Breathing New Life into Old Water Pipelines: Renewal Case Studies in the Southeast U.S.

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ABSTRACT

Water utilities across the United States are rapidly realizing that their existing buried infrastructure has a finite useful life. Many are embarking on aggressive pipeline condition assessment and renewal programs. As utility budgets continue to decrease, it is imperative to find the most cost effective methods to preserve and extend the life of existing assets. Prior to initiating the construction phase of a renewal program, utilities must analyze their existing water distribution systems, develop long term strategies, and reach consensus on appropriate renewal methods and materials.

A first step in any water pipeline renewal program is to develop a realistic set of goals and objectives. Several factors can influence the program objectives such as, main break/leak frequency, existing system materials, poor flow capacities, chronic discolored water, etc. These issues, as well as many other factors will likely be considered as the goals and objectives are developed.

A thorough review of the original installation records will help determine the system composition. Classification of pipe types, pipe sizes, and determining installation dates are among the more important tasks associated with this step of program development. A review of pipe performance history is equally important. By correlating break and leak historical information with infrastructure composition and installation dates, trends in pipeline performance will likely become evident. These activities will lead to prioritizing where the overall renewal program needs to focus.

This presentation includes an overview of the application of following potable water pipeline renewal processes:

- 1,800 linear feet of 8-inch diameter cured-in-place-pipe (CIPP) on cast iron pipe (CIP)
- 44 linear feet of 24-inch diameter carbon fiber internal point repair on ductile iron pipe (DIP)
- Large diameter elastomeric internal joint seals on 84-inch prestressed concrete cylinder pipe (PCCP)

INTRODUCTION

All water conveying pipelines have a finite useful life, regardless of the material from which they are constructed. The conditions to which a particular pipe is subjected may determine whether its useful life spans several hundred years or only several decades. Many factors contribute to the degradation of these conduits. For example:

- unlined uncoated metallic pipelines are subject to both internal and external corrosion
- corrosion may develop on the metallic components of concrete water mains may if they are not properly protected
- internally lined metallic mains are generally protected from internal corrosion, but may experience external corrosion if they are not protected from a corrosive backfill material
- plastic pipe materials, though usually not affected by corrosive environments, may become brittle and split as they age
- the layers of an asbestos cement conduit may delaminate over time

Knowing this, utilities have begun to more seriously investigate methods and technologies by which they can renew their existing buried infrastructure in a cost effective manner.

In an effort to appease a customer base that has grown increasingly intolerant of construction activities, utilities are now focusing much of their attention toward trenchless pipeline renewal methods in lieu of the more traditional open-cut methods. Often these trenchless technologies allow a utility to increase productivity, decrease renewal costs, and reduce the impact of construction on the surrounding areas. Further advantages can often be realized by reusing the existing conduit to the maximum extent possible. Renewal solutions that make use of the existing conduit run the gambit from non-structural spray applied linings to a fully structural replacement within the host pipe.

This paper will review pipeline renewal program development and highlight three recent construction projects, each involving a different trenchless solution:

- 1,800 linear feet of 8-inch diameter CIPP installed in an existing 8-inch diameter cast iron water main
- 44 linear feet of 24-inch diameter ductile iron main repaired using a carbon fiber textile
- an internal joint seal installed to repair a circumferential break in an 84-inch diameter PCCP.

CURED IN PLACE PIPE

Introduction

In an effort to develop a better understanding of structural water main rehabilitation technologies, Charleston Water System (CWS), in Charleston, SC contracted with Water and Sewer Innovative Resources (WASIR) to install approximately 1,819 linear feet of 8-inch diameter Sanexen Aqua-Pipe®.

WASIR is a professional services organization that provides technical and cost effective solutions in the drinking water and clean water industry for public and private clients. Aqua-Pipe® is a cured in place pipe (CIPP) material developed by Sanexen Environmental Services, Inc. specifically for the structural rehabilitation of water mains.

The CIPP liner is approved for use in potable water applications. The liner is a composite material consisting of two layers of woven fabric and a polymeric internal membrane. The zone between the woven material layers is flooded with epoxy resin as the liner is being pulled into the host pipe. The epoxy resin is cured using hot water.

The pilot project was conducted in the former Charleston Navy Base in North Charleston. The location was fairly isolated which reduced many of the typical pedestrian and vehicular traffic concerns. The length of pipe that was lined was composed of both cast iron pipe and ductile iron pipe. Most of the cast iron main had been lined in situ with cement mortar, but there was some footage that was unlined and heavily tuberculated. There were no active services on the pipeline; therefore no temporary water main was required.

The pipe was isolated from the adjacent distribution system and divided into eleven individual sections. The pipe was cleaned in advance of the lining crew's mobilization. The method used to clean the 8-inch water main involved a combination chain rotor and high pressure jet nozzle. The cleaning head, actually designed for sewer cleaning, consists of a spinner nozzle at the end of a high pressure hose. The spinner head has several short lengths of chain attached that are designed to cut away debris from the pipe wall. The advancement and spinning action of the nozzle are a result of the high pressure water spray. The lengths of the chains attached to the head are set so the cleaning or cutting of any debris takes place at the inner pipe wall. The high pressure spray then carries any cuttings to the access point in the pipe. There was some apparent damage to the corporation stops or the pipe wall as a result of the cleaning. The lining crew mobilized and began work on Monday, October 26, 2009 and lined the last section of pipe on Wednesday, November 4, 2009.

Installation Process

Installation of the lining is a pull-in process rather than an inversion process. That is, the tube is pulled through the pipe with a winch rather than being inverted with a column of water. The tube consists of two distinct layers of woven fabric, one inside the other. An ambient cure epoxy resin is injected between the fabric layers and evenly distributed by a pair of rollers, *Figure 1*. The inner most layer is coated with a water proof polymeric membrane to prevent the uncured epoxy from flowing through the inner fabric layer.

Once the tube is pulled through the host pipe the inner liner only is stretched at 3,000-lbs to insure there is no excess material inside the pipe that could cause undue wrinkling. At this stage the pig, or swab, launching and receiving “cannons” are attached to the free ends of the liner. The foam pigs, which are double the diameter of the host pipe, are launched using water. As these foam pigs traverse the tube the Aqua-Pipe® liner is pressed against the inside wall of the host pipeline, *Figure 2*. The epoxy resin is forced into the fabric layers fully saturating both.

With the pipe now fully expanded ambient temperature water is circulated through the tube for 15-minutes. Hot water, 150-160°F is introduced and circulated through the tube for approximately 2-hours to accelerate the cure. A 12-hour cool-down period follows the 2-hour “cook” time. During this stage of the process the pressure inside the tube is maintained at 25-psi.

The following morning the fully cured liner can be trimmed flush with the ends of the host pipe and the final product closed circuit television (CCTV) inspected. The liner is then subjected to a hydrostatic test for 1-hour at 125-psi. Following a successful pressure test, service laterals can be reinstated robotically, the line disinfected, and the line reinstated.

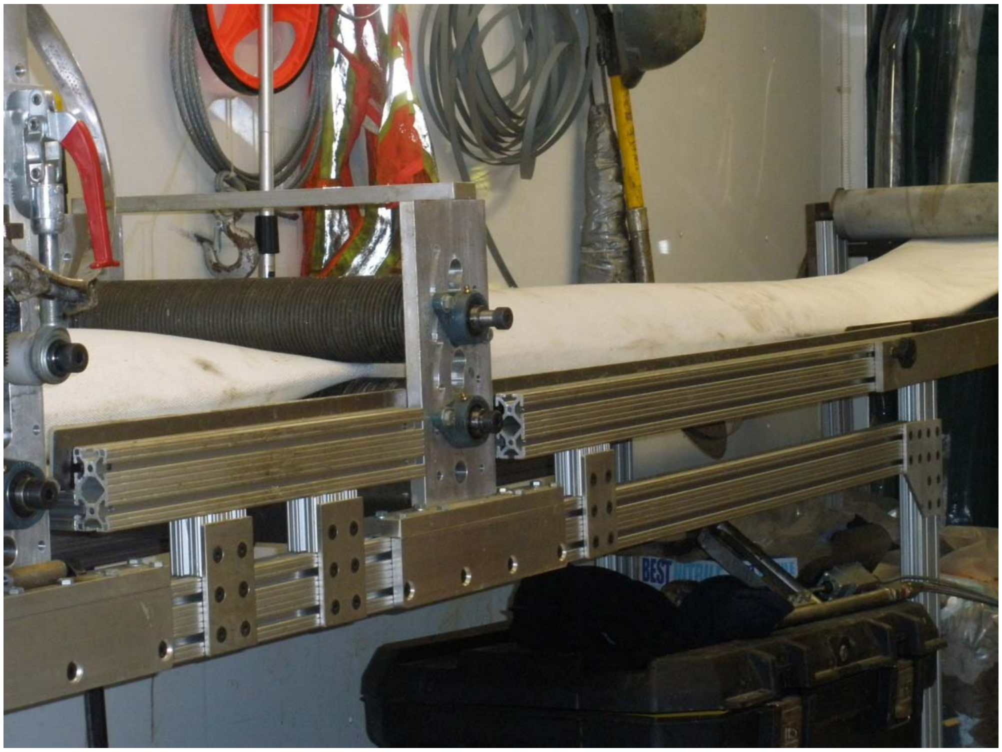

Figure 1: Tube filled with epoxy resin, roller system

Figure 2: Rounded Aqua-Pipe® after swab pass into receiving "cannon"

CARBON FIBER TEXTILE

Introduction

As part of its drinking water distribution Louisville Water Company (LWC) maintains a 2.4 million gallon reservoir in the south central region of its network. The floor, walls, and roof of the reservoir are constructed of reinforced concrete. The reservoir walls are approximately 26-feet tall. The reservoir walls are covered with a steep earthen berm and the reservoir roof has approximately 1-foot of earthen cover.

Aware that a leak existed on the reservoir site, but unsure of its origin, LWC personnel drained the structure to investigate. While performing the internal inspection of the concrete floor and walls it was discovered that the 24-inch fill line had drained when the reservoir was emptied. The outlet of the fill line is approximately 2-feet above the reservoir floor and approximately 10-feet higher in elevation that valve used to isolate the pipeline. Upon further investigation, two substantial cracks were discovered in the flow line of the 24-inch ductile iron pipe.

Due to the extreme depth of the pipeline, constraints of the site, and relatively short duration the pipe could be out of service LWC selected a solution that could be implemented quickly and required no excavation. LWC contracted with Carbon Wrap Solutions, LLC to supply a carbon fiber textile with which to line two failed segments of pipe. The installation of the fiber would be carried out by a local contractor, Southern Pipeline Construction, Inc., following training and certification by Carbon Wrap Solutions, LLC. Further, Carbon Wrap Solutions, LLC provided construction oversight during the installation process.

Installation Process

Pipe access was fairly simple and required no excavations. The open pipe end in the reservoir served as one access and a disassembled 24-inch check valve, contained in a concrete vault approximately 120-feet from the reservoir, served as the second entry point. The pipe wall was thoroughly washed using a high pressure water blast and allowed to dry prior to the installation of the carbon fiber material.

The raw material was supplied in rolls of 2-foot width. The carbon fiber textile was cut to length to allow for approximately 6-inch of overlap of each piece. Each piece was then 'wet out', *Figure 3*, with epoxy and folded in half longitudinally creating a double layered, 1-foot wide strip. The carbon fiber material was applied circumferentially in overlapping segments. The strips were applied to the pipe wall, overlapping approximately 1-inch circumferentially. Once the first application had dried sufficiently a second double layer was applied. Due to the degree of degradation in one of the pipe segments, longitudinal strips were also applied to this joint, *Figure 4*. The longitudinal material was applied at the crown, springline (both sides), and the flowline. The longitudinal strips were installed between the two circumferential applications. The limits of the lining included the entire length (20-feet) of each joint plus an additional 1-linear foot past the bell and spigot end of each.

Figure 3: Wetout of carbon fiber textile

Figure 4: Installation of longitudinal ribs

INTERNAL JOINT SEAL

Introduction

Cobb County Marietta Water Authority operates a 105-million gallon per day water treatment plant north of Atlanta, Georgia. The discovery of fluoridated water in the ground water underdrain system was the initial indication of a potential leak at the Plant. During unrelated construction, excessive amounts of ground water was encountered leading the utility to suspect they may have a breach in one of the large diameter pipeline on site. A man-entry inspection of an 84-inch prestressed concrete cylinder pipe (PCCP) revealed a circumferential break in the pipe near a bell and spigot joint. The failure was widest at the pipe's crown and ran to the springline on both sides. The proximity of the crack led the inspectors to suspect the weld at the bell ring had failed.

Given the fact that the pipeline in this area was constructed using restrained joints and that this segment of pipe was not subjected to high pressures it was considered a fairly low risk for total failure. The utility's immediate concern was to stop the leak to prevent further damage to the pipe itself and eliminate the water loss, and return the pipeline to service as soon as possible to meet customer demand. An internal joint seal was determined to be an acceptable solution and Miller Pipeline Corporation was retained to install a WEKO-SEAL® to repair the pipeline. The internal joint seal is a flexible rubber, internally applied, leak clamp that ensures a non-corrodible, bottle-tight seal around the full inside circumference of the pipe-joint area. This type of seal is routinely used for sealing leaks at pipe joints; however, its use in this instance was considered appropriate. The rubber seal is held in place with stainless steel rings that are jacked tightly against the seal forcing it against the pipe wall.

Installation Process

In this installation an extra wide seal was used. It was held in place with 4-individual stainless steel bands, *Figure 5*. The installation process routine is fairly simple and consists of the following procedure:

- the joint or crack is pack with hydraulic cement to eliminate voids behind the rubber seal
- the pipe wall is coated thoroughly with a food grade lubricant
- the seal is centered over the joint or crack
- the stainless steel bands are jacked into place on either side of the seal
- an air test is performed to assure a tight seal between the pipe wall and the rubber seal

Figure5: 84-inch diameter WEKO-SEAL®

SUMMARY

As drinking water utilities embark on upgrading of their buried infrastructure it will be in their best interest to be familiar with the ever expanding variety of options available to rehabilitate their facilities. Further, given the fact that consumers are less tolerant than ever of disruption not only to their service, but to their daily routines, special dedication will likely be required to customer service as the utility's assets are renewed.

As the pipeline system analysis process matures, utilities will be better positioned to determine the best approach, or approaches, for renewing their water distribution systems. New techniques for renewing pipelines are emerging regularly. These range from newly formulated rapid cure coatings to fully structural cured-in-place pipe (CIPP) liners. Obviously there will be a wide variation in cost for these new products. Generally speaking, non structural coatings cost less than fully structural liners. It is essential that utilities understand the benefits and the limitations of each material and technology as they develop their program goals and objectives.

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