TECHNICAL BRIEF

Deflection of Flexible Plastic Pipes

Concrete Pipe Association of Australasia

Introduction

The reality of using flexible plastic pipe is that a combination of high quality soil material along with proper compaction, is required for the system to function structurally. Since flexible pipe is so dependant on correct installation techniques, it has become more and more important that deflection testing becomes mandatory, and that tests be performed more than 30 days after the completion of the installation.

Why do flexible pipes deflect.

FACT: Steel reinforced concrete pipe is rigid and the inherent structural strength of the pipe carries both imposed earth and traffic loads.

FACT: Flexible plastic pipe is exactly that – FLEXIBLE! It relies on the composite action of the soil/pipe structure for it's structural integrity.

Deflection Testing

When a flexible plastic pipe is installed it will deflect! This deflection will continue to increase as the pipe loses stiffness with time or as a result of the consolidation of the fill material!

Installed plastic pipe, relying predominately on the interaction between the soil backfill and the pipe stiffness for the structural integrity, is assessed primarily by the extent of the deflection once it is installed.

AS/NZS 2566.2 specifies the deflection limits for each material type within a given time frame. It also details the process for deflection testing, which cannot be compromised if the design life of the pipeline is to be achieved. If the pipe deflection exceeds the specified limits the pipe has failed!

AS2566.2, Section 5.7

"Deflection Criteria"

At present this section of the Standard does not cover structural and hydraulic adequacy in enough detail to allow specifiers to set appropriate criteria for flexible pipe. There should be provision for the testing of structural and hydraulic adequacy, which is dependant on deflection.

Structural Adequacy: The deflection measurement is the key issue in terms of validating the adequacy of installation. The structural adequacy of the installation in the long term is dependent on the deflection not exceeding the specified values.

The Standard currently only requires that this deflection be measured as it were in the short term. The standard should specify a second measurement of deflection after a longer term when the installation has had a period of seasonal moisture change and that some consolidation of the soil support has taken place. For example; this period, nominally 12 months, could be aligned with the hand over of asset from constructing contractor / developer to local authority. Then this second deflection measurement can be monitored against the allowable deflections in clause 6.5.1

Hydraulic Adequacy: An adequate installation means one that is capable of sustaining the required hydraulic capacity. Deflection will have immediate effect on this as the capacity is directly related to the hydraulic radius (D/4)

AS2566.2, Appendix O

"Diametral Deflection Measurement"

At the time of issue of the Standard it was acknowledged that the use of a proving tool/mandrel was the most common method of testing a line for "deflection compliance" Whether flexible plastic pipelines, unless third or second party inspected, are ever checked, and whether the proving tool is compliant, is an area requiring clarification.

Recently the use of CCTV surveys to inspect adequacy of installation of non-man-entry stormwater pipelines has become common practice. This technology allows for the measurement of the deflection of pipelines using laser profiling in conjunction with CCTV surveying. Output of results in DVD, VCR and hard copy are provided at the requisite level of accuracy.

There is no reason to delete the existing proving ring methodology in principle but there must be scope to add an alternative method to measure the deflection and document it with the routine qualitative report.

Review of this whole issue raises questions as to the origin and calibration of proving tools and to the calibration and calibration checks of the apparatus by registered third parties.

Facts about CCTV

CCTV Equipment

Laser video imaging is an extremely accurate technology for determining not only the degree of deflection of flexible plastic pipe installations, but also the most probable cause of structural deficiencies. The light ring of the apparatus is projected a set distance away from the camera so that the entire ring is in view by the inspection camera. Deflection is measured by using a computer and software. Where deflection is evident, the image is captured and software is used to measure the deflection occurring at the point of the projected laser ring.

The inspector sets the required intervals for the deflection measurements to be taken. If higher deflections are observed between the set intervals, then additional measurements are taken at these locations. Deflection measurements are taken in the vertical and the horizontal positions unless other deflection is noted by the video inspection. Some systems allow for continuous monitoring for deflection in which a preset deflection value such as 5% can be entered into the program.

The laser ring shows areas of significant plastic pipe distortion such as crown flattening and vertical and horizontal deflection that may or may not be observed or captured by video inspection alone. The technology can also pick up vertical and horizontal joint offsets and cracking.

Case Study

Detailed video inspections were performed on randomly selected flexible pipelines at various sites in Victoria and South Australia. The inspections were conducted in three phases.

In phase one a detailed video inspection of the pipeline was conducted utilising a CCTV inspection camera with high intensity lighting.

Phase two involved the use of a laser profiling attachment to the camera. The laser profiler operates in darkness to enhance the visibility of a projected laser ring inside the pipeline. The laser ring significantly shows areas of pipe distortion such as cracking, crown flattening, vertical and horizontal deflection that may not be observed or captured by video inspection alone.

Phase three was a detailed evaluation of the laser profiling data and the production of a comprehensive report.

One test involved a 1200mm diameter HDPE flexible pipe drainage system installed underneath a main suburban road. The pipeline, constructed in early 2005, was tested in November 2005. The camera progressed for 148 metres through the pipeline before the test was abandoned due to excess debris. Table 1 list the results that were determined after evaluation of the laser profiling data.

It was found that the pipeline had deflected at 5% or greater of the original diameter at an average of every 9 metres – less than 12 months after it was installed! How will this pipeline perform structurally and hydraulically in the long term? That is something for the consultants to determine, but using CCTV laser profiling has at least alerted the asset owners to the problem well before a catastrophe occurs!

STOP PRESS

This pipeline has since failed catastrophically! It is thought that infiltration of soil through the pipe is the likely cause of the failure. The structural strength of the backfill is critical to the pipes integrity.

Distance (metres)	Condition
34	5% height/diameter loss
35	10% height/diameter loss
39	5% height/diameter loss
46	10% height/diameter loss
52	10% height/diameter loss
67	25% height/diameter loss
79	10% height/diameter loss
80	10% height/diameter loss
	Infiltration recorded
90.3	Lining separated
	Infiltration recorded
96	10% height/diameter loss
109	5% height/diameter loss
114	5% height/diameter loss
120	Infiltration recorded
126	5% height/diameter loss
131	10% height/diameter loss
144	5% height/diameter loss
148	10% height/diameter loss
	Infiltration recorded

The resulting hole

Comment

The American Concrete Pipe Association reports that the trend towards improved deflection testing specifications has begun in the USA. As a result, a number of governing authorities have altered their specification for testing, specifying a maximum deflection limit of 5%. These include:

- **Florida Department of Transportation (DOT)** asks to provide the engineer a video DVD and report using video equipment with laser profile technology for inspecting pipe. Pipe that indicates deflection that appears to be in excess of that allowed by Specification, the Engineer may require further testing of the pipe. Remove, replace and retest pipe failing to meet the specific deflection requirements for the type of pipe installed, at no cost to the Department.
- **Kentucky DOT** reduces contractor payment for pipe by up to 50% where incorrect installation causes the pipe to deflect beyond 5% deflection limit.
- **North Carolina DOT** requires inspection after approximately 600 mm of backfill is in place, at 30 to 45 days, and at 11 months after completion of the project. Maximum deflection must not exceed 5% of the nominal diameter. Failure to pass the deflection test will result in the pipe being removed and replaced with new pipe at no expense to the owner within 30 days.
- Illinois DOT requires testing after 30 days and that any pipe over 5% deflection (not meeting the specification requirements), be replaced.

REFERENCES

1. Concrete Pipe News, American Concrete Pipe Association, Winter 2006 pp 4-5
2. "You Should Know" Bulletin 129 – "Taking Responsibility", American Concrete Pipe Association
3. You Should Know" Bulletin 136 – "Trend Toward Deflection Testing HDPE Pipe Installation", American Concrete Pipe Association
4. AS/NZS 2566.2:2002 "Buried flexible pipelines" Part 2: Installation