Overview

As the U.S. water system deteriorates, utilities are becoming concerned about the U.S. Environmental Protection Agency’s (EPA) estimate of $334.8 billion to support U.S. drinking water infrastructure through 2027 (EPA 2013). Given the enormity of the costs and service disruptions required to replace water main networks, water utilities must select renewal technologies appropriately, work closely with other city departments in planning and executing renewal projects, and minimize the technical and social costs of pipe renewal.

- Renewal encompasses the actions of repair, rehabilitation, and replacement (Grigg 2004):
  - Repair: To restore functionality of existing pipes after damage or breakage.
  - Rehabilitation: To restore or upgrade existing pipes to an original or improved condition through extensive work.
  - Replacement: To provide a substitute for a distribution pipe or pipe segment.

All water utilities repair broken pipes or leaks, though some utilities are more aggressive than others with their programs. Some utilities regularly rehabilitate pipes, while others emphasize replacement without much rehabilitation activity.

Even as methods for repair, rehabilitation, and replacement have advanced over the past decade, many water utilities choose traditional methods (e.g., cement mortar lining) more often than newer techniques (e.g., epoxy...
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lining). The primary reasons for this preference include concern about possible water quality contamination, higher prices, and a greater degree of familiarity with the more traditional methods.

Repair Technologies
New technologies and methods are emerging for locating pipe breaks, using improved and evolving excavation equipment, and applying materials to repair the problem. Repair technologies include installation of a repair sleeve, clamps or patches for spot repairs, and internal joint seals to eliminate leaks in joints for pipes 16 inches or larger (AWWA 2014).

Carbon fiber reinforced polymers (CFRP) are also used to strengthen concrete structures and for internal pipe repairs. Over past several years, WRF has funded several projects on CFRP renewal of prestressed concrete cylinder pipe (PCCP), which have improved the understanding of mechanisms of CFRP in strengthening PCCP and laid a good foundation for the development of an AWWA standard (Zarghamee et al. 2013, Zarghamee and Engindeniz 2014).

Rehabilitation And Replacement Technologies
Pipeline rehabilitation methods have existed for many years. Cleaning and lining are the most common methods of rehabilitation, however a number of other methods are used.

Pipe Cleaning
Pipes must be cleaned because sediments and corrosion products can accumulate in the pipe, and these materials can interfere with certain rehabilitation methods. Flushing is the most common method of cleaning, along with chemical cleaning, air scouring, and high pressure water jetting, among others (Ellison 2002).

Liners
Water utilities can rehabilitate pipes using nonstructural (e.g., cement mortar and epoxy), semistructural (e.g., close fit pipe), or structural (e.g., continuous or segmented pipe) lining (Figure 1). The most common methods are spray-on application of cement mortar or polymer linings, and these methods protect the pipes from internal corrosion and improve system hydraulics and water quality.

Cement-mortar lining (CML) has been in use for almost 100 years. Although it can prevent internal pipe corrosion and extend the lives of water mains for many years, it also provides little extra strength to the pipeline. So, if a pipeline is badly damaged from corrosion and has limited remaining strength, it may not be the best option for CML (AWWA 2014).

An epoxy lining can be used where cement linings have been deteriorated by soft water or on pipes that were used bare (no CML). This method is favorable for small pipes, and its useful life has been estimated at approximately 40 to 60 years (Deb et al. 2006, 2010).

Trenchless Replacement
Pipe replacement through pipe bursting is viewed as having both potential and risk. It is often used for sewer work but can be used for water systems as well. The chief benefit of pipe bursting is the limited need for excavations. However, reconnection of service lines can be very expensive and time-consuming, resulting in additional excavations and costs (Ellison 2001).

Structural Spray-on Lining
Although spray-on technologies can result in greater cost-effectiveness and less disruption to the community, additional research and tests need to be conducted to

![Figure 1. Through-thickness structure of linings (a) factory applied, produced by the by the centrifugal process (b) in-situ applied, produced by the projection process](source: Muster et al. 2011)
determine whether a lining can survive the fracturing of the pipe under pressure (Ellison 2010).

Other Considerations
It is important for water utilities to minimize downtime during pipe repair, rehabilitation, or replacement. To reduce the amount of service disruption for customers, utilities can establish an above ground temporary pipe network. However, even though this temporary network provides water service to customers, it also can generate customer complaints and can be expensive to provide (Rockaway and Ball 2007).

Given that water main breaks can damage roads and interrupt traffic, water utilities should coordinate pipe renewal activities with their local departments of transportation, as this work may require substantial road restoration. Also, a major road paving project can sometimes be the impetus behind water pipe rehabilitation or replacement. Water pipe work might be indicated if the pipe in that area is distressed or otherwise subject to failure so as to decrease the risk of needing to excavate through new pavement for pipe repair. The resulting pavement patches can be a point of annoyance for motorists and nearby residents.

References


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