Rigid And Flexible Pipe Design, Installation And Lifetime Cost

Tony Gordon
Technical Principal - Three Waters

Water NZ Conference 2018

Introduction

- Pipes are too often ‘buried’ rather than ‘installed’
- Pipes are typically identified as either ‘rigid’ or ‘flexible’
- There is no fundamental reason to exclude either pipe type from consideration
- The design and construction requirements for both differ
  - These differences have an impact on installation and lifetime costs
  - These differences need to be understood and considered to provide a best-value installation

Contents

- Some Basics
- Pipe Support
- Construction
- Construction Monitoring
- Asset Life
- Cost Implications
- Summary
- Questions

Some Basics

- What is a rigid pipe and what is a flexible pipe
- Basis of design
- Different behaviour under load
- Some terminology

What is a rigid pipe and what is a flexible pipe

- The definition depends upon the pipe’s response to external loading and its interaction with the surrounding soils

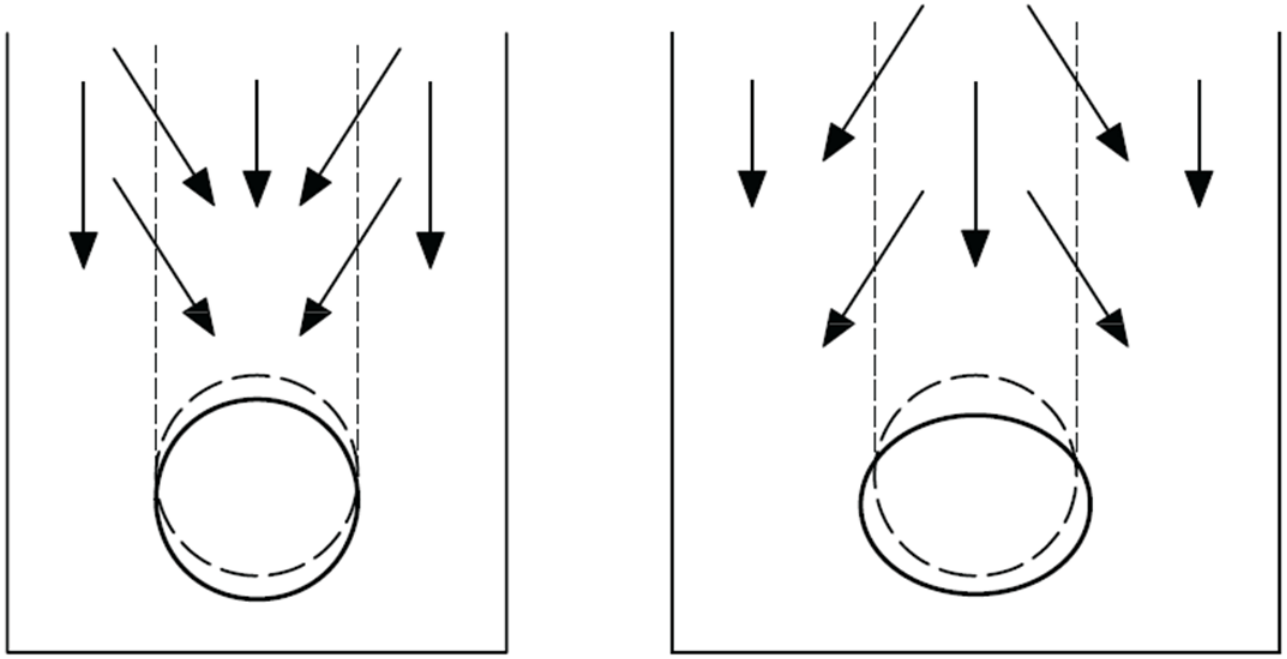
The Basis for Design

- The basis for design is the interactive system consisting of the pipe and the surrounding soil

Different Behaviour Under Load

(From BS 9295)

Figure 2 **Rigid and flexible pipe behaviour**



a) Rigid

b) Flexible

NOTE Displacement and deflection exaggerated for illustrative purposes.

Fill and Support Terms

(From AS/NZS 3725)

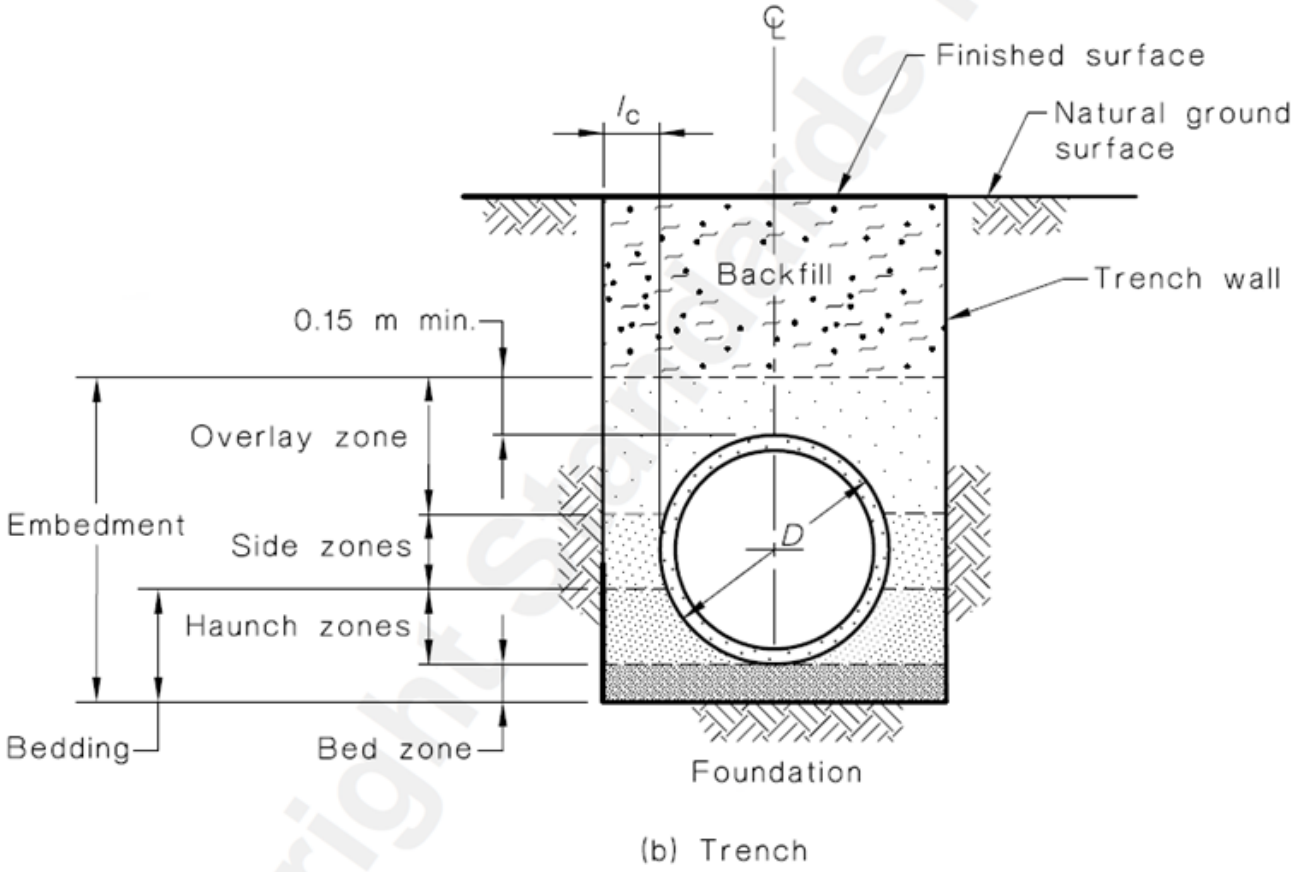


FIGURE 1 FILL AND PIPE SUPPORT TERMS

Pipe Support:

- Bedding requirements similar
- Differ in the ‘support zones’
  - Haunch and side zones for rigid pipes
  - Embedment zone for flexible pipes
  - Volumes of these zones differ
- For a given depth and pipe size the designer has control over pipe strength (class) and quality of pipe support or both
  - Pipe support influenced by the material used, its level of compaction, and its width
  - Sometimes a wider trench is required. Embedment volumes increase more than haunch volumes

Construction

- All materials need to be of a suitable quality (see the Standards)
- Compaction to the standard assumed in the design is vital
- In-situ materials may not meet the requirements
- Imported material may be required

- Watch for excessive construction loads

Construction Monitoring

- Compaction achieved needs to be monitored
- Post-construction testing should be carried out on all pipes
  - Air test
  - Hydrostatic test
  - CCTV
  - Ovality
    - Important test for flexible pipes
    - Deflection is a major design criteria
- Purpose of these is to test the integrity of the pipeline and its joints

Asset Life

Concrete pipe

- Expected to have a service life of 100 years

Plastic pipe

- Design life of 50 years
- If not continuously subject to its design load, service life will exceed 50 years

Asset Life (cont.)

- If loading on pipe increases over that assumed in design, or the installation is faulty
  - Concrete pipes crack
  - Plastic pipes deform and may buckle
- Remedial action
  - Concrete can be reinforced
  - Only practical action to counter significant deflection is removal and replacement
- Whole of life costs should always be considered during the design phase

Cost Implications

Volumes

Standard and Pipe Type	DN	OD	Minimum Trench Width	Bed & Haunch Volume	Overlay Volume	Embedment Volume
	mm	m	m	m^3/m	m^3/m	m^3/m
AS/NZS 2566						
PVC/PE /GRP	300	0.30	0.60			0.26
	600	0.60	1.20			0.74
	900	0.90	1.50			**1.09**
	1800	1.80	2.70			3.53
AS/NZS 3725						
RCRRJ	300	0.37	0.67	0.11	0.19	
	600	0.70	1.10	0.24	0.42	
	900	1.04	1.44	**0.38**	**0.63**	
	1800	2.01	2.67	1.21	1.79	

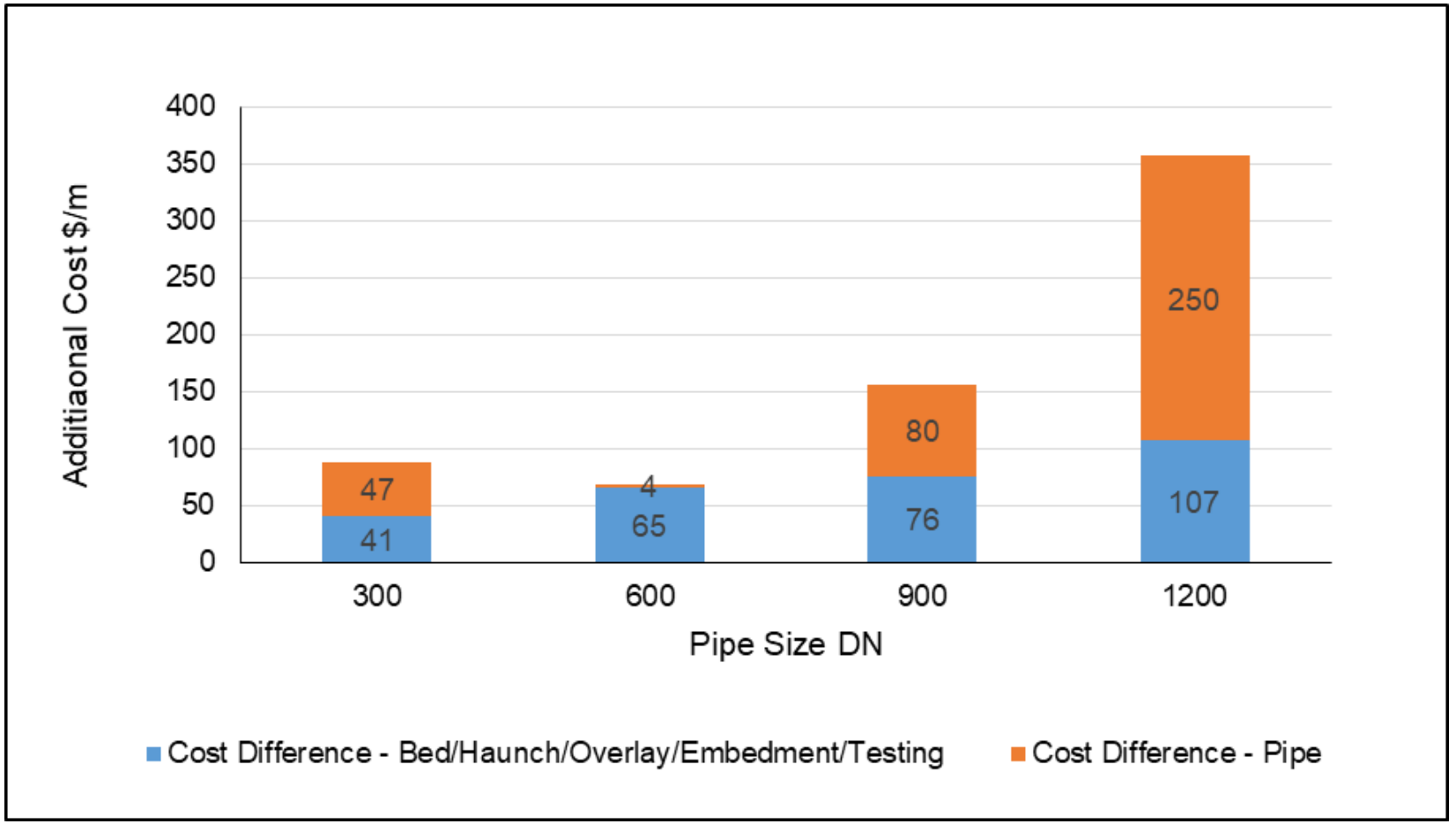
Cost Implications - Example

DN900 Comparison

Item	Unit	Concrete	GRP	Difference
Pipe material cost	$/m	390	470	80
Bed and haunch volume	m^3	0.38	-	
Bed and haunch cost (imported material)	$/m	0.38*$104=39	-	
Overlay volume	m^3	0.63	-	
Overlay cost (re-used excavated material)	$/m	0.63*$52=33	-	
Embedment volume	m^3	-	1.09	
Embedment cost (imported material)	$/m	-	1.09*$104=113	
Ovality testing	$/m	-	35	
Total cost	$/m	462	618	156

Cost Implications - Example

Makeup of Additional Cost of GRP over Concrete Pipe Installations



Summary

- Rigid and flexible pipes differ
  - In their material properties
  - How they behave in the ground
- These differences influence
  - Design
  - Installation
    - Support
    - Testing requirements
- If not considered these differences will impact the asset life and the whole of life cost of the installation

Questions