CASE HISTORY

Centrifugally Cast Fiberglass-Reinforced Polymer Mortar Pipe for a Large-Diameter Interceptor Sewer

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This article discusses one city's approach to preserving the integrity of its infrastructure through the use of corrosion-resistant piping systems. Technological developments in centrifugally cast fiberglass pipes have provided installation advantages and lifelong benefits to municipalities.

The City of Los Angeles operates more than 620 miles (998 km) of sewers, numerous pumping plants, and four wastewater treatment plants. These serve more than 3 million people, plus commercial and industrial facilities. The city's sewage and storm drainage system is complex and sometimes overloaded, and often needs updating and expansion to meet the demands of the growing population.

Over the years, Los Angeles has dealt with some serious problems with system capacity, especially with the city's North Outfall Sewer system (NOS), an elliptical brick sewer that was completed in the 1920s and extended in the 1940s. Beginning around 1993, centrifugally cast fiberglass-reinforced polymer mortar (CCFRPM) pipe was used to rehabilitate much of the lower end of NOS, one of the largest outfalls within the city. The rehabilitation took place over several years and included a number of different projects.

Fiberglass pipes are generally one of two types. They are either filament-wound or centrifugally cast. Figures 1 depicts centrifugal casting of fiberglass pipes. The materials are placed in multiple layers, building from the outside to the inside using mold rotation to achieve forces of up to 70 g's. Manufacturing of fiberglass pipes by centrifugal casting began in the 1950s when a Swiss textile manufacturer, seeking a replacement for the traditional wooden rollers, invented the process. The filament-winding process, already established at that time, was found to be unsuitable because the outside surface produced was not smooth enough. Soon the glass fiber-reinforced polyester resin system was expanded and promoted as a piping product. This pipe manufacturing technology came to the United States from Europe in the late 1980s. Many of the same qualities that made it acceptable as a textile roller are now being realized in trenchless piping installations, and the use of CCFRPM pipes for infrastructure applications is growing. To date, more than 3.8 million ft (1.2 million m) of CCFRPM pipe have been installed. The predominant growth has been in the large-diameter sanitary sewer market because of the material's corrosion resistance.

CCFRPM pipes have been used in the Los Angeles area, including the city and surrounding county, since 1989. A total of 50 miles (80 km) of CCFRPM pipe ranging from 24 to 96 in. (0.6 to 2.4 m) in diameter has been delivered. These rehabilitations accomplished several goals for the lines: they provided structural in-

FIGURE 1

Centrifugal casting of fiberglass-reinforced mortar pipe occurs with materials being placed (glass shown left, resin right) within a rotating steel mold.

FIGURE 2

Induced ring flexural strain level tests on CCFRPM segments.

tegrity, stopped corrosion, provided leak-free systems in the area of the rehabilitation, and often maintained or increased flow capacity.

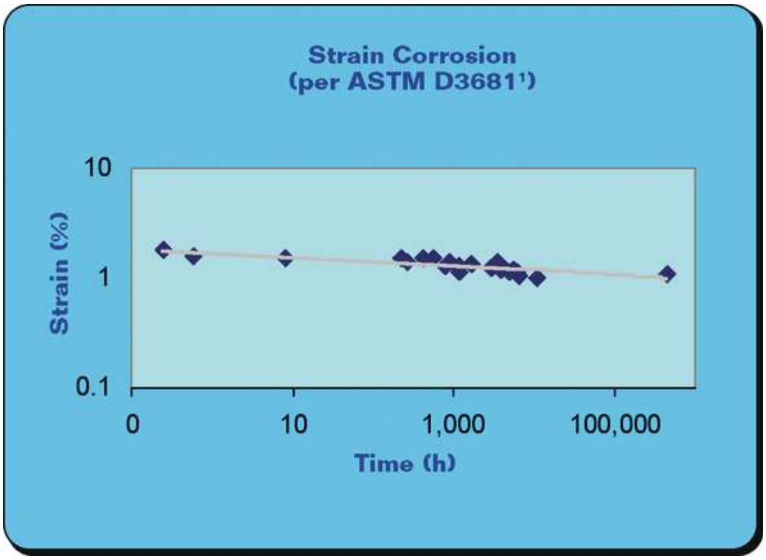
Hydraulic considerations are usually a major factor when determining the suitability of an existing sewer line for rehabilitation. In many cases, a smaller relining pipe can actually increase flow relative to the larger existing host pipe. Slip-lining does decrease diameter, but this is usually offset by the much-improved hydraulics of the new liner pipe relative to the deteriorated existing pipe. Especially in larger diameters, it is not only possible but also typical to achieve higher flow capacity once the line has been rehabilitated.

It is important to consider the total installed life cycle cost of the project, and trenchless installations are no exception. A true cost comparison must also consider the costs incurred or avoided throughout the design life of the sewer. The total cost includes expenses experienced over the study period to operate it, maintain it, repair it (if necessary), and ultimately replace or rehabilitate it, not just to purchase and install it. By recovering all of the potential flow capacity from the existing infrastructure, the asset can be preserved and future costs can be delayed.

Yet, despite the city's extensive rehabilitation, in 1998 several communities in South Los Angeles were affected by sewage overflows caused by insufficient capacity of the existing system. The heavy El Nino rains were too great a burden for it to handle. To rectify the situation, the Regional Water Quality Control Board issued a cease and desist order requiring the City of Los Angeles to upgrade the sewer system serving the center of the city and setting a specific time limit for the work.

A lengthy environmental study was conducted and further improvements to the existing NOS and construction of a new sewer were recommended. The city determined that the best way to relieve the wet weather sewage overflows and provide needed capacity for future population growth was to construct a new sewer. The East Central Interceptor Sewer (ECIS) was designed to relieve and augment the NOS. The entire project is designed to provide sufficient waste water capacity until at least 2050. CCFRPM pipe was specified as a material for the new ECIS construction. A variety of

FIGURE 3



Induced ring flexural strain levels vs time to failure for each test specimen. Test results are used to predict life expectancy.

FIGURE 4

84-in.-diameter 600-ton axial capacity CCFRPM being lowered into the jacking frame.

factors influenced the specification, including corrosion resistance, historical performance, and constructability.

To demonstrate the expected life in an acidic environment, such as the city's sanitary sewers, CCFRPM pipes must be tested in accordance with ASTM D3681[1] and D3262.[2] The accelerated 10,000-h test in 1 normal sulfuric acid (H_2SO_4) solution (pH 0.3) has become the basis for design life due to corrosion in sanitary sewer environments (Figures 2 and 3).

An 84-in. (2.1-m)-diameter CCFRPM pipe was installed by microtunneling for the section of outfall, which connects the old NOS to the new ECIS tunnel. Figure 4 shows a 10-ft (3-m)-long pipe being placed into the jacking frame. The microtunneling installation then inserted the pipe directly behind a tunneling machine. The soil was removed by a slurry system and the line and grade were controlled with precise laser equipment. Figure 5 shows a member of the construction crew monitoring progress of the jack and the slurry removal that runs beneath him.

For an adjacent piping reach, 66-in. (1.7-m)-diameter pipe was installed by traditional tunneling methods. This consisted of placement of a primary tunnel with the corrosion-resistant liner material inserted within. Next, the liner was blocked in place and the annular space between the primary liner and the carrier pipe was grouted in place using cementicious grout material. The 66-in.-diameter pipe was part of a siphon that also included additional 66-in.-diameter pipes placed by microtunneling methods as three air jumpers above the siphons. Several special fittings and pipe sections were supplied for various locations, including 78-in. (2-m) segments for the drop shaft.

The need for three parallel tunnels with minimal clearance of <2 ft (0.6 m) between the three lines was one of the reasons for the use of the 66-in. CCFRPM pipe. CCFRPM pipes have an efficient pipe wall cross-section with a high strength-to-weight ratio that permits a thinner pipe wall. The high modulus, high compressive strength CCFRPM pipe material is achieved by the engineer's placement of materials. The glass fibers are oriented predominantly near the outside and inside of the pipe wall, near the areas of highest hoop bending stress.

Conclusions

Now that the ECIS is in service, it will provides hydraulic relief for the current

FIGURE 5

Segmental pipes being continually jacked forward as excavated material is removed via a slurry system.

at-capacity sections of the NOS, as well as capacity for future increases in flow. The project will help minimize odor complaints by diverting flows out of the NOS. Additionally, completion of the ECIS sewer tunnel will allow the middle section of the NOS system to be closed for cleaning, repairs, and rehabilitation. Extensive infrastructure improvement projects continue in this and other areas of the country with CCFRPM pipes.

References

1. ASTM D3681, "Standard Test Method for Chemical Resistance of 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition" (West Conshohocken, PA: ASTM, 1996).

2. ASTM D3262, "Standard Specification for 'Fiberglass' (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe" (West Conshohocken, PA: ASTM, 1996).

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