Roadshow:
New Zealand 14-18 October 2019

Information session

Aimed at Asset Owners and Specifiers of Steel Reinforced Concrete pipe and associated products.
Administration

- Facilities
- Evacuation Procedures
- Timing and Break
- Phones (OFF)
- Questions (if essential; then ask; otherwise at the end)
Introduction
CPAA Members in NZ – Hynds and Humes

- **Chris Thorpe** –
  - Senior Technical Sales Engineer, Humes
- **Mobeen Ali**
  - Drainage Category Manager, Hynds
- **Andrew Ruffles**
  - Executive Director CPAA
Content

1. Introduction
2. ‘This is how you design it.’
   1. Design of Rigid Pipe (SRCP)
   2. Design of Flexible Pipe (Plastic)
3. ‘This is how you test it.’
   1. Testing of SRCP
   2. Testing of Flexible Pipe
4. PipeClass - Tutorial
5. Publications
   • Field Testing of Concrete Pipe - CPAA
   • Manhole Document – CPAA
   • NZ Pipeline Inspection manual – Project Max
   • Deflection Testing - CPAA
   • Acid Sulphate Soils - CPAA
   • Selecting Material for Bedding - CPAA
6. Wrap up and Q&A
Specifying Pipe Materials:
Identifying the Risks

Rigid and Flexible
(Concrete and Plastic)
Background

...We have delivered CPAA concrete pipe installer training and we found some surprises...

- Since October 2015 CPAA members have delivered the CPAA Concrete Pipe Laying Course for Installers.
- We have completed over 100 sessions to date.
- We have trained over 1000 Installers nationwide.
- We found that only 12 had previously received any formal training in laying concrete pipe.
Background

Specifying Pipe Materials
• After rolling out the Installer Training we realised that we needed to share this information and close the gap.
• We want to promote to you the roll out of a specifier/designer course - presentation.
  – Highlighting some of the things Designers/Engineers often ask us about.
Background

Specifying Pipe Materials

• Identifying the pros and cons. of each
• Considering Risk and who takes Risk
Specifying Pipe Materials

Aim of the presentation:

To raise awareness and clarify the differences between rigid and flexible pipes in terms of material properties, risk and design considerations, installation requirements and quality assurance.
Specifying Pipe Materials

To do that I will summarise...

• How to design rigid pipe,
• How to design flexible pipe (drawing comparisons)
• How to test rigid pipe
• How to test flexible pipe

This will include material properties, risk and design considerations, installation requirements and quality assurance
Specifying Pipe Materials

Rigid

We will cover...

• Design concepts,
• Standards, Loads, installation, bedding and compaction,
• Grading of material,
• Determination of pipe strength class,
• Trench and embedment geometry,
• Elliptical reinforcement,
• Importance of Uniform Support.
Introduction – Design concepts

“The concept of a rigid pipe is one that has sufficient inherent strength to carry the working load on its own.”

“The concept of a flexible pipe is one that deflects sufficiently and through interaction with the soil embedment develops sufficient combined strength to carry the working load.”

These two different pipe materials have different design criteria and installation criteria so, they must be treated differently.
Concrete Pipe Standards

AS/NZS 3725:2007
Design for Installation of buried concrete pipes

AS/NZS 4058:2007
Precast Concrete pipes (pressure & non pressure)

Specifiers & Designers
Installers
Manufacturers
Rigid Pipe

AS/NZS 3725:2007
“Design for installation of buried concrete pipes”

This Standard:

- Calculation of vertical loads
- Minimum test cracking load
- Classifies pipe installation and bedding
- Requirements for soil materials
- Requirements for compaction of soil around pipes.

AS/NZS 3725 is used hand-in-hand with AS/NZS 4058 to determine the most appropriate class of concrete pipe.
Rigid Pipe

AS/NZS 3725
AS/NZS 3725

Detailed backfill requirements

- AS/NZS 3725 assumes in design that there will be a uniform support for the pipe.
- Standard includes recommended grading for selected fill materials.
- Appendix and commentary include a detailed description.
- Assumes that selected materials graded in accordance with Tables 6 & 7 of the Standard are used for the installation of concrete pipe.

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Weight passing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0</td>
<td>100</td>
</tr>
<tr>
<td>2.36</td>
<td>100 – 50</td>
</tr>
<tr>
<td>0.60</td>
<td>90 – 20</td>
</tr>
<tr>
<td>0.30</td>
<td>60 – 10</td>
</tr>
<tr>
<td>0.15</td>
<td>25 – 0</td>
</tr>
<tr>
<td>0.075</td>
<td>10 - 0</td>
</tr>
</tbody>
</table>

Grading limits for select fill in bed and haunch zone from AS/NZS 3725 Table 6

<table>
<thead>
<tr>
<th>Sieve size (mm)</th>
<th>Weight passing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.0</td>
<td>100</td>
</tr>
<tr>
<td>9.5</td>
<td>100 – 50</td>
</tr>
<tr>
<td>2.36</td>
<td>100 - 30</td>
</tr>
<tr>
<td>0.60</td>
<td>50 -15</td>
</tr>
<tr>
<td>0.075</td>
<td>25 - 0</td>
</tr>
</tbody>
</table>

Grading limits for select fill in side zone from AS/NZS 3725 Table 7
Rigid Pipe

**AS/NZS 3725 Backfill Compaction requirements**

a) It shall be demonstrated through construction plans, quality control plans, and field trials that the degree of **compaction** shown in Table B of the Selecting Materials for Bedding Steel Reinforced Concrete Pipe Engineering Guideline, corresponding to the selected bedding type and material, can be achieved...

<table>
<thead>
<tr>
<th>Bedding Type</th>
<th>HS3</th>
<th>HS2</th>
<th>HS1</th>
<th>H2</th>
<th>H1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding Material</td>
<td>I_d</td>
<td>R_d</td>
<td>I_d</td>
<td>R_d</td>
<td>I_d</td>
</tr>
<tr>
<td>SW, SP, GW, GP</td>
<td>70</td>
<td>95</td>
<td>60</td>
<td>90</td>
<td>50</td>
</tr>
<tr>
<td>SC, GC</td>
<td>n/a</td>
<td>n/a</td>
<td>70</td>
<td>95</td>
<td>60</td>
</tr>
</tbody>
</table>

**NOTES:**
1. I_d refers to Density Index (%) and is for cohesionless materials (refer to Clause 8, AS/NZS 3725 for more information).
2. R_d refers to Dry Density Ratio (%) and is for cohesive materials (refer to Clause 8, AS/NZS 3725 for more information).

b) Methods to prevent **migration of soil fines** from, and into the bedding material, shall be provided when ground water movement or existing soil and bedding conditions are conducive to particle migration...
Rigid Pipe

Design & installation considerations - AS/NZS 3725 Selecting class of pipe

- AS/NZS 3725 design determines the class of pipe required.
- The strength class is based on the hoop strength of the pipe.
- Hoop action requires the pipe to be uniformly supported...

Design & installation considerations - AS/NZS 3725
Embedment materials – concrete pipe

- Rigid pipe - low dependency on soil-pipe interaction.
- The selection of the installation support type determines the load class of pipe to be specified.
- The inherent strength of concrete can be further increased by using higher class bedding.
- If the bedding is disturbed there is still a high level of residual strength.

![Concrete Pipe Diagram](image)
**Rigid Pipe**

**Design & installation considerations**

**Shape and dimension of embedment**

The shape of the embedment determines the effects of the dead and live loads on the installed pipe.

- In a **trench** the walls provide frictional support to the fill material over the pipe. The frictional forces reduce the effect of the fill load on the pipe.

- In an **embankment** formation the fill material either side of the pipe settles further than the soil prism of width $D$ directly over the pipe. The frictional forces increase the effect of the fill load on the pipe.
Rigid Pipe

Design & installation considerations – Importance of Installation

- Hoop action requires the pipe to be **uniformly supported** along its entire length.
- Correct orientation essential where **elliptical** reinforcement is used.
- Elliptical reinforced concrete pipes in NZ have Swiftlifts & are clearly marked TOP
Rigid Pipe

Design & installation considerations

- Why should pipe be evenly and uniformly supported along the length of its barrel by suitable fill material.

- What type of concrete pipe is more likely to be affected by this?

- What about concrete pipe where there is excessive movement?
Rigid Pipe

Design & installation considerations

DIG TO HERE

PUSH HOME

NEAT FIT
# Pipe Support - Summary

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
<th>BEDDING FACTOR (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>UNCONTROLLED</td>
<td>1</td>
</tr>
<tr>
<td>H1</td>
<td>10% HAUNCH</td>
<td>1.5</td>
</tr>
<tr>
<td>H2</td>
<td>30% HAUNCH</td>
<td>2</td>
</tr>
<tr>
<td>HS1</td>
<td>10% HAUNCH + SIDE</td>
<td>2</td>
</tr>
<tr>
<td>HS2</td>
<td>30% HAUNCH + SIDE</td>
<td>2.5</td>
</tr>
<tr>
<td>HS3</td>
<td>30% HAUNCH + SIDE + EXTRA COMPACTION</td>
<td>4</td>
</tr>
</tbody>
</table>
Specifying Pipe Materials: Flexible
Specifying Pipe Materials

We will cover...

- Design concepts,
- Standards, for design and for installation.
- Ring bending stiffness,
- Design rather than performance criteria,
- Structure is built in the field not made in the factory,
- Deflection and soil pipe envelope,
- Importance of post-installation testing to confirm design parameters.
Flexible Pipe

Standards

AS/NZS 2566.1:1998
Buried flexible pipelines – Structural design

AS/NZS 2566.2:2002
Buried flexible pipelines - Installation

Specifiers & Designers

Installers

Manufacturers

Standards

Polyethylene
AS/NZS 5865:2005 Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications

PVC
AS/NZS 1260:2009 PVC-U pipes and fittings for drain, waste and vent application

GRP
ISO 10467:2004 Plastics piping systems for pressure and non-pressure drainage and sewerage -- Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin

Flexible Pipe
Flexible Pipe

AS/NZS 2566.1 – Structural Design

“This standard sets out a practice for the structural design of buried flexible pipes which rely primarily upon side support to resist vertical loads without excessive deformation.”

AS/NZS 2566.2 – Installation

“This standard specifies requirements for the installation, field testing and commissioning of buried flexible pipe with structural design in accordance with AS/NZS 2566.1”
What is a flexible pipe?
“The concept of a flexible pipe is one that deflects sufficiently, by interaction of the soil embedment, sufficient combined strength to carry the working load.”

Ring Bending Stiffness:
“Is an indication of the ability of a pipe to resist deflection. It is determined by deflecting the pipe using line loading and no side support.”

- Is in the form of a SN rating e.g. SN4, SN6, SN8 and SN16
  - E.g. 16000 N/m/m
- Generally provided by the manufacturer
- Initial 3 minute ring bending stiffness
- Long term 2 year ring bending stiffness
- Long term 50 year ring bending stiffness
Flexible Pipe

AS/NZS 2566.1 Structural Design - Design Based Standard

Design

- In flexible pipe design the structure is built in the field.
- Flexible pipe AS/NZS 2566 requires two acceptance checks –
  - **Design acceptance** - the design office check
  - **Performance acceptance** - the field check short term vertical deflection in the installed flexible pipe.

- AS 2566.1 notes:
  - "**deflection measurement** is a valuable method of assessing the adequacy of embedment material placement and compaction".
Flexible Pipe

AS/NZS 2566.1 Structural Design – Design Based Standard

- It is a design requirement to determine that the installed pipe will act in a flexible manner.
- It is based on attaining the required embedment properties, & predicted installed pipe properties which include:
  - vertical deflection
  - ring bending stiffness
  - buckling effects, and
  - defined pipe/soil relative stiffness ratio
- Designers must check that the pipe deflects enough, relative to the soil, to ensure the soil envelope will take the loads.
Flexible Pipe

AS/NZS 2566.1 Structural Design – Design Based Standard

- AS/NZS 2566.1 outlines the required short term and long term deflection limits for flexible pipes.
- As flexible pipe strength decreases over time deflection will increase over time.

<table>
<thead>
<tr>
<th>Pipe Materials</th>
<th>Allowable short-term 30 day deflection</th>
<th>Allowable long-term 1 year deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP</td>
<td>4.0%</td>
<td>4.8%</td>
</tr>
<tr>
<td>ABS, PE, PP, PVC</td>
<td>5.0%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>
# Flexible Pipe

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter</th>
<th>Concrete</th>
<th>Plastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe</td>
<td>Pipe diameter class</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Embedment</td>
<td>Width of trench</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Depth and type of fill</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Loads</td>
<td>Calculate unit weight of fill</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate service live load</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate construction load</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Select soil support condition</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Select load class</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Deflection</td>
<td>Calculate short term pipe stiffness</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate long term pipe stiffness</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Nominate embedment soil modulus</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate theoretical pipe deflection</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Check calculated deflection is within limits</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Strength</td>
<td>Calculate shape factor</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate long term bedding strain</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Check strain within allowable limits</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Buckling</td>
<td>Calculate vertical construction service loads</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate ∑ loads for buckling</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Calculate allowable buckling pressure</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>Check ∑ loads &lt; allowable</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Thermal</td>
<td>Impact of site temperatures on joints</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>
Flexible Pipe

Design & installation considerations

Compaction – Soil Moduli

Table 3.2 of AS/NZS 2566.1 also provides values for Soil Moduli for the different materials.

Native Soil Modulus (MPa) – “The effectiveness of the embedment depends on the lateral restraint offered by the zone of the native soil (see Figure 3.1). Disturbed or unstable native soils cannot be counted on to provide the degree of restraint necessary for developing the passive soil resistance required to prevent excessive pipe deflections and distortions. Hence, the embedment is not considered to be effective in supporting the pipes unless the native soil has an adequate density and stiffness.”

Note: Native soils, which may not have the required density and stiffness, include soft clays, soils containing organics materials, and swelling soils.
Flexible Pipe

Design & installation considerations

The main training package then goes into a some detail covering:

• Embedment Materials
• Shape and dimensions of the installation
• Compaction
• Soil Moduli
• Loadings
• Long term ring compressions strain caused by ring bending thru deflection
• The need for an appropriate level of deflection; within limits
• How to deal with composite profiles side walls where the neutral axis is offset
• Buckling
Specifying Pipe Materials: Identifying the Risks

Testing: Rigid
Rigid Pipe

Quality Assurance/ Quality Control

Post Installation Tests

In the standard there are no post installation tests for structural integrity. However, there are three tests that can be considered to test the workmanship of the installation.

• Air Test

• Water Tightness Testing

• CCTV

For more details refer to CPAA Technical Note – Performance Testing of Non-Pressure Concrete Stormwater Pipelines
Rigid Pipe

Quality Assurance/ Quality Control

Post Installation Test

• Air test
  • Concrete is a porous material so there is allowance made for some loss of pressure during testing.
  • Air pressure loss is not directly related to potential water loss.
  • Air test is good for acceptance but not for rejection.

• Water tightness Testing
  • For a successful test the pipeline should be soaked for an appropriate time.
  • For more information refer to the CPAA Technical Note.
Specifying Pipe Materials: Identifying the Risks

Testing : Flexible
Flexible Pipe

Quality Assurance /Quality Control

Post Installation Test

Flexible pipe materials - TWPE, GRP & PVC
  • Air Testing
  • Water Leakage Testing
  • Deflection Testing
Flexible Pipe

Quality Assurance /Quality Control
Post Installation Test

Flexible pipe materials - TWPE, GRP & PVC

- Deflection Testing

**AS/NZS 2566.1 notes:** “Deflection measurement is a valuable method of assessing the adequacy of embedment material placement and compaction”.

**AS/NZS 2566.2 notes:** “For non-pressure pipelines, and where structural verification for pressure pipelines is required, deflection shall comply with the test criteria of Table 5.6”.

Post Installation Test
Flexible Pipe

Quality Assurance /Quality Control

Post Installation Test

Acceptable Pipe Deflection

- If flexible pipe exceeds the designed deflection limits in the field, it can lead to creep and buckling, resulting in sudden failure.

- This can only be measured once the pipe is in the ground as the pipeline strength is dependant on the soil envelope – not the pipe material.

<table>
<thead>
<tr>
<th>Pipe Materials</th>
<th>Maximum Allowable Short - Term Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRP</td>
<td>4.0%</td>
</tr>
<tr>
<td>PVC, PE, PP</td>
<td>5.0%</td>
</tr>
</tbody>
</table>
Flexible Pipe

Quality Assurance /Quality Control

Laser Profilers

- Specified in USA by a number of DOT’s. Example: Florida DOT
- CPAA Guideline – Deflection Testing of Flexible Pipe
- www.cpaa.asn.au (Technical Publications)
Flexible Pipe

Quality Assurance / Quality Control

Laser Profilers
Flexible Pipe

Quality Assurance / Quality Control

Proving Rings

- Procedure for proving rings is outlined in Appendix O of AS/NZS 2566.2.

- These should be rigid, non-adjustable, and legged.
Flexible Pipe

Quality Assurance /Quality Control

Where in NZ is deflection testing specified?

- Auckland Council
- Watercare
- Christchurch – Gravity Pipelines
- Gisborne District Council
- Kaipara District
- Whakatane District Council
Summary

- Concrete and flexible pipes are very different materials.

  - **Rigid pipeline:**
    - Performance Standards – strength
    - Factory performed load tests to AS/NZS 4058
    - Proof load test is routine and part of process

  - **Flexible pipeline:**
    - Design Standard- requires designer to check to ensure the soil envelope will take the loads (AS 2566.1).
    - Field – laser profile checks (short term and long term) to ensure deflection limits have not been exceeded due to inadequate installation (CPAA Guide).
Concrete Pipe Association of Australasia

PipeClass
AS/NZS 3725:2007
Design for installation of buried concrete pipe
Design and selection

Hydraulic design complete – choose standard diameter

Select type of pipe required (drainage, pressure, jacking)

Installation type
Bedding factors
Loading conditions expected
Support type
Compaction level
Determine Class of Pipe

Environment/cover
Load class
Proof load/Ultimate load
Testing procedures

AS/NZS3725
AS/NZS4058
### Project Details

- **Job number:** CPAA0104
- **Last modified on:** 17-Jun-2011
- **Notes:** This is an example and not a real life scenario.
- **Designer:** David Millar
- **Company:** Concrete Pipe Association of Australasia
- **Client:** CPAA
- **Project:** Example project
- **Description:** An example of how the PipeClass program can work

### Designs

<table>
<thead>
<tr>
<th>Name</th>
<th>Summary</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1</td>
<td>1200 RRJ Class 2 drainage pipe, 2.000 m height of fill, H2 bedding support, trench condition, vertical walls</td>
<td></td>
</tr>
<tr>
<td>Example 2</td>
<td>750 FJ Class 2 drainage pipe, 2.000 m height of fill, H1 bedding support, trench condition, vertical walls</td>
<td></td>
</tr>
<tr>
<td>Example 3</td>
<td>1800 RRJ Class 2 pressure pipe, 2.000 m height of fill, HS2 bedding support, trench condition, vertical walls</td>
<td></td>
</tr>
<tr>
<td>Example 4</td>
<td>900 RRJ Class 2 drainage pipe, 2.000 m height of fill, HS2 bedding support, embankment condition, positive projection</td>
<td></td>
</tr>
<tr>
<td>Example 5</td>
<td>2400 RRJ Class 3 drainage pipe, 2.000 m height of fill, HS3 bedding support, trench condition, vertical walls</td>
<td></td>
</tr>
</tbody>
</table>
Pipe

Application: drainage

Joint type: rubber ring joint

Nominal diameter (mm): 600
Actual external diameter, D (mm): 699

Socket external diameter = 827 mm

* Uniform bedding support and sound foundation is most important for small diameter pipe.

Barrels
- Single barrel
- Multiple barrels

Number of barrels: 2
Barrel spacing, Ic (mm): 200
Socket spacing = 72 mm

Pipeline orientation
Orientation of pipeline relative to centreline of road or rail:
- Perpendicular
- Longitudinal
- Both or skew
Pipe

Application: pressure

* Ensure that actual pressures are input in the other loads section of the In Service Design Loads page.

Joint type: rubber ring joint

Nominal diameter (mm): 600
Actual external diameter, D (mm): 699

Socket external diameter = 827 mm

* Uniform bedding support and sound foundation is most important for small diameter pipe.

Barrels

- Single barrel
- Multiple barrels

Number of barrels: 2
Barrel spacing, Ic (mm): 200
Socket spacing = 72 mm

See help for information on multi-cell pipe installation condition.
from Figure 4 of AS/NZS 3725:2007. For compacted fill, it is:

<table>
<thead>
<tr>
<th>Diameter Range</th>
<th>Barrel Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;= 600mm diameter</td>
<td>150mm</td>
</tr>
<tr>
<td>&gt; 600mm, &lt;= 1200mm diameter</td>
<td>200mm</td>
</tr>
<tr>
<td>&gt; 1200mm diameter</td>
<td>D/6 where D is the outside diameter of the barrel</td>
</tr>
</tbody>
</table>

The minimum spacing between adjacent pipe sockets, for socketed pipes, is 50mm. If a value of spacing less than the default value is input a warning will be displayed.

**Confirmation**

The barrel spacing (180 mm) is less than the recommended value of 200 mm, however if compaction can be achieved in the bed and haunch zones then the value selected may be used.

- [ ] Compaction can be achieved, accept lower barrel spacing of 180 mm.
- [ ] Adopt minimum recommended barrel spacing of 200 mm.

To achieve compaction between such pipes normal mechanical compaction methods may not be suitable and as such the use of alternative methods of compaction may be required such as:
- Flooding of a sand backfill (note provision for water to escape is required)
- Placement of a single sized aggregate such as a concrete aggregate with suitable tamping (note in some native soil conditions the use of a geotextile will be required)
- Placement of a self compacting slurry or cement stabilised fill.
- Or some other suitable means which does not require mechanical compaction techniques.

Note that the minimum required spacing between adjacent pipe sockets may, for some socketed pipe diameters, result in a larger default value for the barrel spacing (lc) than recommended by AS/NZS 3725:2007.

AS/NZS 3725:2007 Clause 6.3.3.3 Multiple Pipe Conditions states, “Where two or more pipes are laid side by side in a single trench or embankment the working load per pipe due to fill (Wg) is calculated as for the embankment condition using equation 2 (formula for positive projection condition).”
**Earth Loads**

**Installation condition:**
- Trench condition
- Vertical walls

**Soil**
- Soil type: wet clay
- Density (kN/m³): 20
- Ku: 0.1100

**Dimensions**
- Trench width, B (m): 1.055
- Fill as: height of fill
- Height of fill, H (m): 2.000

**Support**
- Support type: HS2
- Bedding factor: 2.5

Choosing the right support for your specification is extremely important. Compaction levels must be achieved in the haunch and side zones for bedding factors to be achieved.
Earth Loads

Installation condition: trench condition with vertical walls

Soil
- Soil type: wet clay
- Density (kN/m³): 20
- Ku: 0.1100

Dimensions
- Trench width, B (m): 1.055
- Fill as: height of fill
- Height of fill, H (m): 2.000

Support
- Support type: HS3
- Bedding factor: 4.0

Recommended for high embankment situations where there is good control of side fill compaction. Installation technique is very important, particularly for large diameter pipe. In difficult installation circumstances CLSM may be used.

Choosing the right support for your specification is extremely important. Compaction levels must be achieved in the haunch and side zones for bedding factors to be achieved.

More on CLSM.
The bedding factors included in PipeClass for each support type are shown in the adjacent table. The reduced bedding factors can be selected when the grading limits required for the material in the haunch zones cannot be met.

A detailed description of each support type is contained in AS/NZS 3725:2007 Design for installation of buried concrete pipes. A brief description of each support type is given below.

**Type U Support** – Uncontrolled. In this type of support pipes are basically placed directly on the excavated foundation and then backfilled with no specific control of compaction. If there is a rock foundation then there is a minimum requirement for compacting the material to be placed in the bed zone. This type of support is only recommended for minor pipelines where there are light loads and little or no live loads.

**Type H1 & H2 Supports** – Haunch Support. In these types of supports compacted granular material is placed in the bed and haunch zones to varying heights and compaction standards. The H2 support is recommended for most drainage pipe installations not under roadways.

**Type HS1, HS2 & HS3 Supports** – Haunch and Side Support. In these types of supports compacted granular fill is placed in the bed zone in addition to the material placed in the bed and side zones of the type H supports. The extent and compaction requirements of the different support types vary. The HS2 support type is recommended for most installations under a roadway and the HS3 support is recommended for embankment fill situations.

**Controlled Low Strength Material (CLSM)** - Can be used as an alternative to mechanically compacted granular fill used in the haunch and side zones. Materials such as slurry fill, flowable fill, mortar, soil-cement slurry and non-shrink fill may all be suitable provided they are of suitable stiffness and stability. Refer to AS/NZS 3725:2007 for detailed information on CLSM's.
In Service Design Loads

Standard vehicle loads

- Category: New Zealand Road Vehicles
  - 0.85 HN (lightly trafficked) load
  - HN (normal) load
  - HO (overweight) load (includes UDL)

Distribution of in service live loads

For in service live loads in the range 0.200 - 0.399 m of fill:
- do not distribute

Railway loads

- 300LA, standard gauge

Other vehicle loads

- Flexible pavement - asphalt, density = 21 kg/m³, thickness = 0.000 m
- Point load, 10 kN (10 x 10 mm) treated as dead load
- Uniform surcharge load, 15 kPa applied as direct load
- Weight of internal water

Pipe design

- Controlling loads: earth
- Minimum test load: Tc = 8.6 kN/m
- Proof load = 26.0 kN/m
  - 66% reserve capacity.

Pipe load class 2 selected.

Design life for steel reinforced concrete pipes is in excess of 100 years. In service design loads are applied to the pipeline for its entire design life.
Design for in-service design loads is pipe load class 2 with a type HS2 support (bedding factor = 2.5).

Take care when installing small diameter pipes. Construction loads can cause circumferential cracking in pipes that are not bedded uniformly along their entire barrel.

For construction loads in the range 0.200 - 0.399 m of fill: do not distribute.
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATD400E</td>
<td>Truck, Articulated CATD400E - Total weight (loaded) 65.6 t</td>
<td>construction</td>
</tr>
<tr>
<td>CATD4CIII</td>
<td>Dozer CATD4C Series 3 - Total weight 7.3 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CATD5CIII</td>
<td>Dozer CATD5C Series 3 - Total weight 8.4 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CATD6R</td>
<td>Dozer CATD6 R - Total weight 18.2 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CATD7G</td>
<td>Dozer CATD7 R - Total weight 20.5 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CATD8R</td>
<td>Dozer CATD8 R - Total weight 37.0 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CATD9R</td>
<td>Dozer CATD9 R - Total weight 48.3 t, with standard shoe</td>
<td>construction</td>
</tr>
<tr>
<td>CPAACWH.1</td>
<td>CPAA Construction Vehicle - 20 tonne Excavator + Compaction Wheel 580 mm w...</td>
<td>construction</td>
</tr>
<tr>
<td>CPAACWH.2</td>
<td>CPAA Construction Vehicle - 25 tonne Excavator + Compaction Wheel 580 mm w...</td>
<td>construction</td>
</tr>
<tr>
<td>CPAACWH.3</td>
<td>CPAA Construction Vehicle - 30 tonne Excavator + Compaction Wheel 580 mm w...</td>
<td>construction</td>
</tr>
<tr>
<td>CPAARAM</td>
<td>CPAA Construction Vehicle - Vibratory rammer (up to 75 kg weight)</td>
<td>construction</td>
</tr>
<tr>
<td>CPAAVPL</td>
<td>CPAA Construction Vehicle - Vibratory plate (up to 135 kg weight)</td>
<td>construction</td>
</tr>
<tr>
<td>CPAAVR-10T</td>
<td>CPAA Construction Vehicle - Smooth Drum Vibratory Roller (10 t Static Weight)</td>
<td>construction</td>
</tr>
<tr>
<td>CPAAVR-7T</td>
<td>CPAA Construction Vehicle - Smooth Drum Vibratory Roller (7 t Static Weight)</td>
<td>construction</td>
</tr>
<tr>
<td>CPAAVTR2T</td>
<td>CPAA Construction Vehicle - Vibratory Trench Roller (2 t)</td>
<td>construction</td>
</tr>
<tr>
<td>HLP320</td>
<td>Standard Vehicle, AS/NZS 3725:2007 - Heavy Load Platform HLP320 (part only)</td>
<td>AS/NZS 3725</td>
</tr>
<tr>
<td>HLP400</td>
<td>Standard Vehicle, AS/NZS 3725:2007 - Heavy Load Platform HLP400 (part only)</td>
<td>AS/NZS 3725</td>
</tr>
<tr>
<td>HN</td>
<td>Standard Vehicle, Transit NZ - HN (Normal Loading)</td>
<td>NZTA</td>
</tr>
<tr>
<td>HN-85%</td>
<td>Standard Vehicle, Transit NZ - 0.85 HN (Lightly Traffic) Loading</td>
<td>NZTA</td>
</tr>
<tr>
<td>HO</td>
<td>Standard Vehicle, Transit NZ - HO (Overweight) Loading (includes 3.5 kPa UDL l...</td>
<td>NZTA</td>
</tr>
<tr>
<td>HO-ALT</td>
<td>Standard Vehicle, Transit NZ - HO (Overweight) Loading Alternative (includes 3....</td>
<td>NZTA</td>
</tr>
</tbody>
</table>
Design for in service design loads is pipe load class 2 with a type HS2 support (bedding factor = 2.5).

The fill range(s) shown above indicate the allowable fill height for the nominated construction load. View the graph for more information.

Take care when installing small diameter pipes. Construction loads can cause circumferential cracking in pipes that are not bedded uniformly along their entire barrel.

Distribution of construction loads

For construction loads in the range 0.200 - 0.399 m of fill: do not distribute

Adjustments

It may be possible to reduce the minimum fill height for the above construction loads using one or more of the following options.

- Increase the support type (recommended).
- Increase the pipe load class.

Design life for steel reinforced concrete pipes is in excess of 100 years. Construction loads are applied to the pipeline only during construction.
CPAAVR-10T on a 375mm dia. RRJ Class 2 drainage pipe with HS2 support (BF = 2.5)

- Earth load
- Construction load
- Combined load
- Proof load
- Design fill height (2.000 m)
- Disallowed fill heights
- Allowable fill range (m): 0.703 - 2.000

Load (kN/m)

Fill depth (m)

Set x-axis range (m): 3

Print Close
Design for in service design loads is pipe load class 2 with a type HS2 support (bedding factor = 2.5).

The fill range(s) shown above indicate the allowable fill height for the nominated construction load. View the graph for more information.

Take care when installing small diameter pipes. Construction loads can cause circumferential cracking in pipes that are not bedded uniformly along their entire barrel.

Distribution of construction loads

For construction loads in the range 0.200 - 0.399 m of fill: do not distribute

Adjustments

It may be possible to reduce the minimum fill height for the above construction loads using one or more of the following options.

- Increase the support type (recommended).
- Increase the pipe load class.

Design life for steel reinforced concrete pipes is in excess of 100 years. Construction loads are applied to the pipeline only during construction.
CPAAVR-10T on a 375mm dia. RRJ Class 4 drainage pipe with HS2 support (BF = 2.5)

Graph showing load versus fill depth (m) for different load scenarios:
- Earth load
- Construction load
- Combined load
- Proof load
- Design fill height
- Disallowed fill heights
- Allowable fill range (m): 0.400 - 2.000
Summary

Pipe
1200mm diameter rubber ring joint Class 2 drainage pipe.
Single barrel.

Earth Loads and Installation
Bedding support specified is H2 with a bedding factor of 2.0.
Height of fill is 2.000 m.
Soil type is wet clay with a density of 20 kN/m³.
Excavation volume is 6.4 m³/m (solid).
Bed zone, X = 100 mm
solid volume = 0.183 m³/m, loose volume = 0.219 m³/m
Haunch zone, Y = 415 mm
solid volume = 0.382 m³/m, loose volume = 0.458 m³/m
Overlay zone, O = 150 mm
solid volume = 0.924 m³/m, loose volume = 1.385 m³/m
Ordinary backfill = 1850 mm
solid volume = 3.384 m³/m, loose volume = 5.075 m³/m

In Service Design Loads - applied at design depth of 2.000 m

Construction Loads - applied during construction only
Select print options for design "Design01":

- [x] Pipe Load Summary Sheet
- [x] Pipe Installation And Quantities Sheet
- [x] Detailed Load Report
- [x] Installation Specification
- [x] Construction Load Graphs

[OK] [Cancel]
Load Summary

- Summary of all design parameters
- In service load case combinations considered
- Highlights the controlling load case
- Summary of working load and subsequent test load
- Any design notes identified by the program.
In service load case combinations considered
Highlights the controlling load case
Outlines the specific figures used by the program to determine the working load
Outlines the controlling support type used to determine working load on pipe
Installation Specification for Type H S2 Support

This specification is prepared to ensure the pipe installation conforms with the requirements of AS/NZS 3725.0207 Design for installation of buried concrete pipes.

1. H S2 supports represents an installation with controlled contact of the bed zone and haunch zone.

Excavation and bedding

Prior to completion of excavation, the soil in which the trench is to be excavated shall be assessed for density and stiffness, to the satisfaction and approval of the superintendent.

If it is established that the natural ground will provide effective side support, the trench width for both trench condition an embankment condition shall be as shown on the drawings.

For an embankment installation, the negative projection of the pipe shall be 0.5 times the pipe outside diameter or less. Where the projection of the pipe above natural ground surface is greater than 0.5 times the pipe outside diameter, it will be necessary to construct the embankment to a height above top of bed level at least equal to 0.5 time pipe outside diameter, prior to laying the pipe, and to a width equal to at least 1.5 times pipe nominal diameter on each side of the projected trench width.

The embankment shall be constructed in accordance with the specification for refilling, bed zone. A trench is then to be cut through the constructed embankment.

For a trench installation, if in the opinion of the superintendent, the natural ground is not considered effective in providing the necessary side support, the trench shall be excavated to a width of 4.0 times pipe nominal diameter to the top of bed level.

The wide trench excavation shall then be refilled in accordance with the specification for refilling, side zone.

Refilling in embankment or wide trenches shall be placed in layers not exceeding 150mm when compacted and, if cohesive materials is used, the moisture content shall be controlled to within the range 85 percent to 115 percent of the optimum moisture content. Compaction by v-amplitude, rolling and/or vibration shall be carried out to achieve a minimum Relative Density (RD) of 90% of standard maximum dry density, or a minimum Density Index (DI) of 60 for cohesionless materials.

Density achieved shall be monitored by field testing as directed by the superintendent.

The required trench for the installation, to the width and depth shown on the drawings shall be excavated centrally through the above compacted select fill material.

Excavation shall be to line and level shown on the drawings.

Should the excavation to the required foundation at the bottom of the bed level reveal unsuitable material, which in the opinion of the superintendent is unsuitable, the trench shall be re-excavated to a depth required to remove the unsuitable material and refilled with compacted material conforming to the requirements for the bed zone.

Bedding

Bed zone material shall be select fill. Select fill as defined in AS/NZS 3725.0207 is material obtained from excavation of the pipe trench or elsewhere with a particle size not greater than 19 mm, and which conforms with the following soil classes as defined in Aocenid D of AS 1726.
Research
- Rigid vs Flexible

the results are interesting...
read more >>

The Concrete Pipe Association of Australasia (CPAA) represents manufacturers of steel reinforced concrete pipe and associated products who are committed to the use of AS/NZS 4058 "Precast concrete pipe (Pressure and non-pressure)" and AS/NZS 3725 "Design for the installation of buried concrete pipe", as the benchmarks in industry.

The Association aspires to represent excellence in design, manufacture, application, and technology of steel-reinforced concrete pipe and associated products.

Steel reinforced concrete pipe – built to last for over 100 years!
Recent relevant publications

- Field Testing of Concrete Pipe - CPAA
- Manhole Document – CPAA
- NZ Pipeline Inspection manual – Project Max
- Deflection Testing - CPAA
- Acid Sulphate Soils - CPAA
- Selecting Material for Bedding - CPAA
Loads on Circular Precast Concrete Manholes and Access Chambers - 2019
The 4th edition of the New Zealand Gravity Pipe Inspection Manual incorporates the evolution of pipeline inspection and the changing requirements of the water industry since the publication of the 3rd Edition in 2005. The scope of the revision was identified in the report prepared for the ‘Evidence Based Investment Decision Making for 3 Waters Pipe Network Programme’ a joint initiative between Water New Zealand, IPWEA, University of Canterbury Quake Centre titled “Recommendations for the Revision of the New Zealand Pipe Inspection Manual, December 2016” by ProjectMax. This included consideration of:

- Development of technology
- Increased sophistication of data analysis
- Increased emphasis on asset management as a key driver of service and efficiency
- The creation of other guidelines such as the “Meta-data Standards”
- Benchmarking and desire to align more closely with other international standards and practices
- A desire for more, and better, guidelines

This edition observes a change in title of the manual with the addition of ‘Gravity’ to differentiate this manual from pressure pipelines which are intended to be covered in separate publications such as “National Asbestos Cement Pressure Pipe Manual, February 2017”.

The 4th edition makes comprehensive changes intended to improve the ability of the industry to scope the works required, undertake inspections to a consistent and high-quality standard and then interpret the outcomes in relation to the maintenance and/or renewal of the asset in accordance with best asset management practices. The manual has been completely revised and substantially extended to align with the industry’s desire to incorporate more guidance and specific requirements. For the first time this edition includes a process for the inspection of manholes, laterals and acceptance of new and lined pipes.

Some of the most significant changes have been made to the classification of pipe and pipe materials.
Special thanks to:
Hugh Blake-Manson and David Beckwith (Citycare Water)
Husham Al-Saleem and Frank O’Callaghan for specific technical contributions to Section E3 Assessment of New and Lined Pipe, Marc Ciochetto for sections B1.1 Preparation of Drains and Sewers for Inspection and Irmana Garcia Sampedro (Christchurch City Council) Oliver Modricker, Mark Thomson, Bahram Yari (ProjectMax) for feedback and contributions throughout the manual.
Greg Preston (University of Canterbury, Quake Centre) and EQC for coordination and funding of the research to determine the scope of the revision.

Contributions were also made by the following individuals and organisations in preparing and developing the manual: Americo Dos Santos (Hynds Pipe Systems), Andrew Ruffles (CPAA), Auckland Council Healthy Waters and Tauranga City Council for Section E3 Assessment of New and Lined Pipe. Christchurch City Council for Masonry Pipe defects Section B2.3 Condition Classification Codes
E3.2.4 Reinforced Concrete Pipe Evaluation and Acceptance Criteria – Post Installation

Table E3.1 – Assessment of Cracks in New Reinforced Concrete Pipe Post Installation

<table>
<thead>
<tr>
<th>Defect</th>
<th>Description</th>
<th>More Conditions</th>
<th>Acceptable</th>
<th>Engineering Assessment</th>
<th>Repair or Replace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal Crack&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Less than 300mm long</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Autogenously healed</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 0.15mm width</td>
<td>Full pipe section (joint to joint)</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.15mm-0.5mm</td>
<td>Full pipe section (joint to joint)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full pipe section &amp; observed in more than one quadrant&lt;sup&gt;1&lt;/sup&gt;</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5mm-1.0mm</td>
<td>Full pipe section (joint to joint)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Full pipe section &amp; observed in more than one quadrants</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>In an aggressive environment</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 1.0mm</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circumferential Cracks&lt;sup&gt;2,3&lt;/sup&gt;</td>
<td>Autogenously healed</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 0.15mm width</td>
<td>Extending full pipe circumference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.15mm-0.5mm</td>
<td>Extending full pipe circumference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple circumferential cracks extended full pipe circumference and space less than D/2</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5mm-1.0mm</td>
<td>Extended full pipe circumference</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple circumferential cracks extended full pipe circumference and spaced less than D/2</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>In an aggressive environment or where fine material has been used in the bedding and backfill</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 1.0mm</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
While cracking of rigid pipes is relatively easy to observe with CCTV the deformation of flexible pipes is not. The CCTV will not show obvious signs of deformation when deformation is at or close to the short-term allowable limits.
Deflection Testing of Flexible Pipe
Selecting Materials for Bedding

Selecting Materials for Bedding
Steel Reinforced
Concrete Pipe

Concrete Pipe Association of Australasia
Acid Sulphate Soils
Wrap up

1. Introduction
2. ‘This is how you design it.’
   1. Design of Rigid Pipe (SRCP)
   2. Design of Flexible Pipe (Plastic)
3. ‘This is how you test it.’
   1. Testing of SRCP
   2. Testing of Flexible Pipe
4. PipeClass - Tutorial
5. Publications
   • Field Testing of Concrete Pipe - CPAA
   • Manhole Document – CPAA
   • NZ Pipeline Inspection manual – Project Max
   • Deflection Testing - CPAA
   • Acid Sulphate Soils - CPAA
   • Selecting Material for Bedding - CPAA
6. Wrap up and Q&A
Q&A
For more information:

http://www.cpaa.asn.au/
Concrete Pipe Association of Australasia