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Slipline Methodology Rehabilitates Large-Diameter Water Main

Because of increasing leaks in a water main and costly repairs, a Virgin Islands utility turned to slipline technology to rehabilitate the main, minimize commercial disruptions during the rehabilitation, and mitigate corrosion. **MUSTAFA ABUSAOUD AND RICHARD BOTTEICHER**

THE US VIRGIN ISLANDS, located in the Leeward Islands of the Lesser Antilles, encompass the islands St. Croix, St. John, and St. Thomas. With a population of more than 51,000 people and a heavy influx of visitors, St. Thomas is the tourism hub for the three islands.

The Virgin Islands Water and Power Authority (WAPA) provides clean drinking water for residents of the three major islands. An autonomous entity of the Virgin Islands government, WAPA serves about 100,000 residents and visitors. WAPA produces and supplies about 4 mgd of clean drinking water through approximately 275 miles of transmission lines on all three islands, including about 73 miles of piping on St. Thomas.

In 2008, WAPA began to explore rehabilitation or replacement of a 24-in. ductile-iron pipe (DIP) water main along the St. Thomas Harbor. Installed in the 1970s, this major transmission artery had an increasing history of leaks along the seawall abutting St. Thomas Harbor. These leaks required costly and disruptive repairs along one of the island's busiest pedestrian and auto thoroughfares. The

1 The original 24-in. DIP pipeline was laid in a shallow trench along the waterfront.

2 One segment of the DIP pipeline was replaced because of failure associated with corrosion.

FPVCP was loaded into a typical fusion machine to be joined.

rate at which the leaks occurred indicated overall pipeline integrity was declining. Concluding that continued costly repairs of the pipeline were no longer feasible, WAPA personnel launched a thorough evaluation to find a permanent solution.

PIPELINE CONDITION ASSESSMENT

The 24-in. DIP pipeline had been installed in a shallow trench along the waterfront apron and capped with concrete, which served as the apron next to the roadway and between the roadway and waterfront. The area, composed mainly of fill materials, was created when the harbor had been improved (Photograph 1).

Over the years, various problems with the 24-in. DIP pipeline arose, particularly those caused by pipeline corrosion resulting from exposure to harbor-influenced groundwater below the concrete pavement (Photograph 2). The pipe sits above the surface in three locations to accommodate conflicts with other utility lines and the shallow nature of the pipeline (Photograph 3). These locations enable personnel to easily observe and assess pipeline performance. Based on the pipeline's history of costly repairs, WAPA personnel decided to replace or rehabilitate the 24-in. DIP pipeline in its entirety.

MATERIALS AND METHODS EVALUATION

Providing its own engineering design services, WAPA conducted extensive research of available rehabilitation and replacement methods. Because of the pipeline's location in a busy, congested area, the utility's main consideration was to limit the socioeconomic disruption caused by construction. Another purpose of the rehabilitation was to mitigate corrosion caused by the salty, seawater-influenced groundwater and environment. To address these goals, WAPA used slipline trenchless installation with corrosion-resistant thermoplastic pipe.

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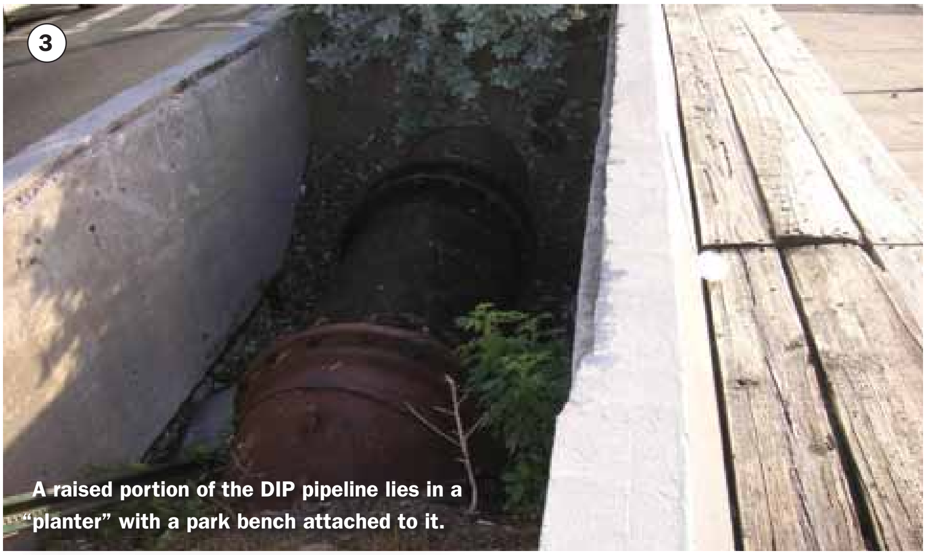


A raised portion of the DIP pipeline lies in a "planter" with a park bench attached to it.

PHOTOGRAPHS: VIRGIN ISLANDS WATER AND POWER AUTHORITY

FPVCP uses standard PVC-compatible fittings and hardware.

An insertion pit was created at the edge of the cricket field as part of the sliplining process.

Sliplining as a rehabilitation or replacement method is simple. A new pipeline that's smaller than the host pipe to be rehabilitated is inserted into the existing line and reconnected on either end. Water then flows through the new pipeline, which is installed within the orginal, debilitated pipeline. The major drawback to this method is the reduction in flow area of the new pipeline compared with the existing line. But in WAPA's case, the utility was able to reduce the 24-in. DIP main to a 20-in. nominal pipe and still maintain the line's required service parameters. In addition, where constraints existed or where it made more economical or construction sense, the cut-and-cover method could be used and tied into the sliplined portions with thermoplastic pipe.

To use sliplining technology, the piping material must be "slipped" or pulled into the existing host pipe via a tensile force, which requires that the joining method used with a particular pipe must provide a tensile capacity to pull the material into place. WAPA personnel evaluated several piping materials and chose a 20-in. dimension ratio (DR) 18, or pressure class 235 psi, fusible polyvinyl chloride pipe (FPVCP).

FPVCP TECHNOLOGY

FPVCP uses a thermally fused or bonded connection instead of a mechanical and/or gasketed connection like other PVC pipe-joining technology used today. Two plain-end lengths of FPVCP are joined by heating the ends of the pipes until a fusible bead of material is formed on each, and then the pipe ends are brought together and held under pressure until they cool to ambient temperature.

The resulting joint creates a monolithic length of pipe, which is fully restrained from one length to the next. With successive joints, a fully restrained length of pipe can be created and installed via pulling or a tensile load, which makes such an approach ideal for trenchless installation methods, such as horizontal directional drilling, pipe bursting, and sliplining. Another advantage of the FPVCP joint is that, unlike other mechanically restrained PVC pipe connections, it doesn't increase the overall pipe diameter at the connection and provides the same tensile and pressure carrying capacity as the pipe itself.

The plastic's inherent flexibility allows the pipe to bend. Safe pulling force is based on tensile testing used to verify the fusion joint's tensile capacity. The minimum recommended bend radius is determined through testing and is consistent with a typical PVC bend radius of about 250 times the pipe's outside diameter. This takes into account axial stress encountered in bending the pipe cross-section along with other axial stresses during pipe insertion, such as those used for slipline installation.

FPVCP is handled, moved, bedded, connected, repaired, and installed in much the same way as conventional bell-and-spigot PVC pipe. FPVCP may be tapped using standard tap equipment and tapping saddles. In addition, taps can be performed whether or not the line is under pressure and immediately after installation. When connecting FPVCP to an existing system or to another PVC pipe, standard connection hardware may be used (Photograph 4), including restraining gland technology, pipe couplers, flange adaptors, mechanical joints, and the bell of a similarly sized and specified PVC pipe. Crews and operations personnel familiar with PVC systems won't require retraining or additional equipment to work with FPVCP after installation.

ALTERNATIVE SELECTION

Following the condition assessment and design evaluation, WAPA used FPVCP material installed by a combination of slipline rehabilitation and open-cut replacement. As an inert thermoplastic, PVC provides a pipeline free from corrosion

Compared with dig-and-replace rehabilitation methods, the use of sliplining and FPVCP saved WAPA about $400,000.

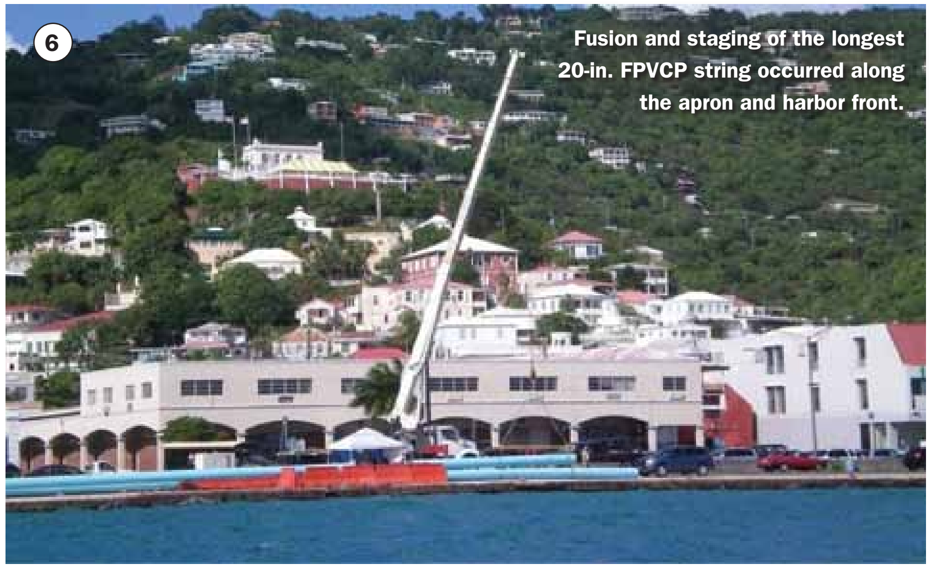
concerns. In addition, the thermally butt-fused product could be installed with sliplining methodology, allowing large sections of the project to be completed without requiring a full dig-and-replacement rehabilitation. The monolithic outer diameter of the pipe and joint also allowed for the largest outer- to inner-diameter flow area of any piping material evaluated, while still maintaining the required pressure class. In other words, the largest flow area would be realized for the largest pipe that could be installed in the existing 24-in. DIP.

CONSTRUCTION

Approximately 3,600 ft of 24-in. DIP in the harbor area was slated for replacement. To minimize disruptions, the work was scheduled to coincide with scheduled street repairs. Outside of the roadwork area was an additional 1,000 ft of pipeline that needed to be replaced or rehabilitated and about 2,700 ft outside the harbor apron area—in front of a middle school, under a cricket field, and continuing toward a cargo port area. Therefore, sliplining with 20-in. FPVCP was chosen for the remaining 1,000 ft of the harbor apron area, under the cricket field, and a stretch near the cargo port roadway. Another 3,700 ft of FPVCP was installed in 200-ft increments in areas where the pipeline was to be replaced with conventional excavation technology. Because the existing pipeline passed under several businesses in one area, the pipeline was rerouted.

Construction began in the cricket field and an adjacent area near a middle school because of work completion deadlines regarding cricket season and school activities.

An initial insertion pit was created at the edge of the cricket field (Photograph 5). The pit provided space to insert two separate lengths of 20-in. FPVCP—one about 640 ft toward the cargo port and one about 480 ft toward the harbor. Because of storm drainage infrastructure in one section of the cricket field, direct-bury construction was used to lower the line under the conflicts.



6 Fusion and staging of the longest 20-in. FPVCP string occurred along the apron and harbor front.

The project's primary and longest slipline installation occurred along the harbor, from a post office to the road-widening area. This almost 1,000-ft stretch was installed in one pull. With the insertion pit located along the harbor apron, the pipe was pulled in toward the post office. The pipe string was fused along the apron and the harbor front (Photograph 6). This length of pipe was pulled into the existing 24-in. DIP and reconnected at each end using common restrainer glands and ductile-iron fittings for use with PVC pipe.

Five sections of FPVCP—approximately 1,640 ft of 20-in. pipe—were installed via open-cut, dig-and-replace methodology. These areas included insertion pits for sliplined portions, several storm drainage crossings that required abrupt pipeline direction changes, and several areas in which the alignment was changed. These sections were installed with fused FPVCP sections in approximate 200-ft lengths, which were coupled with ductile-iron fittings or couplings and restrainer glands. The 200-ft lengths were used because that was the maximum open-trench length that could be maintained in consideration of the harbor-influenced groundwater present.

The slipline and 20-in. FPVCP portion of the project were completed in the summer of 2010. The rehabilitated line was pressure tested at 150 psi for 2 hours and placed into service.

PROJECT SUCCESS

Original project goals—to limit disruptions in a congested area and replace the failing 24-in. DIP pipeline with corrosive-resistant material—were achieved. The project also reflected the ability of trenchless sliplining to accommodate project adjustments. Compared with dig-and-replace rehabilitation methods, the use of sliplining and FPVCP saved WAPA about $400,000 on this project.

RESOURCES

- AWWA Manual of Water Supply Practices M28: *Rehabilitation of Water Mains*, 2001 (catalog No. 30028).
- AWWA Standard G200-09, Distribution Systems Operation and Management (catalog No. 47200).
- Najafi, Mohammad, 2010. *Trenchless Technology Piping*. McGraw Hill, WEF Press, and ASCE Press (catalog No. 20741).