Advanced Condition Assessment & Pipe Failure Prediction Project

Optimal management of water infrastructure

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Innovation and development in critical pipe failure

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Overview

The Advanced Condition Assessment & Pipe Failure Prediction (ACAPFP) Project is a vibrant collaboration of researchers and water utilities from around the globe dedicated to solving a major problem - failures in ageing critical pipelines which deliver fresh water to towns and cities of the world. Failures in "critical pipes", those with diameters typically greater than 300 mm, present a major challenge to cost effective management of water pipe assets.

To support this major initiative, members of the world's water industry committed some $13.4 million in cash and in-kind to the project for five years, commencing in July 2011.

The partners in this research project include Sydney Water Corporation, UK Water Industry Research Ltd., Water Research Foundation of the USA, Water Corporation (WA), City West Water, Melbourne Water, Yarra Valley Water, South Australia Water Corporation, Queensland Urban Utilities, South East Water Ltd, and Hunter Water Corporation. On the research side, Monash University leads the project, supported by University of Technology Sydney and the University of Newcastle.

What the project will achieve

This project will deliver the ability to improve the prediction of failure of cement lined cast iron water mains, taking into consideration existing and new failure rate data for existing pipe networks, modern interpretation of different pipe wall condition assessment technologies, the prediction of pipe corrosion based on physical-chemical models and the prediction of probabilities of failure based on analytical models of pipe mechanical responses.

Value to the water industry

Benefits for the water industry from the failure prediction models include:

- Improved targeting of high risk critical pipe renewals contributing to savings in investment – achieving up to 20% saving on current investment levels is feasible
- Improved preventitive maintenance strategies providing better targeting of pipes ahead of failure, with resulting less disruption to customers
- Improved potential for failure prevention utilising the concepts developed through project research outcomes
- Improved value to customers and shareholders, and enhanced reputation for water utilities.

Project Activities

Three Activities make up the core of the project:

Activity 1 – How, when and where will critical pipes fail within our network? Monash University is conducting the research for this Activity.

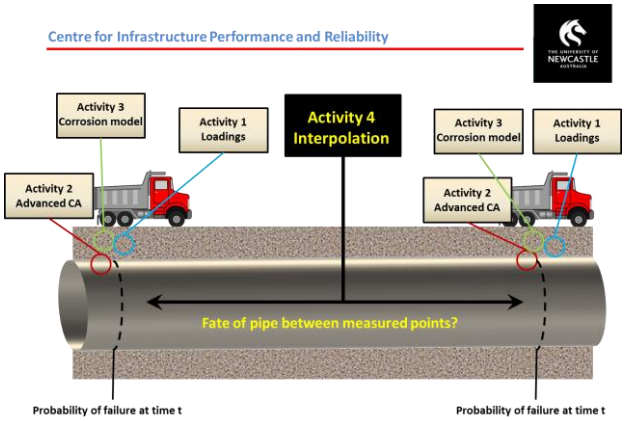
Activity 2 – How do we assess the condition of the pipe cost-effectively? University of Technology Sydney is conducting the research for this Activity.

Activity 3 – How do we estimate current pipe corrosion and deterioration and likely future deterioration accurately with respect to the environment? University of Newcastle is conducting this Activity.

The key outcomes of these activities include the evidence based validation of the research outcomes related failure prediction and corrosion modelling at a given point on a critical pipe, and improved interpretation of condition assessment noting limitations and strengths.

Two more recent activities are in progress. These are:

Activity 4 " Improving confidence in critical pipe failure prediction" - The aim of Activity 4 is to improve current capacities to predict the likelihood of pipe failure for a given length of pipe. Figure 1. iIllustrates how Activity 4 relates to Activities 1 – 3.



Figue 1. Illustration of how Activity 4 will improve prediction of pipe failure by interpolation between measurements at fixed points.

Activity 4 has five components:

4(a) – Enhancing the reliability of condition assessment of buried large diameter water mains (UTS)

4(b) – Reducing the uncertainty of non-destructive, indirect measurement with linear polarisation resistance (LPR) (University of Newcastle and UTS)

4(c) – Predicting the likelihood of pipe corrosion and its severity along the pipe to forecast failure (University of Newcastle)

4(d) – Enhancing the reliability of emerging technologies that have not yet been incorporated into the current research project (UTS)

4(e) – The probability of failure (Monash University).

Activity 5 "Knowledge management" - This Activity focuses on knowledge management and decision support for the water industry partners and involves all three universities.

Update on Activities 1, 2 and 3

Activity 1

The outcome of Activity 1 will be twofold: (1) Improved methods for estimation of pipe remaining life considering available information including condition assessment data; (2) Development of practical concepts for monitoring of new pipelines using optical fibres and other sensors.

Current work includes monitoring of stresses in the Sydney Water test bed, monitoring of pressure transients in water networks, development and validation of pipe failure models using field case studies, field measurements and full scale pipe burst tests, investigation of pipe material properties and failure potential, and development of optical fibre technologies for pipeline monitoring.

Activity 2

Activity 2 will deliver outcomes including; - Improvements to magnetic flux leakage (MFL) and broadband electromagnetics (BEM) sensing technologies, a database providing for the direct evaluation of the effectiveness of various technologies, and guidelines for selecting inspection technologies for a range of common application scenarios based on the relative merits of the technologies evaluated.

Current work includes investigation of simulation models for two additional condition assessment technologies. They are (i) modelling with finite element analysis (FEA) of an acoustic wave propagation technology applied to a fluid filled pipe and (ii) modelling with FEA of a remote field eddy current technology in conjunction with the ground truth to improve sensor localisation. At this stage, detection and verification of pipe construction features such as joints has been developed using machine learning.

Activity 3

This Activity is focussed on development of a model for the long-term exterior corrosion penetration of cast iron (and other ferrous) pipes taking into account the soil wetness properties, chemical properties, factors introduced by the backfilling and other construction operations, as well as the possibility of microbiologically influenced corrosion driven by soil and applied nutrients (such as fertilizers). The work is based on the most recent corrosion research for the progression of corrosion penetration with exposure time. Since traditional data sources do not cover all data requirements the project partners agreed to a novel data collection protocol now being applied by a number of water utilities as part of normal operations.

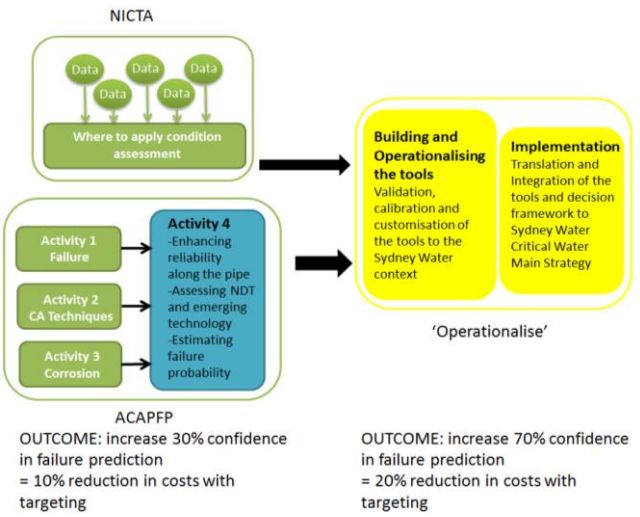
Current work includes application of 3D laser imaging techniques, to characterize the surface state around the circumference of selected pipe sections.

Other projects related to the Advanced Condition Assessment and Pipe Failure Prediction Project projects include the NICTA (now Data61) – Sydney Water research collaboration and the research agreement between Monash University and the Melbourne Water administered Smart Water Fund.

Operationalisation and Implementation of Research essential for the Water Industry

The ACAPFP Project has challenged some of the fundamental beliefs on which existing pipe maintenance regimes are founded and has delivered significant new knowledge. It has provided a better understanding of the failure mechanisms in pipes, how to interpret information from condition assessment (CA) tools more effectively, and the mechanisms governing pipe corrosion. The project outcomes so far have had major implications for critical pipe maintenance, for example, in managing pressure transients in water utilities, in formulating condition assessment contracts, and in data collection protocols for soil condition and forensic analysis. The outcomes are generic in nature and the analysis has been restricted to the 600 mm cast iron in situ lined 1920 test bed pipe at Strathfield within Sydney Water.

Further value for the water industry can be realised by operationalising the research outcomes from both initiatives to a wider cohort of pipes. A case study approach will provide the opportunity for the water industry to tailor and adapt the outcomes for its own business needs. During the operationalising phase these outcomes will be validated as tools.



Summary

The objective of the Advanced Condition Assessment and Pipe Failure Prediction Project is to solve the problem of failures in critical pipelines which deliver water to the towns and cities of the world. The outcome of the project is provide value to the customers of the water industry with a focus on innovative pipe failure predictive capability and to deliver benefits to the shareholders through improved targeting of mains for investigations, condition and risk assessment, thereby providing greater return on investment in pipe renewals.

For further information contact:
Chief Investigator Professor Jayantha Kodikara
jayantha.kodikara@monash.edu
Industry Partners' Representative Dammika Vitanage
dammika.vitanage@sydneywater.com.au
Project Manager Philip Stevens
phil.stevens@monash.edu