Asbestos Cement (AC) water mains deterioration and failure prediction models: An UKWIR and WSAA Collaboration

Need for Project

Across the world, the failure rate of Asbestos Cement (AC) mains is increasing. With around 100,000km of AC mains[1] in Australia and the UK & Ireland, there is real concern that accelerated replacement of these pipes will be necessary in the near term.

In recognition of this issue, UK Water Industry Research (UKWIR) and the Water Services Association of Australia (WSAA) worked collaboratively to help improve the understanding of why such assets fail in order to plan investment appropriately.

Consultants

Specialist consultants from across the world have been engaged to deliver this key project for the water industry. The WSAA project was delivered by WSP, supported by Harmonic Analytics, whist the UKWIR project was delivered by Ovarro Ltd, supported by Atkins and University of Surrey.

Objectives

The key objectives for this collaborative project were to:

- Carry out a review of global research and relevant case studies to determine or identify:
    a) the predominant failure modes of AC pipes;
    b) why and how AC pipe failure occurs; and
    c) factors that affect the rate of deterioration and the risk of failure (e.g. soil conditions, water chemistry).
- Carry out a review of pipe deterioration and failure data from both the UK and Australia, looking at failure modes and break rates.
- Develop predictive models for estimating AC pipeline failure.

Whilst both projects considered the deterioration of the pipe barrel, the UKWIR project also included joint deterioration. The WSAA project is Stage 1 of a 4-stage modular programme with future planned work including evaluation and field trials of condition assessment technologies, verification of the models produced and also evaluating rehabilitation options and developing decision support tools.

Key factors affecting rate of failure

The key factors affecting the rate of AC mains failure are:

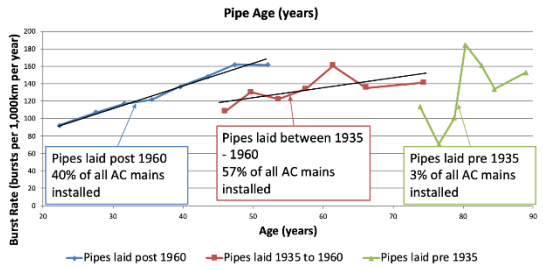
- **Age** – the longer a pipe is exposed to any of these factors then the greater the risk of failure.
- **Diameter** – smaller pipes are more susceptible to failure.
- **Failure History** – if a pipe has failed previously it is more likely to fail again.
- **Pressure** – the higher the pressure (static or transient) the greater the risk of failure.
- **Soil** – pipes installed in free draining soils are less susceptible to failure. Pipes in reactive clays are more susceptible.
- **Manufacturing Standard** – pipes manufactured between 1960 and 1978 are less susceptible to failure,

[1] Almost 60,000 in the UK & Ireland, 60% of which have been in service for over 50 years and approximately 40,0000 in Australia.

all other things being equal (see figure 1).

- **Land Cover** – pipes in the road are more susceptible to failure than pipes in the verge.

Figure 1: Deterioration of pipe cohorts (UKWIR)



Other factors contributing factors identified include: **property density, rainfall, frost, soil pH, ground movement, and the aggressivity and hardness of the conveyed water**.

Pipe class is also considered to be a significant contributing factor because it influences pipe wall thickness, although this was not borne out from the statistical analysis due to the limited data available.

Both projects were able to confirm the relative significance of each causal factor considered as part of their project. The two projects used different data sets and data was not always available to both projects for each factor considered in the models. However, by exchanging data, both projects were able confirm model trends by running the other project's data through their model (see figure 2).

Background to key learning

Asbestos Cement is an inorganic composite material consisting of inert asbestos fibres embedded in a cement matrix. Over time the cement binder undergoes physical and chemical changes which reduce the strength of the pipe wall. This lessens the ability of the pipe to withstand loads and increases the likelihood of failure. The thicker the pipe wall the more deterioration the pipe can withstand.

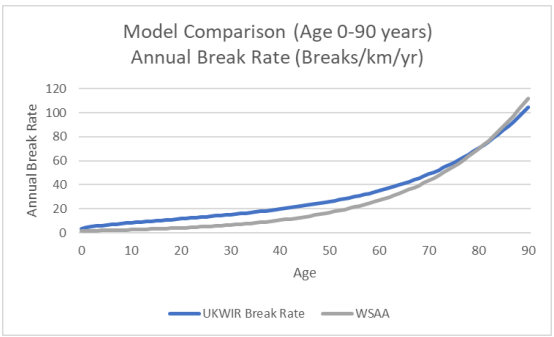
Model Development

The WSAA project used data obtained from eleven Australian water companies. This data represents 278,527 pipes, 94,887 repair events and 13,670 replacement events. Two exponential models were developed:

- average number of breaks – to forecast future levels of service and repair budgets at a network level.
- probability of failure – to identify cohorts of pipes that are vulnerable to failure

The UKWIR models were developed using data from the UKWIR National Failures Database, which provided records of over 600,000 AC pipes laid across the UK, and over 60,000 associated burst records. In addition, over 2 million water sample results were provided by companies, giving nationwide coverage of conveyed water chemistry parameters. Third party data sets were assembled covering weather, land cover and soil information for the whole of the UK. Three individual company datasets were also analysed, where these could provide additional information not available nationally (e.g. pressure data).

Figure 2: Comparison of UKWIR and WSAA data (WSAA)



Benefits

The principal benefits of the projects have been:

- Greater understanding of deterioration rates of AC mains under various mechanisms.
- Enhancing the knowledge of the deterioration of AC pipelines to aid the current AC renewal and maintenance programs, and target condition assessment effectively.
- Demonstrating global collaborative work on an important topic for the water industry.
- Providing models that allow asset owners and other stakeholders to predict and understand future renewals needs of AC pipeline systems.

Next Steps

The recommendations include:

a) evaluation and field trials of condition assessment technologies;

b) verification of the models produced; and

c) evaluating rehabilitation options and developing decision support tools. Data acquired in the course of this future work should also provide improved data on pipe pressure class.

Project Reports

The WSAA reports are available to contributing water companies and will be available to all WSAA members after a 3-year period. UKWIR has access to the WSAA report for its members.

The UKWIR report is available to UKWIR members and contributing WSAA members.

Project Team

In Australia, the WSAA Programme Lead is John Garton (South East Water), with Project Management provided by James Gardner (WSAA). The Australian contractor, WSP Australia Pty Limited, has Matthew Stahl as Project Director with Philip McFarlane as the Technical Project Lead.

In the UK, the UKWIR Industry Lead is David Main (Scottish Water), with Project Management by Rebecca Haylock. The UK contractor, Ovarro Ltd, has George Heywood as Project Director with Luke Hart as Project Manager.