

GEOSPRAY®

Geopolymer Mortar



STORM & SANITARY

CASE STUDY: Pipe Rehabilitation, City of Columbia

BACKGROUND

The Columbia Canal Water Treatment Plant, along with the second Lake Murray Water Plant combine to make up the major treatment operations for Columbia Water. Columbia Water maintains the drinking water treatment, distribution and storage system that services the City of Columbia in South Carolina and major portions of Richland County, some parts of Lexington County, and other local communities. The combined Columbia Canal and Lake Murray plants have a 150 MGD capacity and serve approximately 375,000 customers. The distribution system has more than 2,400 miles of water lines, pump stations, storage tanks and pressure reducing valves that distribute water across 9 major pressure zones.

ISSUE

In 2017 the City of Columbia began a \$45 Million overhaul and renovation of its downtown Columbia Canal Water Treatment Plant. The upgrades of the WTP were in addition to the project to repair the adjacent Columbia Canal, which breached during the historic flooding of October 2015. This 100-year flood turned out to be 10 times worse than expected and caused the greatest crisis in the water department's history. During the flooding the nearly 200-year-old Columbia Canal wall gave way, forcing the first ever system-wide, boil-water advisory. The levels of the Broad and Congaree rivers rose more than 12 ft above normal levels and water rushed into the Columbia Canal. Dating back to the 1820s, the canal once served as a shipping lane for cargo. A hydroelectric plant was added in the 1890s, which was still supplying power to the grid up to the time of the flood. The canal is also the source of water to the treatment plant's 60-million-gallon reservoir. While a temporary dam was installed by the National Guard to restore the City's water supply, a long-term rehabilitation solution was required to restore and service the needs of the community.

The City had known that the canal was a critical point of concern and had been working to understand and test rehabilitation options since the late 1990s. While sections of the canal are open channel, other sections included brick arch tunnels that range in size from 4 ft x 6 ft to 8 ft x 8 ft and are used to carry runoff under the emergency water reservoir prior to discharge into the Broad river. These sections fell under the operation of the water treatment plant specifically and were not part of the larger repair of the open channel canal.

PROJECT DETAILS

Location: City of Columbia, South Carolina

Application: Brick and granite water canal

Installation: June 2019

Client: City of Columbia under

Contractor: Pizzagalli Construction Company

Product used: GeoSpray



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OPTIONS

The existing storm water conveyance tunnels were originally constructed of brick and granite arched pipes. The City began to investigate the options for restoration and rehabilitation of the tunnel, many of which were quickly decided to either not be feasible or practical as a repair. CIPP was ruled out due to both the size and the shape of the tunnel, and it was determined slip-lining would restrict the area of flow too greatly due to the changing size and shape of the structure. They also decided against other custom-grouted liners due to cost, lead time, and construction duration.

In 2011, the City learned of a new technology, geopolymer mortar spray-applied rehabilitation, that was being marketed to the City by an existing contractor, Inland Pipe Rehabilitation (IPR). The technology offered a geopolymer mortar to structural repair and line large diameter structures. Based on the timing, constructability and cost consideration, the City decided to do a pilot project using the technology.

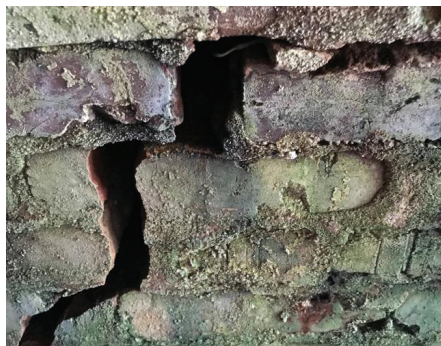
SOLUTION

In late summer of 2012, the City of Columbia under Pizzagalli Construction Company, the general contractor for the wastewater treatment plant rehabilitation, sub-contracted a 440 linear ft section of 72-inch x 60-inch concrete and stone tunnel to IPR. It was the City's first project with spray-applied geopolymers and offered the City a long-term look at the technology. Prior to specifying the remainder of the storm water conveyance tunnel running under the WTP, the City conducted a complete inspection of the pilot project and found the structure to be unchanged since its installation five years prior. The image to the right shows the inspection conducted in 2018.



In order to expedite funding of the conveyance tunnel rehabilitation, the scope was included as part of a competitive low-bid project for a \$45 million plant upgrade. Inland Pipe Rehabilitation (IPR) was selected by the low-bid general contractor, Adams-Robinson, based largely on three factors – prior experience with the pilot project on this conveyance tunnel, good standing relationship with the City, and proximity of their office to the jobsite to reduce mobilization costs.

The project was awarded to IPR with work starting in June 2019. The contractor chose GeoSpray® geopolymer mortar produced by GeoTree Solutions. The full project consisted of lining 120 linear ft of 54-inch x 72-inch arched brick pipe and 455 linear ft of 96-inch x 96-inch arched brick pipe. Much of the existing material had granite blocks in the lower section of the pipe and brick in the arch. Many sections had severe deterioration.





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In order to apply a geopolymer liner, all active water flow must be stopped, including infiltration. The existing structure had in some cases nearly 24-inches of granite or brick, this material had either significant areas of missing mortar or areas where mortar was likely never present. To stop the active infiltration, injection grouting with hydrophobic grouts was performed in problem areas. Additionally, once grouted and cleaned, the entire structure was pressure washed and prepared for lining.

Prior to any work starting a temporary by-pass was installed. At the North East tunnel locations a retention pond was built with sandbags upstream of the tunnel. A two-inch electric submersible pump was dropped into the pond. The discharge of the pump was attached to a two-inch PVC pipe, which was attached to the brick wall of the tunnel for 70 ft discharging the water into the pipe downstream beyond the repair area. All voids in the floor were drained from upslope to down slope, then low strength flowable fill was poured into the voids to level the existing conveyance tunnel floor. Next the two-inch PVC pipe was dropped to the floor until the walls were hand sprayed with the geopolymer repair mortar then reattached to the tunnel wall while the floor was then hand sprayed with the geopolymer repair mortar.

At the South tunnel a retention pond was built with sandbags upstream of the manhole in the clear-well (our access point) and upstream of the tunnel repair area. A 6-inch Godwin HS 150mm hydraulic pump was installed at ground level at the access point with 40 ft of suction hose attached. Two-hundred ft of rubber discharge hose was attached to the pump head inside the manhole and discharged into the canal. All voids in the floor were drained from upslope to down slope then flowable fill was used to fill voids and level the tunnel invert. These pumps ran until the linear application was complete.

At the downstream discharge to the river a large sandbag dam was constructed in a ditch between the river and the tunnel to keep a possible rising river out of the tunnel. The contractor installed 3-inch and 4-inch pumps with 30 ft of suction hose in the ditch and 150 ft of suction hose was installed to carry water to the river with filter bags attached to the ends. All pumps were monitored and checked around the clock and ran until the lining was completed.

One of the more challenging aspects of this rehabilitation was the section that runs underneath the treatment plant that had significant infiltration. The original plan was to use a polyurethane injection grout to provide a protective sheet from the soil surrounding the tunnel. However, the recent flood waters left a portion of the tunnel with no surrounding soil, as it was washed off when the dike was breached. Consequently, the contractor elected to first spray the geopolymer lining, then apply an injection grout between the geopolymer lining and interior brick wall.

The project was divided into three sections. The first was approximately 455 linear ft and the other were each approximately 60 linear ft. The first step of the application was to pour a 2 ft thick floor to the structure with a low strength (3000 psi) compressive strength flowable fill concrete. This was necessary to smooth and level the full section of the tunnel floor, allowing improved hydraulics and facilitating hand-sprayed lining operations. Pouring the floor for the whole project length took two days. Preparation and grouting of each of the sections took approximately one to two days per segment.



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Once the floor was poured the conveyance tunnel was prepared to receive the lining. The contractor hand-sprayed the geopolymer mortar to create the required design thickness. The material was pumped up to 500 feet after being mixed on the surface, and the thickness was built up over several applications. Typically, for hand-spray applications, material will first be applied on the tunnel wall near the invert, then on the vertical wall and then on the crown. The final application being applied to the invert. One of the key advantages of this specific geopolymer mortar is that it bonds chemically to itself and doesn't allow for the formation of a cold-joint which may occur on multi-layer applications of other cementitious materials. The 455 linear ft section took eight days to spray and the other two sections took less than two days each.



The full project construction of the conveyance tunnel rehabilitation was completed in under three weeks. After the liner was completed a pressure grouting technic was used to grout behind the lining and stabilize the soil, this required cutting ports into the lining that were then repaired with the same geopolymer after the grouting was complete.



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