A custom-made pipe carrier and pusher was designed to install the 120-in. CCFRPM pipe. Photo credit: Buller Photography

Help for Houston

By Erin Boudreaux

Centrifugally cast, fiberglass-reinforced, polymer mortar pipes installed beneath the city surface

The city of Houston operates and maintains approximately 6,000 miles of gravity sewer with diameters from 6 to 144 in. The average daily wastewater flow through the system is estimated at 277 mgd. Some of these sewers are 80 ft deep, and the city's extensive urban population makes accessing them for inspection and repair difficult.

Constructed in the mid 1980s, the Northside Sewer Relief Tunnel (NSRT) was the largest of Houston's deep sewer tunnels. In 1988, the NSRT was completed and put into service. It was lined with a mechanically attached liner of high-density polyethylene (HDPE). In the early '90s, sections of the liner began to fail leading to overflows and the liner's removal. In 1994, an inspection found that more than half of the tunnel showed signs of corrosion.

In early 2000, multiple engineering firms began designing the rehabilitation of about 8 miles of the reinforced concrete pipe (RCP) tunnel. This was known as the Northside Sewer Rehabilitation Program. Due to funding constraints, these projects were put on hold until around 2007 to 2008 and beginning with the largest diameter sections first, NSRT was bid in phases.

Innovative Installation Techniques

NSRT - Area 5, Phase One was put out to bid in September 2011. It was decided in the design process to slipline the RCP with Fiberglass Reinforced Thermosetting Plastic (FRP) pipe. Boyer Inc. of Houston was awarded this phase. The company installed 2,200 ft of 120-in. centrifugally cast, fiberglass-reinforced polymer mortar (CCFRPM) pipe. The flush reline CCFRPM pipe was manufactured by Hobas Pipe USA of Houston. The existing tunnel was approximately 132 in. in diameter, and the 120-in. CCFRPM pipe has an outside diameter (OD) of 126 in.

"This size pipe had never been installed before inside a 132-in. tunnel and Boyer was ready to take on the challenge. In fact, Hobas had never manufactured this size pipe before," said Datta Shirodkar, P.E., project manager, Boyer Inc.

NSRT - Area 5, Phase One was designed by the engineer as a sliplining project to install the pipe in live flow.

"We knew from the beginning that it was not possible to install such a large pipe in minimum live flow and decided to carry the pipe in place one joint at a time. Bill Ofiel, one of our senior project managers, designed a custom pipe carrier to transport the 120-in. pipe inside the 132-in. tunnel and a custom pipe pusher to push one joint of pipe into another [bell-and-spigot connection]. Boyer Inc. also developed a way of making miters on site by cutting two pieces of pipe at an angle and then joining the pieces together using a FWC coupling. This method of making miters using FWC couplings was used on smaller size pipe but never on a pipe with 126-in. OD," Shirodkar said.

"The size and weight of the pipe along with the constraint of installing it inside a 132-in. ID [inside diameter] tunnel forced us to think outside the box and come up with new and innovative methods. There were a lot of stressful moments and passionate discussions within our team during the course of this project and the successful installation of the pipe without any re-work made it all worth the effort," he said.

Restoring Structural Integrity

NSRT - Area 4 bid in April 2012 and consisted of about 4,900 ft of the same 120-in. flush reline pipe. Oscar Renda Contracting of Roanoke, Texas, was the low bidder on NSRT - Area 4. NSRT - Area 5, Phase Two was awarded to Oscar Renda in March 2014 and they installed 3,000 ft of 120-in. pipe in early 2016. Before Oscar Renda could begin the installation, they had to prepare the existing tunnel.

"Most of the joints had deteriorated and were leaking groundwater. The former corrosion protection system was in disrepair and had to be removed. Finally, many areas of the tunnel contained up to 3 ft of debris that had settled into the existing system. The cleaning process required us to remove the debris as well as sheets, battens and anchors from the protection system," said Bart Adams, Houston area project manager, Oscar Renda Contracting.

In addition, Oscar Renda prepped the tunnel by essentially pressure washing it to remove any loose debris and inject the joints to stop the groundwater infiltration.

The flush reline pipe was manufactured with a flush bell-spigot. The flush bell-spigot joint consists of an integral straight bell fixed to one pipe end that seals to the spigot end of another pipe by compressing an elastomeric gasket contained in a groove on the spigot. An important characteristic of this joint in relation to this project is that the joint has approximately the same outside diameter as the pipe, so when assembled, the joint is essentially flush with the pipe outside surface.

"This allowed a clearance of only 3 in. around the pipe and a very tight fit. The existing tunnel was 50 to 60 ft below grade and only a limited number of access shafts were installed," Adams explained.

Overcoming Challenges

A project of this scope has its challenges. During the bid phase there was no confirmed method of bypassing the flows in the Northside Sewer system. The exact flows going through the NSRT 4 portion of the system were not known at the time of the bid. The bid documents explained that the contractor was responsible for bypassing, blocking and/or diverting 33 mgd of average daily flows. After the system was installed, adjustments had to be made due to the average daily flows being much higher than anticipated.

"The biggest issue for the NSRT 4 project was how to bypass the flows in the system. The city of

Houston Wastewater Operations was a big help in working with us to figure out the best route to divert the flows within the system to maintain operations and be able to install the pipe," Adams said. "Over several months, many coordination meetings were conducted, and several iterations of the bypass system were developed before Oscar Renda and the city of Houston were able to agree on a path forward. An additional complexity to the NSRT 4 project was that both projects were dependent on the same bypass system. An additional bypass system was set up on the NSRT 5 project to bypass additional lines coming into that system. All flows were being diverted to the 69th Street Wastewater Treatment Plant."

The traditional segmental slipline installation method of a liner pipe being pushed or pulled into an existing pipe, usually during episodes of live flow, was not utilized on this project. The existing RCP tunnel was made of mitered sections that would not allow the traditional sliplining method. Instead, a combined method of sliplining and tunneling was used to install the new 120-in. pipe. The pipe sections were carried into place and assembled inside the tunnel, much like a two-pass operation with the host pipe serving as the primary tunnel. There are a number of curves throughout both phases; this along with the condition of the existing RCP made traditional segmental sliplining difficult.

"Sliplining could not be used because the relining pipe could not be pushed through the mitered sections of the existing tunnel using a true sliplining method. Pipe carriers had to be used in order to take individual pipe pieces through the tunnel to the point of installation. Extensive surveying and modeling was used to map the miters in the existing tunnel. This information was used to develop the layout for the reline pipe segments. During the installation, once the straight run of pipe reached a mitered section, dimensions were confirmed, and a system was developed in the field to miter each section of pipe as required. This method allowed us to make adjustments in the field in order to minimize delays to the installations," Adams said.

Hobas manufactured the pipe in varying lengths to assist with this process.

"The Hobas FWC gasket-sealed, push-on coupling seals directly to the unmodified exterior pipe surface. Since the OD is constant along the entire pipe section, field length changes may be accomplished by simply cutting the pipe at the desired location, chamfering the cut end and joining with the FWC coupling. This is true for pressure applications as well as non-pressure service," said Randy Whiddon, field service manager, Hobas Pipe USA.

Successful Installation

Approximately 10,000 ft of 120-in. CCFRPM pipe was installed deep beneath Houston. Creative installation techniques allowed for a successful project. The remaining phases of the NSRT currently are under design. w&wd

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