Spray It to Save It

Trenchless structural spray coating turns a nightmare scenario into a successful pipe project

- By Suzan Marie Chin & Mary Shafer

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There's one word for traffic disruptions around Harrisburg, Pa.: ugly. When two dual, or "double-barrel," pipelines running deep beneath one of the area's busiest arteries showed signs of deterioration, no one wanted to do a dig and replace. The Pennsylvania Department of Transportation (PennDOT) settled on a trenchless structural solution, saving months of surface disruption and more than $2 million.

Harrisburg nestles between the eastern slopes of Pennsylvania's tightly packed Allegheny Mountains and Cumberland Narrows of the Susquehanna River. The city of nearly 50,000 people is surrounded by small towns that have been absorbed into the sprawling state capitol.

Just across the river lies Camp Hill, home to the Book Clubs of America, which depend on state highways 11 and 15 to transport inventory to and from huge warehouses. Many other transportation-intensive businesses also rely on this artery, which runs along the river through the town of Wormleysburg.

The Harvey Taylor Bridge connects Route 11/15, called North Front Street in the borough of Wormleysburg, with the capitol's busy downtown and government complex just on the other side of the Susquehanna. Beneath this bridge on the Wormleysburg side is a culvert that collects water from a small tributary and storm runoff from the bridge. It sends this water directly into the river through a double-barrel set of 75-ft-long, 54-in.-diameter corrugated metal pipes.

About a half mile to the southeast sits the John Wormley House Historic Site, home of the city's founder. Next to this site, another double-barrel set of similar storm water pipes—88 ft long and 60 in. in diameter—drains to the river.

This stretch of North Front Street, which runs along a preserved riverfront park area, has an average daily traffic factor of about 17,000 vehicles. When a PennDOT inspection revealed the beginnings of serious structural deterioration and crushing (deflection) in both sets of pipes, it presented a nightmare scenario.

Solutions Options

"When we started this project in 2000, we tried to do it locally, in house," recalled Nexa Giboyeaux, PennDOT highway design project manager. "Due to traffic control issues, we never finished that project. We could never replace those pipes."

In 2007, Giboyeaux took control of the project, hiring engineering firm Larson Design Group, Montoursville, Pa., to conduct a problem study and solution analysis.

Larson determined that the problem was the pipes' depth. At 20 ft below ground, replacing them would mean digging a 10-by-20-ft trench on each site to allow for required upsizing of the pipes to box culverts.

This would have been necessary to bring the circa-1945 pipes up to modern code standards for water conveyance structures. Then the trenches would have had to be backfilled and road approaches milled and repaved—all without compromising the environment or historic site.

Even with detours, most of the work would have needed to be done at night to reduce traffic impact, requiring roughly 10 weeks of site preparation and dig-and-replace work per pipe and totaling approximately nine months to complete the project. Along with gobbling up time, the project was estimated to cost $4.2 million, and that was if the culvert beneath the bridge did not require upsizing.

“If we were to have to replace those culverts, we would have probably had to upsize them for the new designs—probably to at least a box culvert,” said Kevin Keefe, PennDOT’s assistant construction engineer. “Then you’re talking about $700,000 to $1 million.”

Giboyeaux knew this was unacceptable. Concerned about their ability to make a choice in time to meet the deadline for bid day, she tasked Larson with researching alternatives and spent a great deal of time seeking information on the Internet.

Larson moved forward with the hydraulic study and flow impact reports for the several options being considered. “We had a brainstorming session with PennDOT management,” Giboyeaux said. “We ran a few different scenarios and picked the top technologies that met time, money, quality, safety, environmental and traffic impact requirements.”

With traditional pipe replacement and upgrading to box culverts off the list, viable choices included trenchless cured-in-place pipe lining and structural spray coating over pressure-jetted pipes and grout-filled voids.

Environmental Concerns

“Nowadays, environmental impacts are a big, big obstacle for us to do major things,” Giboyeaux said. “We’re going ‘green,’ and a lot of things are going on out there that limit how we can fix a road.”

It was this environmental concern as much as its structural strengthening and protective characteristics that pushed SprayRoq SprayWall polyurethane coating to the forefront of considered options. Larson gave a presentation of its findings to a gathering of PennDOT supervisors arranged by Giboyeaux, and the department opted to try the spray.

Abel Recon, infrastructure rehabilitation contractors based in Mountville, Pa., won the bid to apply the product. General Manager Hap Witmer previously had approached PennDOT representatives at a tradeshow, and an engineer invited him to give a presentation on the SprayWall’s structural capabilities.

“They were very interested in using the product on a project that was going to be less disruptive to traffic,” Witmer said. Because both sets of pipes were accessible to man entry, no trenches needed to be dug.

The spray also releases no volatile organic compounds, protecting parks and wildlife, according to Witmer. Another environmental consideration was that because the pipes outfall directly into the river, no debris or contaminants of any kind could be allowed to enter water flowing out of the rehab zone. Due to this requirement—and no actual digging taking place—only standard general permits from the Department of Environmental Protection were needed, reducing application and approval wait time.

Site Prep & Application

From a logistics perspective, the two sites were not challenging. “We did the whole project with a spray truck, a prep truck and a pickup truck,” Witmer said. “We just parked in the normal parking spots alongside the road and worked out of those.”

Abel worked the sites with a crew of seven people, taking hoses into the pipes from the top of the

culverts. Other than footprints up and down the banks, there was no evidence that the workers had been there, so no restoration was needed.

First, site preparation was done. Temporary walls and dikes were created using boards and sandbags to divert the water flow from the work pipe into its twin until rehabilitation was complete, after which the setup could be switched.

The existing structure was coated with an old coal-tar epoxy, a common coating put on corrugated metal pipe to increase longevity. Most of the epoxy was intact and offered good adhesion with the SprayWall coating, but Abel needed to pressure wash any loose material from inside the pipe using pressures between 2,000 and 3,000 psi.

The technicians installed tightly woven catchment bags at the end of the pipes to allow water to flow through while catching any coal-tar epoxy debris and keeping it from entering the river or collecting on the riverfront preserve.

Next, some grouting needed to be done to restore the corrugated profile of the pipes near the exposed ends, where air and moisture had pitted and then eaten through the pipe structure. This is where the soil had begun to come through.

This demolition and surface preparation work was achieved during a single 12-hour day shift for each pipe. Then, the night shifts came on and did the spray application of the polyurethane coating.

The structural coating was applied at a relatively uniform 500-mm thickness based on the ASTM 1216 material design equation for structural integrity of materials. Uniformity was audited by American Testing of Lancaster, brought in as a third-party inspection consultant to ensure objective results.

Application was achieved at a rate of about 10 ft per hour. Roughly, 15,000 lb of material was used for all four pipes. Because of the quick cure time, water flow could be restored within minutes of finishing the coating application and thickness testing.

Abel's crews were able to do this round-the-clock work because it was all taking place below ground, with no interruption to traffic. Pleasant May weather with the required curing temperature of 50˚F aided smooth progress.

Significant Savings

The upshot of PennDOT's choice to use a trenchless structural applied coating to rehabilitate existing assets instead of performing traditional dig-and-replace work yielded significant savings of time, human resources and money—not to mention the immeasurable salvaging of public goodwill that would have been lost to a lengthy, disruptive surface job.

"The original scope for the project was to replace these pipes and do ADA [Americans with Disabilities Act] ramps in the intersections to current standards," Giboyeaux said. "We'd have milled old pavement from the road, and then down into 2 in. of roadway. We'd remove all that black material, then we put down brand new overlay on the road. With all that, together the budget scope was $4.2 million."

Instead, the pipe rehabilitation cost $275,500, and the entire project cost was $1.4 million. Opposed to 10 weeks per pipe replacement, there were about four days per dual pipe rehabilitation.

"We minimized the traffic impact, minimized—and in places eliminated—all environmental impact, saved money and time: all with one quality product. Oftentimes we don't have the luxury to close down a road. This will be an excellent tool to use to expedite a project without impacting several

sources."

SIDEBAR

Planning for Deep Conditions

PennDOT's Hap Witmer is not one to let a new opportunity pass him by. Once Abel Recon had completed the Wormleysburg double pipe rehabilitation project successfully, he struck while the iron was hot and pursued more structural spray coating projects.

"I'm actually in the design phase for another corrugated pipe job," Witmer said. "It's buried about 85 ft deep."

When PennDOT had originally constructed the site's road, which passes through a valley and then climbs a mountain, it laid a pipe to accommodate a stream at the valley bottom and filled the rest in, paving over it. Now the road needs some help.

Abel can access the 72-in. corrugated pipe by parking its trucks at the top of the hill and stretching hoses down to it. Workers will be able to prep and spray it even though the trucks cannot get down to the pipe. This is an efficiency Witmer can appreciate— getting the job done without dragging equipment down to the bottom.

"I think the application will be 750 mils on that one," he said. "When you get so deep, the ASTM standard really doesn't do any justice because you get into what they call the wormhole effect."

Chip Johnson, P.E., of SprayRoq explained this effect: "We use ASTM 1216 to design for the thickness in shallow to moderately deep structures, and this includes the variable for groundwater. The soil conditions at these depths are considered elastic and therefore allow for live loads and water table loads to the buried structure. This is what we use in our calculations for SprayWall."

"Getting beyond these depths," Johnson continued, "we get into what we call a tunneling or wormhole effect. This is the case where the soil prism is considered rigid and not elastic, so the external loads are dissipated by the more rigid 'soil.' We do know that the loading is not as dynamic as what we experience in deep-cover, high water table conditions. The phenomenon that has been shown to model this dissipation in loading and is the accepted theory is the Boussinesq solution; in layman's terms, the deeper you go, the less that specific load affects the structure."

"Because of this, we stay on the conservative side and go with a deep condition analysis such as what Abel Recon has shown," Johnson said. "We use a 1.5 design multiplier—the large-diameter conduit accepted safety factor per the Utah State study from the 1980s—on maximum conditions, usually 500 mils. This gives you the 750 mils that we have proposed."

With the design parameters met, the environmental and community impacts minimized and cost far below traditional methods, the rejuvenation of an aging storm water system can complete its ugly duckling transformation.

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