Glass Reinforced Plastic Panels Rehabilitate Century Old Sewer

Fort Wayne, IN, faces the challenge and expense of maintaining an aging sewer system.

By Lynn E. Osborne

The Taylor Street combined sewer is a 100-year old, 72-in. diameter, two-ring brick sewer. Located under a busy multiple-lane road, the sewer makes a 90-degree turn at the intersection of Taylor and Nelson Streets near downtown Fort Wayne. Although crown cracks are not uncommon in large-diameter brick sewers, an assessment found that this line exhibited crown cracks with significant vertical deflection. In addition to mortar loss and a severe diagonal crack in the 90-degree bend, the sewer also had a 4-ft by 5-ft section of bricks missing.

Engineers suspected that the diagonal cracking in the 90-degree bend was caused by forces from the flow's thrust during heavy rainfall. The structural problems were believed to be caused by groundwater infiltration through the walls of the sewer. Cracks and permanent deformation are often a result of the loss of external support and uneven loading. Based on their assessment, engineers recommended rehabilitating about 140 ft of the sewer at two different locations.

They considered several rehabilitation alternatives, each of which was evaluated on its ability to 1) restore the sewer's structural integrity, 2) maintain or increase flow capacity, 3) minimize disruption to Taylor Street, and 4) meet the established budget requirements.

Mortar loss and severe diagonal cracking in the bend were compounded by a 4-ft by 5-ft section of missing blocks.

Glass reinforced panels (GRP) met all four project criteria. It would restore the sewer's structural integrity, conform to the sewer's odd shape, and maximize flow capacity. It could also negotiate the 90-degree bend and would meet the budgetary requirements.

GRP panels are reinforced, filled, thermoset resin panels that are used to rehabilitate large gravity sewers and drains. To install them, workers enter the sewer and fit the panels together to form a full segment in the shape of the original sewer. They then fill the annular space between the structural panels and the host sewer with grout.

Cost-Effective Panels

GRP panels are typically cost-effective on sewers ranging from 54-in. to 144-in. in diameter—and even larger in some applications. The panels can be manufactured to accommodate sewer size changes and to negotiate bends, and can be used in sewers of virtually any length. The distance between shafts can be long, providing proper safety precautions are taken.

Because of the flexibility in composite design and wall thickness range, sewers rehabilitated with GRP panels can withstand high loadings. GRP panels, as a result, are a particularly good choice in deep and/or non-circular sewers with high groundwater and/or soil loadings.

Like standard gravity GRP pipes, GRP panels are composed of a gel coat, corrosion veil, fiberglass, thermoset resin, and fillers. The gel coat, which protects against corrosion, is a non-

After panels were lowered down the Nelson street shaft they were carried through the sewer and around the 90-degree bend to the designated location under Taylor Street where they were assembled.

porous layer on either the panel's interior or both interior and exterior surfaces. The corrosion veil, which consists of a thin fiberglass veil, provides further corrosion protection and stability.

To provide a high-strength, sandwich-like structure, different forms of fiberglass are concentrated on the interior and exterior surfaces. These fiberglass layers are "wetout" with a thermoset resin, while the inner core of polymer concrete is a mixture of thermoset resin and sand filler. If desired, the panel can have a rough outer surface consisting of either a textured surface or pea gravel. This rough surface provides a friction fit between the panel and the cementitious grout.

This test assembly of the 90-degree bend was first done on the manufacturing plant floor to verify the proper alignment.

Because of the smooth interior gel coat surface, Manning 'n' values of 0.010 to 0.011 can be used for flow calculations for the finished panel product. At Fort Wayne, because of the 90-degree bend and irregular host sewer, a conservative 'n' value of 0.011 was used for design.

The panels used in Fort Wayne, known as Insituform ArmorGRiP™ Panels (www.insituform.com), were manufactured using the Multiple Viscosity Infusion (MVI) process with closed molds. The MVI process is a proprietary technology used to manufacture composite parts. The process allows mixtures of differing viscosities to be used simultaneously during the molding process. The process is designed to direct targeted materials to specific locations within the composite during a single manufacturing process.

The result is a sandwich composite with reinforcing fiberglass layers near the surfaces with a polymer concrete core. The typical physical property range is a flexural strength of 12,000 to 18,000 psi and a flexural modulus of 1,400,000 to 2,000,000 psi.

Design Parameters

For the Taylor Street Sewer, the design parameters included the host pipe's length, cross-section measurements, wall thickness, alignment, and construction material; pipe ovality; soil depth of cover and density; live load; groundwater level; and safety factors. The GRP panels were specified to have flexural strength and flexural modulus of elasticity of 16,000 psi and 1,450,000 psi, respectively. Because of the difficulty of determining the configuration and cross-section of the existing sewer, the wall thickness was not finalized until the construction contract was awarded.

After being awarded the construction contract, Affholder Inc., a subsidiary of Insituform, began by measuring the sewer cross-section every five ft to determine GRP panel dimensions. Because the vertical deflection varied greatly along the sewer sections to be rehabilitated, questions were raised about the size and shape of panels that could be

The 90-degree bend with a 30-in. side connection before repair.

installed—as well as whether the rehabilitated sewer could maintain the required flow capacity.

Affholder then worked with the city and its engineering consultant to determine the most appropriate cross-section for the installed GRP panels. After analyzing the sewer's calculated flow rates at different points before and after rehabilitation, the team chose 68.5-in. by 62-in. panels with a wall thickness of 0.83 in. This size allowed for a minimum annular space of 1.5 in. in most locations and provided a post-rehabilitation flow rate equal to or greater than the flow rate in the original sewer.

The 90-degree bend with a 30-in. side connection after repair.

Given the small size of the manhole entrance and the need to carry the panels around the 90-degree bend, Affholder chose to use a two-piece panel system; each 180-degree panel segment was two ft long and weighed about 150 lb. The upper and lower panel sections would be connected by an axial joint of a tongue and groove configuration and attached to the adjacent segments with bell and spigot-designed circumferential joints. Both the axial and circumferential joints would be bonded together with epoxy.

Only after the panel dimensions were determined were the panel molds constructed and manufacturing begun. During this time, Affholder excavated an eight-ft diameter shaft at a manhole on Nelson Street to the top of the sewer. Affholder installed the first set of panels in a 40-ft long section beneath Taylor Street. After cleaning the sewer, the construction crew lowered the panels down the Nelson Street shaft and then carried them through the sewer and around the 90-degree bend to the designated location under Taylor Street.

After setting the panels in place with wooden blocks, Affholder bonded them together with epoxy. Once the first 40-ft section was installed, workers finished the installation by grouting the annular space with a cementitious grout. The panels were blocked within the host pipe to fix the line and grade. This process also helped minimize GRP panel deformation during grouting and prevented the panels from moving during high flow conditions before grouting.

Workers then addressed the second part of the rehabilitation project: a 100-ft section of pipe beneath Taylor Street and the Taylor Street/Nelson Street intersection. Seventeen trapezoidal-shaped panels had been custom manufactured that, when fitted together, formed a 90-degree bend. These panels had first been assembled on the manufacturing plant floor to verify the proper alignment. Each joint comprised five-degrees of the bend, which was 36-ft long and included two transition panels.

Lateral Reinstatements

Before grouting the panels into place,

Affholder had to first reestablish the connecting sewers. The contractor completed five lateral reinstatements, including one 30-in. connection in the 90-degree using a saw with a diamond-tipped blade to cut an appropriately sized hole through the panel. The lateral was then reinstated with an inserted PVC pipe set in place with epoxy. After the epoxy cured, the PVC pipe was cut flush with the inside surface of the panel and the annular space grouted.

Because the Taylor Street sewer is a combined sewer, flow during dry weather is minimal. Affholder, therefore, completed its work during dry weather, eliminating the need for temporary flow diversion.

Still, several inches of flow were often present in the sewer during the panels' installation. This environment required the installation crew to pay particular attention to safety and the use of proper materials. The epoxy bonding agent used, for example, was required to be able to cure under water. If proper procedures or materials had not been used, any joint leak would have been quickly found during the grouting operation. The installation crew also had to use precautions when rainfall events occurred and produced high flows in the line.

Monitoring pending rainfall, in fact, required close coordination between Affholder and Fort Wayne officials. While worker safety was their top priority, the crew also had to take measures to protect equipment and secure panels that were already installed. Securely blocking the panels in place before grouting was important to preventing movement during both grouting and rainfall events.

Under the terms of the contract, the project was to be completed in 120 calendar days. Fifty-six days after the "Notice to Proceed" order was given, panels began arriving on the jobsite. It then took 39 days to install the panels and reinstate the connecting sewers. Adding in shaft closure and site cleanup, the entire project was completed in about 113 days.

The Taylor Street Combined Sewer Rehabilitation Project was completed well within the specified schedule and the established budget. The GRP returned the structural integrity to the sewer at the intersection of Taylor and Nelson Streets, while maintaining the pre-rehabilitation flow capacity. Equally important, the daily commuters traveling back and forth on Taylor Street never realized that the old brick sewer lying beneath the street was undergoing rehabilitation. The result was an efficient and economical rehabilitation solution with minimal impacts to local residents and to the environment. GE

Mr. Osborne, P.E., is Engineering Manager, Insituform Technologies, Inc., and can be reached at losborn@insituform.com. All photographs used courtesy of Insituform Technologies, Inc.