Sewer Rehabilitation Using Shotcrete

By Randle Emmrich

For more than 70 years, century-old brick, clay, and tile sewers have been rehabilitated with shotcrete. Most of these sewer systems are found in the United States' major cities where the infrastructure was put into place by hand between 80 and 100 years ago. It is impressive to view the craftsmanship that went into the construction of these miles of pipe. It is just as impressive to witness how well they have held up over time. Unfortunately, most of these systems are reaching or exceeding their life expectancy and are in need of rehabilitation or repair. Enter shotcrete.

All of these sewer systems, whether they are sanitary, storm, or combined, are located under roadways, buildings, and other structures—not exactly convenient or cost-effective for tearing up and rebuilding. Thankfully, these structures do not need to be closed, dug up, or altered for a shotcrete liner to be installed. In fact, most of the time the public is unaware that work is being performed underneath them.

Shotcrete equipment can be set to the side of the road near the manhole used for accessing the pipe. Water in the pipe can be diverted, bypassed, or handled within the sewer line. If the sewer is in structural disrepair, reinforcing steel can be installed and a 4 to 6 in. (100 to 150 mm) shotcrete lining can be constructed (in essence, a new concrete pipe is built inside the existing one using the old sewer as a back-form). If the sewer is structurally sound but is experiencing water leaks, soil infiltration, or loose clay/bricks/tiles, a 3 in. (75 mm) thick polypropylene fiber-reinforced shotcrete lining is sufficient, along with a grouting program to fill any voids outside of the sewer. A shotcrete lining can add 50 years of new life to a sewer.

Most of these old systems are large in diameter (ranging from 4 to 21 ft [1.2 to 6.4 m]) and can be horseshoe, elliptical, or round in shape. Usually the flow in the sewer never reaches full capacity; therefore, a 3 to 6 in. (75 to 150 mm) lining does not impact the sewer's capability of handling peak flows. In addition, the hydraulic capacity can be increased due to smoothing of the lining using shotcrete. Shotcrete is especially beneficial in that it is versatile and can be placed over abnormalities and around tight turns in the system, unlike other rehabilitation liners. In addition, manholes do not need to be enlarged or altered as long as a person is able to gain access to the sewer line. Other rehabilitation liners can require 4 ft (1.2 m) diameter manholes to place the new liner.

Coastal Gunite Construction Company completed the rehabilitation of a large-diameter,

Fig. 1: Existing 100-year-old brick combined sewer

Fig. 2: Installed galvanized welded wire reinforcement (2 x 2 in. [50 x 50 mm], 12 gauge)

brick, egg-shaped combined sewer in late 2013 in Muncie, IN, for the Muncie Sanitary District (MSD). The project was advertised as a cured-in-place pipe (CIPP), modified polymer liner, or shotcrete rehabilitation job. When the bid results were announced, shotcrete was by far the most economically sound option. The sewer is 100 years old (Fig. 1) and the 6500 ft (2000 m) section that was rehabilitated ranged in size from 48 to 56 x 92 in. (1.2 to 1.4 x 2.3 m). There were a few 24 x 36 in. (0.6 x 0.9 m) sections that were subcontracted to Insituform Technologies (a CIPP contractor). The project was designed by GRW Engineers, located in Indianapolis, IN.

This particular sewer rehabilitation project consisted of installing a 3 in. (75 mm) thick welded wire fabric reinforced shotcrete lining around the entire circumference of the sewer line. The sewer was fairly clean of debris, but some root and loose brick removal was required prior to the installation of the wire. The installed welded wire reinforcement consisted of 2 x 2 in. (50 x 50 mm), 12/12 gauge galvanized wire conforming to ASTM A185 (Fig. 2). The wire was placed 1 in. (25 mm) from the existing brick substrate with 1/4 x 3 in. (6 x 75 mm) hook anchor bolts spaced 24 in. (0.6 m) in each direction (Fig. 3).

Coastal Gunite opted to use dry-mix shotcrete batched on-site. The compressive strength requirement was 5000 psi (35 MPa) at 28 days, and was easily accomplished with the site-batched mixture. Once the reinforcement was installed, the shotcrete was placed in two lifts (Fig. 4). To ensure that the required shotcrete thickness was achieved, measuring pins were placed at 5 ft (1.5 m) centers in each direction (Fig. 5). The final finish of the shotcrete was a brush finish parallel to the direction of the flow in the sewer (Fig. 6). Coastal Gunite mobilized in June 2013 and all shotcrete lining was

Fig. 3: Close-up of wire reinforcement lap and brick substrate

Fig. 5: Measuring pin installed to ensure correct thickness of shotcrete

Fig. 4: First lift of dry-mix shotcrete

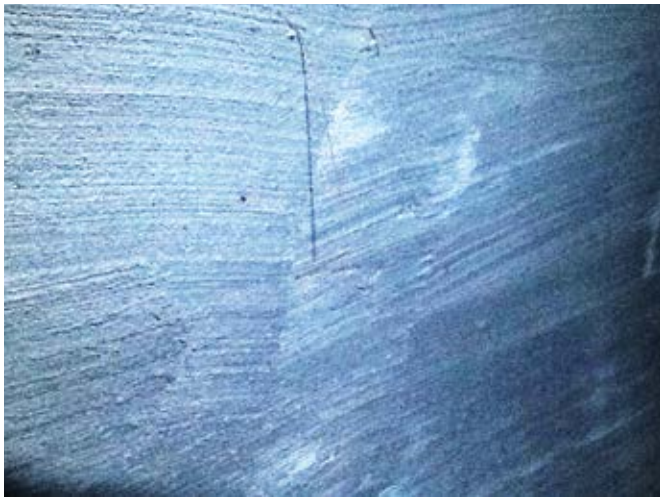

Fig. 6: Brush finish parallel to the direction of the flow

completed by December 2013 before cold and wet weather became an issue.

One complication encountered throughout the project was the control of water—not the flow inside the sewer pipe itself, but the seepage of groundwater through the invert. Due to the age of the sewer and the brick composition, the grout between the bricks was deteriorated (or missing!) in many sections, allowing a steady stream of groundwater to infiltrate the system. This was not discovered until a complete bypass system was established to handle the internal flow of water.

Because shotcrete cannot be successfully installed on top of running water, Coastal Gunite had to determine how to prevent/control the external infiltration of water into the pipe system's invert. Solutions considered included external grouting, wellpointing, and diversion. In this instance, the chosen solution was a wicking product to divert the flow away from the shotcrete during placement.

MSD was pleased with the end result and satisfied that they obtained a liner that would last for many years to come (Fig. 7). They were also happy that the roadways were left undisturbed, the traveling public was detoured in only a few areas, and the aboveground site conditions were restored to conditions better than they were prior to the start of the project. The largest benefit to MSD was the savings they gained by choosing shotcrete over another lining system. Coastal Gunite was happy to learn that the city of Muncie, IN, will consider the use of shotcrete to rehabilitate more of their aging sewers in the future and tell other municipalities about their positive experience.

Fig. 7: Finished shotcrete lining

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