Advanced Condition Assessment & Pipe Failure Prediction Project

Optimal management of water infrastructure

Fact Sheet No. 2, December 2012
Progress on Activity 1

In August 2011 international water research organisations, Australian water utilities and three Australian universities came together through a collaborative research agreement, and committed overall funding of $16 million (including $4 million cash) over five years to find ways of finding a solution to the problem of failure in critical pipes.

The partners in this research project include Sydney Water Corporation, Water Research Foundation of the USA, UK Water Industry Research Ltd, Water Corporation (WA), City West Water, Melbourne Water, South Australia Water Corporation, South East Water Ltd and Hunter Water Corporation.

Monash University leads the research supported by University of Technology Sydney and the University of Newcastle. Other collaborators include Water Environment Research Foundation and Dr Balvant Rajani of Rajani Consultants Inc.

Round 1 of the project covers three activities initially:

Activity 1 How, when and where will pipes fail within the entire network?

Activity 2 How do we assess the condition of the pipe cost effectively?

Activity 3 How do we calculate pipe deterioration rates accurately with respect to the pipe environment?

Further Activities planned for Round 2 include:

Activity 4 What is the time-dependent probability of failure along the pipeline?

Activity 5 How do we transfer the new knowledge to the industry for optimal pipe management?

All five activities are due for completion by 2016.

Activity 1 How, when and where will pipes fail within the entire network?

The aim of the Activity is to establish improved methodologies to predict remaining physical life of critical pipes taking into account the effect of external/internal factors, different material types and critical locations and factors within the network.

This activity will draw from Activities 2 and 3 to establish the failure state and to determine the remaining physical life of pipes.

Associate Professor Jayantha Kodikara of Monash University is leading this Activity.

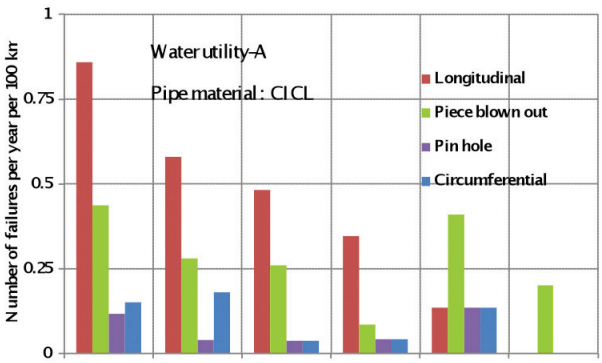

Figure 1: Some typical data representing identified failure modes for large diameter pipes. Dominant failure modes have been identified as longitudinal fracture, piece blown out and pinhole failure. For steel pipes, the pinhole failure was common.

Industry Partners

SA Water · Sydney Water · City West Water · Melbourne Water · South East Water · Water Corporation · Hunter Water

The expected outcomes of Activity 1 include:

- Databases for material properties, external (traffic and soil loads) and internal factors (static pressure and transients) on the basis of data collection and measurement.
- Improved methods of prediction of pipe stress and failure for cast iron and steel pipes.
- Detailed methods for pipe remaining life calculation taking into account external/ internal factors and for pipe deterioration (from Activity 3).
- Identification of critical factors and locations along the pipeline causing failure.
- Concept development for the use of optical fibres for smart pipe monitoring.

Progress to date includes:

- Past pipe failure data from partners and observed failure modes and corrosion patterns were compiled. In addition, a large amount of literature was collected and reviewed. An online database was developed and was shared with the partners.
- Two reports were produced: (1) Critical review of historical information on large diameter pipe failures (mostly on the basis of partner data collected); (2) Concepts for monitoring of new critical water pipelines using optical fibres. (See Fig 1. and Fig. 2)
- Material testing is in progress on failed and corroded pipe samples received from local partners. These include stress-strain behaviour and tensile failure of coupons, ring tests and joint tests.
- Patterns of corrosion were categorised (see Figure 3) and development of detailed models for their analysis have begun using a bottom up approach. Detailed three dimensional finite element analyses were undertaken and simplified models are developed for field application.
- Measurements of pressure transient development is being undertaken in the Hunter Water network (NSW, Australia and numerical hydraulic calibration modelling is underway.
- Detailed plans have been developed for strain gauging and measurement of pipe and soil strains due to traffic and soil ground movement in the Sydney Water pipe test bed.

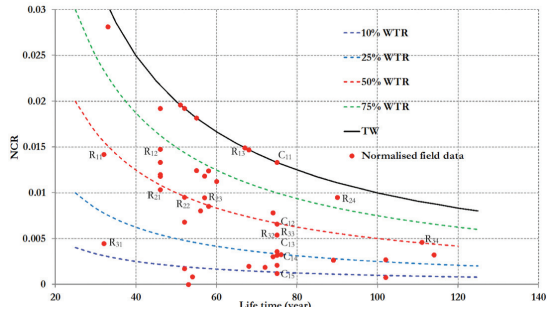

Figure 2: Pipe failure data from Utility- A forensic investigations shown as normalised average corrosion rate (NCR) against pipe life at failure. Normalised average corrosion rate is calculated by dividing the measured maximum corrosion by design pipe thickness. Note that this measure of corrosion rate is an average or secant value and is not representative of the actual corrosion rate the pipe experienced with time, which is variable (Information from Activity 3). Solid line (TW) is for through wall corrosion and other dashed lines represent different levels of corrosion (i.e.,10% WTR means only corrosion has progressed to 90% of the design thickness). Specific failure data falling on these lines indicate that failure has occurred with that level of maximum corrosion. It has been identified that other factors like pressure transients may have contributed significantly to failure when failure has taken place with less corrosion.

Fig. 3A

Fig. 3B

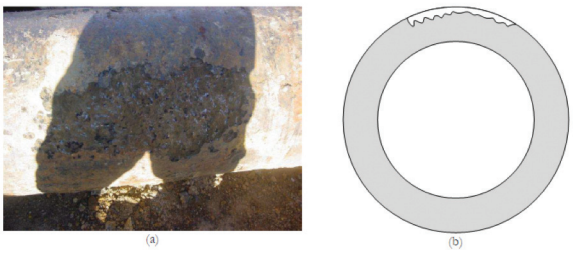

Fig. 3C

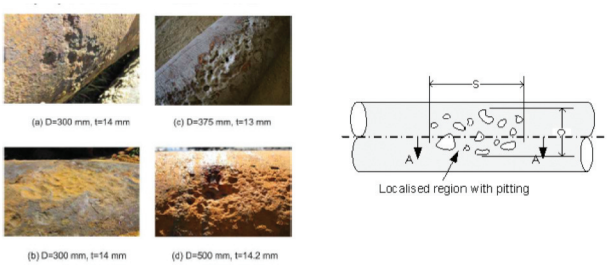

Figure 3: Three categories of corrosion patterns identified.
(A) General corrosion is when the corrosion has progress all over the pipe reducing its design thickness; (B) Patch corrosion is when a patch of pipe is corroded due to graphitisation or geometrically interacting clusters of pits; (C) Pit corrosion is either single pit or a cluster of physically interacting pits.

Research Partners

MONASH University

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

UNIVERSITY OF TECHNOLOGY SYDNEY

International Partners

Water Research Foundation

UK WATER INDUSTRY RESEARCH LIMITED UKWIR