete jacking pipe that is made in Australia and New Zealand to local standards for local conditions.
DESIGNING AND MANUFACTURING CONCRETE JACKING PIPE IN AUSTRALIA AND NEW ZEALAND

The majority of pipe jacks are for sewerage, drainage and other utility applications, and such projects normally involve concrete jacking pipes, particularly in diameters greater than 1050 mm where tunnel boring machines may be used. The design and manufacture of concrete jacking pipe can be influenced by diameter, length of drive, the intended end use of the pipeline, and in some cases, by ground conditions.

Design
Concrete jacking pipe must be able to perform well during two stages of the pipes life – during the installation process, and throughout its service life. James Thomson in the 1993 publication, Pipe Jacking & Micro-tunnelling, provided details of the specific design features that are required for concrete jacking pipes, over and beyond the features of typical drainage and sewer pipe. These were:

- High axial load capacity.
- Close dimension tolerances.
- Squareness of ends.
- Straightness along the length.
- A watertight joint made within the pipe wall, without internal or external projection.
- Joints capable of transmitting axial loads while remaining watertight under angular deflection.

Hence, it is vitally important that concrete jacking pipe exhibits strength that not only allows it to perform under service loads, but is capable of withstanding high stress whilst being installed, particularly at an early stage as turnaround between production and installation can be short.

External loads applied to concrete jacking pipe during or after installation are calculated by:

1. AS/NZS 3725:2007: Design for installation of buried concrete pipes which provides the basis for the calculation of the vertical loads on the buried concrete jacking pipe; and
2. CPAA Design Manual, Designing Concrete Jacking Pipe, which provides the basis for the determination of allowable jacking loads for concrete jacking pipe manufactured in Australia and New Zealand.

Manufacture
In Australia and New Zealand steel reinforced concrete jacking pipe is expected to be manufactured (and selected) in accordance with AS/NZS 4058:2007 Precast concrete pipe (pressure and non-pressure). The main purpose of AS/NZS 4058 is to provide manufacturers with a series of guidelines that allows them to manufacture an appropriate size concrete pipe to the required strength class that will ensure it lasts for over 100 years. They should also be made by a certified manufacturer, so that they will be supplied from a factory which is quality assured to ISO 9001.

Concrete jacking pipes produced in accordance with AS/NZS 4058 is expected to meet specific performance criterion that is applicable to the environment and the intended jacking load conditions.

- Joint selection – joints must be capable of maintaining adequate watertightness or pressure in accordance with its design and the limitations as outlined in AS/NZS 4058 and this guideline; and of transferring the expected axial loads in the jacking process. Generic joint types, both rigid and flexible, are included.
- Cover to steel – for both machine made and wet cast pipe the minimum cover on the external side of the barrel has been increased by 5 mm to allow for a sacrificial layer for unexpected installation conditions.
- Tolerances – the tolerances for concrete jacking pipe have been made tighter than those for typical drainage pipe made to AS/NZS 4058, in particular with reference to external diameter, out of roundness, wall thickness, and straightness.
- Load class – it is recommended that the minimum load class of any concrete jacking pipe selected is Class 3.
- Testing – it is recommended that the watertightness of a jacking pipe and joint manufactured in Australia or New Zealand can be demonstrated by an internal watertightness test, an external joint test or an internal joint test.

External pressure testing at factory

The main two acceptance tests that the pipe will be tested to are for load serviceability (proof load test) and durability (water absorption test).

However, AS/NZS 4058 does not provide enough detail on some of the more specific requirements needed to manufacture concrete jacking pipe for Australian and New Zealand conditions, compared with that required for typical drainage, sewer or pressure pipe.

The Concrete Pipe Association of Australasia introduced an Engineering Guideline, Manufacturing Precast Concrete Jacking Pipe, to help overcome some of these specific requirements that are not covered by AS/NZS 4058, and is designed to be used in conjunction with the Standard to produce quality concrete jacking pipe for Australian and New Zealand conditions.

Highlights
Some of the key areas of difference between concrete pipe made to AS/NZS 4058 and concrete jacking pipe that have been addressed include:

- Joint selection – joints must be capable of maintaining adequate watertightness or pressure in accordance with its design and the limitations as outlined in AS/NZS 4058 and this guideline; and of transferring the expected axial loads in the jacking process. Generic joint types, both rigid and flexible, are included.
- Cover to steel – for both machine made and wet cast pipe the minimum cover on the external side of the barrel has been increased by 5 mm to allow for a sacrificial layer for unexpected installation conditions.
- Tolerances – the tolerances for concrete jacking pipe have been made tighter than those for typical drainage pipe made to AS/NZS 4058, in particular with reference to external diameter, out of roundness, wall thickness, and straightness.
- Load class – it is recommended that the minimum load class of any concrete jacking pipe selected is Class 3.
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Service conditions the material is expected to work in throughout its design life. The main two acceptance tests that the pipe will be tested to are for load serviceability (proof load test) and durability (water absorption test).

However, AS/NZS 4058 does not provide enough detail on some of the more specific requirements needed to manufacture concrete jacking pipe for Australian and New Zealand conditions, compared with that required for typical drainage, sewer or pressure pipe.

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Specifications
To ensure that the concrete jacking pipe to be produced meet the criteria of the specification, the document recommends that the purchaser confirm the following information with the manufacturer before order:

- Intended service requirements for application (pressure or non-pressure water supply, drainage, sewerage, or service ducts).
- Intended installation environment (normal, marine, other).
- Pipe quantity, size (DN or nominal diameter) and load class.
- Actual design diameter.
- Jacking loads (maximum jacking stress) at effective field deflection.
- Watertightness or internal and external pressure requirements.
- Joints capable of transmitting axial loads while remaining watertight under angular deflection.

Example of metal collar used on jacking pipe

Example of the in-wall joint

Example of the butt joint and rubber ring

Example of metal collar used on jacking pipe

Example of the in-wall joint

Example of the butt joint and rubber ring

Example of metal collar used on jacking pipe
Designing steel reinforced concrete pipeline systems requires an understanding of two Australian Standards — AS/NZS 4058 Precast concrete pipe and AS/NZS 3725 Design for installation of buried concrete pipe. To gain a thorough understanding of these documents, and to be able to design to your full capacity, there is a design course available in Australia to suit this specific need.