Session: HDPE Pipe Test

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Education
Master of Business Administration—University of Houston, 1985
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Background and Experience
Rafael Ortega joined LAN in 1981 and has experience in a wide variety of civil engineering fields. As a Vice President, he directs LAN's Infrastructure Large Diameter Business Group and is instrumental to the operation of the City of Houston's $400 million Surface Water Transmission Program capital improvements project. In this role, he has been personally responsible for the design oversight of more than 500 miles of large diameter water transmission mains including nearly 100 miles of tunnels. Mr. Ortega's pipeline expertise is known nationally, through his active involvement on Concrete Pipe, Steel Pipe, and Butterfly Valve American Water Works Association's standards committees.

Mr. Ortega's experience includes several major water line projects (ranging from 20 inches to 96 inches in diameter) as well as pump station and force main analysis and design. This work has included route evaluation, traffic analysis, assignment, and coordination of support services (geotechnical and surveying), detail design, and constructability reviews. He has also performed sanitary sewer rehabilitation design including line replacement, grouting, and slip lining for several municipalities. Mr. Ortega was responsible for coordinating the constructability and biddability review effort for the City of San Antonio and the City of Alvin sanitary sewer construction programs.

Mr. Ortega has designed numerous soft ground tunnels ranging in size up to 120 inches in diameter, performed construction management, construction inspection, field engineering, and wastewater facility design. His other assignments have included utility relocation, storm drainage improvement systems, and water and utility district engineering.

Mr. Ortega was the Chairman of the *Underground Construction Technology* 2007 International Conference and Exposition in Houston, Texas and served as Chairman for the 2008 event in Atlanta. At this same event, he was named the "Most Valuable Professional in the Private Sector" by the Gulf Coast Trenchless Association. He has been a member of the AWWA Steel Pipe Standards Committee for a number of years, and served as Chairman of the American Society of Civil Engineers' Pipelines 2005 Conference held in Houston and will serve again at the 2012 conference in Miami. He has truly "seen it all" as pertains to water transmission facilities and, as such, affords our clients a unique ability to proactively trouble shoot potential design and construction issues, before they occur. Mr. Ortega has performed sanitary sewer rehabilitation design including line replacement, grouting, and slip lining for several municipalities. Other assignments have included construction inspection, utility relocation, storm drainage improvement systems, and water and utility district engineering.

Pilot Project with HDPE Provides Critical Alternative

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ABSTRACT: In an effort to increase competition among pipe materials, the City of Houston (City) authorized the pilot project use of 30-inch high density polyethylene (HDPE) for water transmission main. The pilot project was installed in 1997 for approximately 1,480 linear feet. Years later, the City excavated the test installation to determine its performance. Within 90 days from the excavation, a 42-inch water main suffered a catastrophic failure. This failure occurred in a prestressed concrete cylinder pipe (PCCP), which supplies water to an area of approximately 75 square miles in Houston, Texas.

An immediate assessment revealed more than 25,000 linear feet of deteriorated pipe. Because of the need to return water supply to the area before the following summer peak water demand, only 10 months were available to design, bid and construct the rehabilitation of the distressed 42-inch water main.

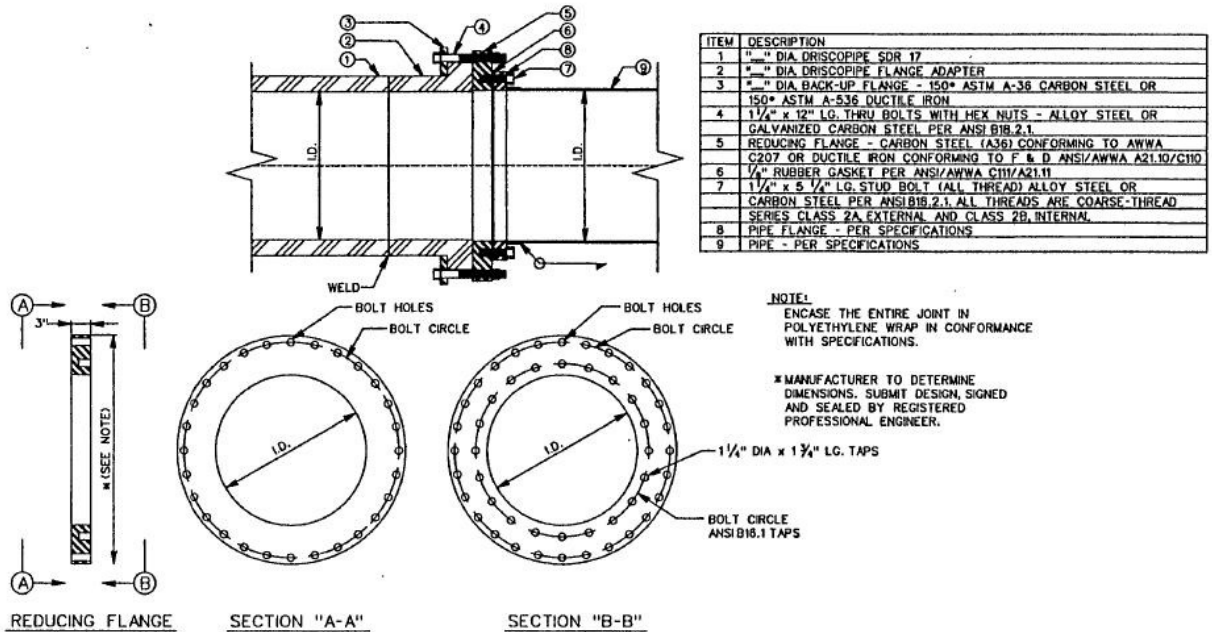
Because the performance of the test installation was consistent with the manufacturer's claims, the City had sufficient confidence to select a rehabilitation option involving sliplining the 42-inch existing 42-inch water main with HDPE. By sliplining the existing distressed water main instead of traditional open-cut installation of a new main, the City restored the surface water supply prior to the onset of the summer peak demand. This method also allowed the City to save an estimated $2 million to $4 million in construction cost.

Introduction

The City of Houston (City), as the regional provider of drinking water, has had an interest in evaluating new products and materials for the water distribution and transmission system. Acceptance of new products must go through the City's Product Approval Committee. Based on the information provided and the subsequent evaluation performed by City engineers, the product may need to undergo further evaluation. Such was the case when Houston first considered the use of HDPE for water distribution and transmission main applications

A 30-inch inside diameter (ID) high-density polyethylene (HDPE) water main was constructed as a "demo" project under the City's Surface Water Transmission Program (CIP No. S-0900-26-3; File No. 10439). The HDPE water main was installed in the fall of 1997. The material specifications required the HDPE to be rated to 100 psi (DR 17) with surge pressure of 150 psi, undergo a field hydrostatic test of 150 psi and the use of heat fused butt joints. Special flanges for connections to bar wrapped concrete pressure pipe as noted below.

Concrete to HDPE Connection Design



Provisions were included in the Contract Documents for WA10641 (Contract 17A) to perform an assessment of the existing 30-inch HDPE water main.

The criteria used for the HDPE assessment was the following:

- Evaluate performance of joints by visual inspection for leaks at butt-fused joints and special flanged connection to concrete pipe.
- Evaluate performance of HDPE material characteristics by direct measurement of the outside diameter (OD) of the pipe to quantify ballooning or elongation due to thrust at bends. This is done by verify that deformations in pipe material (if any) do not exceed allowable stress for HDPE material.

Two locations were identified as critical areas to be representative of the total length of HDPE installed; the 45-degree bend at the intersection of Crofton and Hallshire and the flanged connection to concrete pressure pipe at the intersection Hallshire and Homestead.
The HDPE water main was exposed at each of these locations for visual evaluation of the pipe's performance.

No leaks were observed in the butt-fused joints or at the flanged connection. Also, the OD of the HDPE water main was measured at each of the exposed locations to determine if ballooning or elongation of the HDPE line had occurred as a result of thrust. The OD of the pipe matched the original OD prior to installation. However, if these phenomenons occur simultaneously, they may have offsetting effects that are difficult to quantify individually.

Based on the results of the limited assessment, the HDPE water main at each of the referenced locations is performing adequately under the current operating conditions.

Failure of 42-inch Line

During the early morning hours of June 8, 2004, an existing 42-inch water main in Houston suffered a catastrophic failure. This failure occurred in a pipe section of PCCP installed in 1991 through 1992. The area served by the pump station consists of an area of approximately 75 square miles. Several residential properties were flooded as a result of the failure. The City authorized Lockwood, Andrews & Newnam, Inc. (LAN), to assist in the failure assessment and to design the repair for the water line.

This particular PCCP is the lined cylinder variety, composed of a concrete core, prestressing wires wrapped around a thin steel cylinder, and mortar coating. Figure 1 shows a cross section of typical lined cylinder PCCP. A picture of the failed pipe section is included as Figure 2.

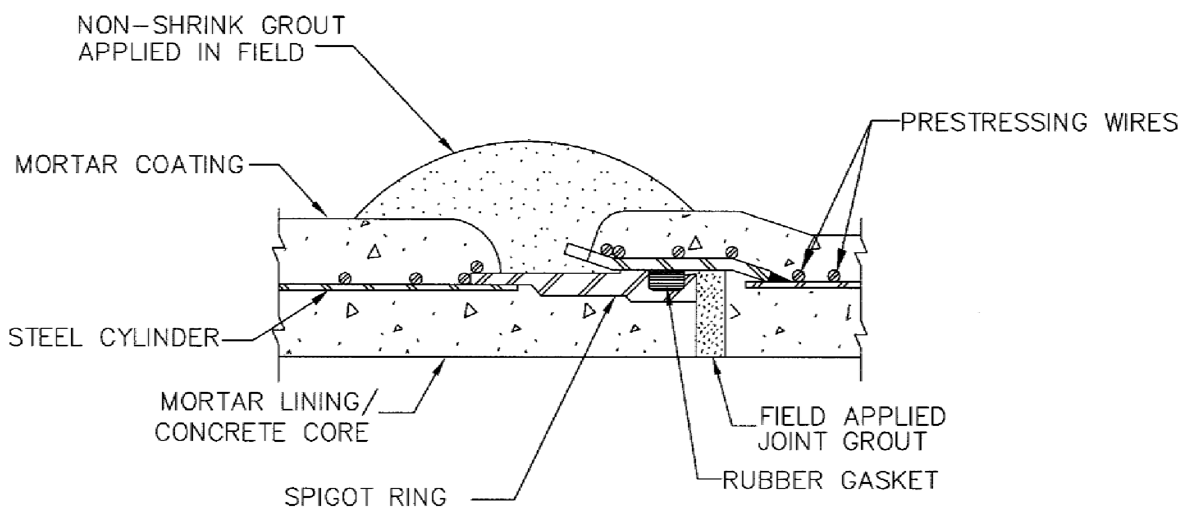


Figure 1. Lined Cylinder – Prestressed Concrete Cylinder Pipe

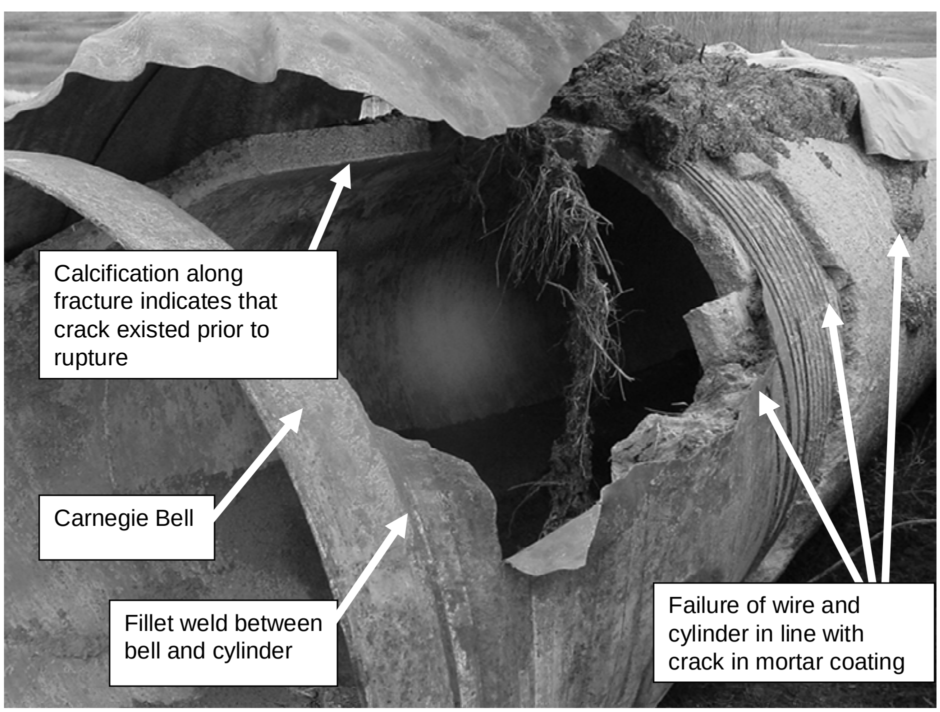
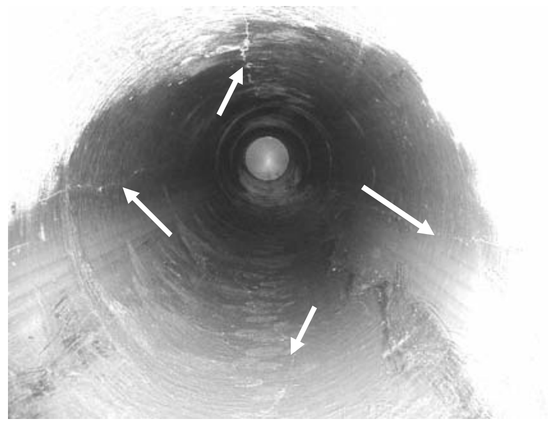


Figure 2. Failed pipe section

Immediately following the rupture, LAN performed a visual inspection of the failed water line and testing of mortar and wire samples. Internal observations revealed the internal cracking appeared consistently at invert, crown, and spring lines for a distance of approximately 25,000 linear feet (see Figures 2, 3 and 4). The visual inspection was accompanied by sounding to determine if the mortar lining was delaminating from the steel cylinder; however, the lining did not exhibit any noticeable delaminations.

Circumferential cracks



Cracks appeared constantly along crown, invert, and springlines

Figures 2 and 3. Interior cracking

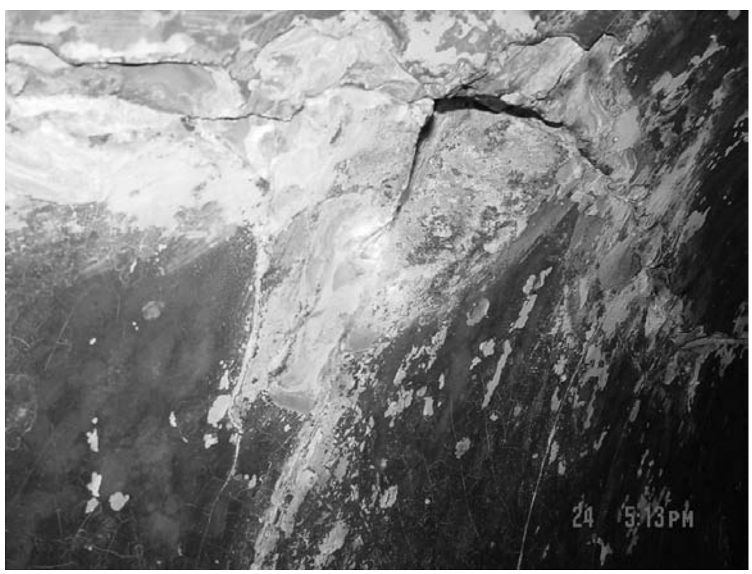


Figure 4. Close-up of interior mortar crack

Several pipe sections were excavated to investigate how the internal cracking correlated to overall pipe condition. Each piece excavated showed signs of external cracking, approximately in line with the internal cracks, indicating the cracks extended through the entire pipe wall. Limited wire testing performed on sample revealed no signs of hydrogen embrittlement or other obvious manufacturing defects.

It was determined the repeated rapid closure of an emergency shut-off valve within the plant probably created pressure transients which could have exceeded the pipe design and caused the cracking. Hydraulic modeling of this closure scenario performed after the failure indicated that pressures in the pipe may have surged above the maximum design of the pipe of 150 psi for a total surge pressure of approximately 300 psi.

Because this line is the only source of surface water to the area, groundwater wells had to be brought online and were required to operate at full capacity in order to meet the water demand during the outage. Hydraulic modeling of the area suggested that groundwater wells alone were not sufficient to meet the upcoming summer peak water demands in the area. Therefore, the City was faced with the task of rehabilitating the 42-inch water line and safely returning it to service before the summer peak demands. This schedule left only 10 months to complete both design and construction.

Design Options

Several options, including replacing the line, were evaluated for restoring surface water to the pump station. Sliplining the existing water line with HDPE meant the existing water line could be used as a primary liner, reducing disruption to pavement and traffic. The disadvantages included requirements that flow into the pump station be shut down during the duration of construction, and the capacity of the line would be reduced to approximately two-thirds of its original capacity.

Sliplining was deemed to be a viable method in this case due to the construction of the existing pipe. At the time the original 42-inch water line was constructed, there was little development in the area and the result was a relatively flat, consistent vertical and horizontal alignment, with few bends. Also, only three interconnections existed along the failed portion of the line.

Other Considerations

Hydraulic modeling showed that current water demand in the area required a pipe with an approximately 36-inch ID, which was achievable by sliplining with HDPE. However, in order to achieve the future projected water needs, an additional parallel water line was planned for the future.

Pipe Design

The existing concrete pipe will continue to degrade over time. As a result, it was determined the HDPE pipe should be designed to withstand the full internal pressure and overburden weight without any credit given to the existing structure. Pipe was specified as SDR 17 for a working pressure of 100 psi and a surge pressure of 150 psi.

SDR 17 HDPE pipe has a wall thickness of approximately 2.3 inches with an OD of approximately 39.37 inches (1,000 mm), leaving little room to maneuver it within the existing 42-inch PCCP. Although the pipe could be pulled in a straight run of up to 4,000 linear feet, it could only be pulled through deflections of up to five degrees. Excavation pits were therefore required at multiple areas where horizontal or vertical bends exceeded five degrees. Pits were also required where valves, fittings and connections were installed, and to remove existing butterfly valves.

The slipline pipe was only 6% smaller than the host pipe with a 42-inch (1,066.8 mm) typical inside dimension. Based on internal inspections, the existing concrete pipe did have a smooth, regular inside surface, however, workmanship of the interior field-grouted joints occasionally left mortar buildup at the joints, reducing the inside dimensions.

To mitigate the risk of getting the HDPE line damaged or stuck in the host pipe, the contractor was required to pull a test mandrel consisting of a 40-foot-long section of HDPE prior to attempting pulling fused sections of pipe.

Construction

During construction, the key to pulling the pipe is a pre-installation inspection—during design. Based on this inspection, the design should account for the majority of pipe ID issues, and the required number of pits and fittings.

The 40-foot-long test section of HDPE which served as a mandrel was a good indicator of the ease of pipe insertion. One additional access pit was required along the project, and was determined when the test mandrel got stuck. The actual HDPE water main never became stuck during pulling. During installation, the contractor was able to overcome friction between the host pipe and the slipline pipe by applying a viscous bentonite material along the invert of the existing pipe prior to insertion.

Photographs included as Figures 6 and 7 show the tight fit of the slipline pipe.



Figure 6 and 7. Pipe installation


Figure 8. Pipe stringing and placement operations

The other major obstacles encountered during construction were traffic control, access to businesses when long runs of pipe were strung out along the right-of-way.

HDPE pipe had to be fused together in sections equal to the distance between proposed insertion pits. The fused sections ranged in length from 1,700 linear feet to 300 linear feet. To reduce impact to traffic and the local businesses, the longer sections were fused in approximately 500 foot runs to avoid closure of cross traffic through median openings at intersections. Once each 500 foot segment was prepared for a particular run these segments were fused in a matter of hours and the entire run was pulled in a single day.

Conclusion

As a result of the City's willingness to evaluate new products, the trial installation of HDPE provided an effective alternative. The option of sliplining the failed 42-inch line ultimately saved the City between $2 million and $4 million from some of the other options considered. The contractor was able to install approximately 6,250 linear feet of pipe per month, and completed installation of the HDPE sections within four months of notice to proceed.

Although the use of HDPE may not be cost effective in all applications, the use of this material for sliplining a failed 42-inch line provided a critical option which allowed the City to save both time and money.