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REHABILITATION OF 100 YEAR OLD STORM WATER CULVERTS

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Central Avenue in Baltimore, Maryland is a major artery that has 4 driving lanes, 2 parking lanes and a 20 foot wide median for most of the project length. Under the median, in the center of the street, is a storm drain that is over 100 years old. For this project about half the pipe length is brick and the remainder is cobblestone. When built, Central Avenue, was a divided street with a canal in between carriageways. Originally it was named Canal Street. The canal became a drainage way and eventually replaced by the brick/stone storm drain and the area around the pipe filled in. The top of the culvert is only 2 to 6 feet below the road surface. At several locations where there is a cross street, the pipe had failed and was previously repaired in the form of timber or steel struts. Some of these median crossings were barricaded to prevent traffic loads on the pipe. As part of the $27 Million reconstruction of Central Avenue, the City of Baltimore decided to structurally rehabilitate the existing failing brick/stone culvert. The culvert consisted of 7 different sizes and shapes ranging from a 5 ft. high by 7.5 ft. wide oval to low arch pipes up to 6 ft. high by 16 ft. wide. The majority of the 3,275 linear feet of pipe rehabilitated was the latter (see Figure 1).

Figure 1 – Existing Storm Culvert

There were many challenges that had to be overcome; low working headroom in the existing culvert and even lower in the rehabilitated pipes (as low as 2.8 ft. in the center and 1.5 ft. at the sides so the crews got very good at “Duck Walking” by the end of the projec), evacuation during storm events, continuously bypass pumped base flow and the downstream 500 ft. was affected by tidal backflows from the Baltimore Harbor outfall. For the most part, traffic control was not a problem since the work was accomplished in the median.

The culvert rehabilitation had to be completed before the majority of the roadwork could start. The culvert rehabilitation subcontractor Boyer, Inc. of Houston, Texas selected the Danby Pipe Renovation system for this project. Danby consists of PVC panels that are mechanically sealed and locked together resulting in a watertight and corrosion resistant form for the high strength cementitious grout which fills the annular space between the liner and the host pipe. The installation sequence was as follows:

1. The culvert was cleared of sediment and debris, consisting primarily of loosened bricks or stones that fell from the ceiling and sand/silt deposited from storms.
2. All the interior surfaces of the drain were cleaned with a high pressure water blast.
3. The steel rebars on the sides and top were placed according to the contract drawings.
4. Steel slab bolsters were installed longitudinally in the bottom as spacers for the bottom PVC panels.
5. The bottom panels were installed, 90° PVC corner fittings attached, and the vertical side panels placed (see Figure 2).
6. The bottom panel bracing system was a combination of steel and wood sections braced to the ceiling.
7. High strength cementitious grout was poured to fill the annular space under the bottom panels and a few inches up the side panels and allowed to obtain an initial set.
8. Curved corner panels bent to the required angle were placed on top of the side panels. The angle varied depending on the size and shape of the culvert.
9. Grout was poured behind the curved corner panels.
10. The grout was allowed to set and the bracing and forms moved to the next section.
11. The top panels were installed.
12. Moveable bracing was placed to support the top panels (see Figure 3).
13. Top panels were grouted.
14. After the grout reached a strength of at least 2,000 PSI (about 24 hours), the bracing was moved to the next section (see Figure 4).

Figure 2-Reinforcing, Bottom & Side Panels

Essentially this was a "leapfrog" type of installation where the crews kept moving ahead and were working on different aspects of the installation as each sequence was completed.

Figure 3-Top Panel and Moveable Bracing

The grout was a 5,000 PSI compressive strength design mix which consisted of Portland Cement, fly ash, sand, ground granulated blast-furnace slag and super-plasticizer. The test

cubes consistently broke at 9,000-10,000 PSI. Since this was a shallow pipe and the culvert was under the roadway median, it was not necessary to pump the grout. Holes were drilled down from the surface into the existing drain and 4" PVC pipes were installed. The grout was delivered in transit mix trucks and poured through a funnel arrangement into the 4" pipe and into the culvert. It was directed to the bottom panels and curved corner panels through piping connected to the 4-inch down pipes. The top panel was grouted directly. The Grout injection pipes were placed about every 25 linear feet. A total of 4,400 CY of grout was used for the 3,275 LF of rehabilitated pipe with 118 CY being the most placed on a single day. The manner in which the grout was placed insured that the entire annular space between the liner and the host pipe was completely filled with grout. Since the grout is very fluid when placed, it flowed into any cracks and replaced any missing mortar or bricks creating a solid composite structure.

There were numerous service connections and connected drains ranging from 4-inch VCP to 54-inch diameter brick, including some box shapes that all had to be connected and sealed.

Figure 4-Completed Rehabilitation

The $9 Million rehabilitation portion of the project was successfully completed in July 2013. The result is a storm culvert that will support the current and future traffic loads, has an increased hydraulic capacity in spite of the reduced cross-section due to the smooth liner surface, a corrosion resistant pipe that is sealed against infiltration and exfiltration and a part of the City's storm system that will be worry-free in the future. All the stakeholders; the Owner, design engineer and the construction manager were extremely pleased with the finished product and we anticipate that the rehabilitated storm drain will function for at least another 100 years.

Owner: City of Baltimore Department of Transportation
Design Engineer: Whitman, Requardt & Associates, LLP
General Contractor: Monumental Paving
Liner Installation Subcontractor: Boyer, Inc.
Liner Supplier: Danby LLC

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