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JULY 2022

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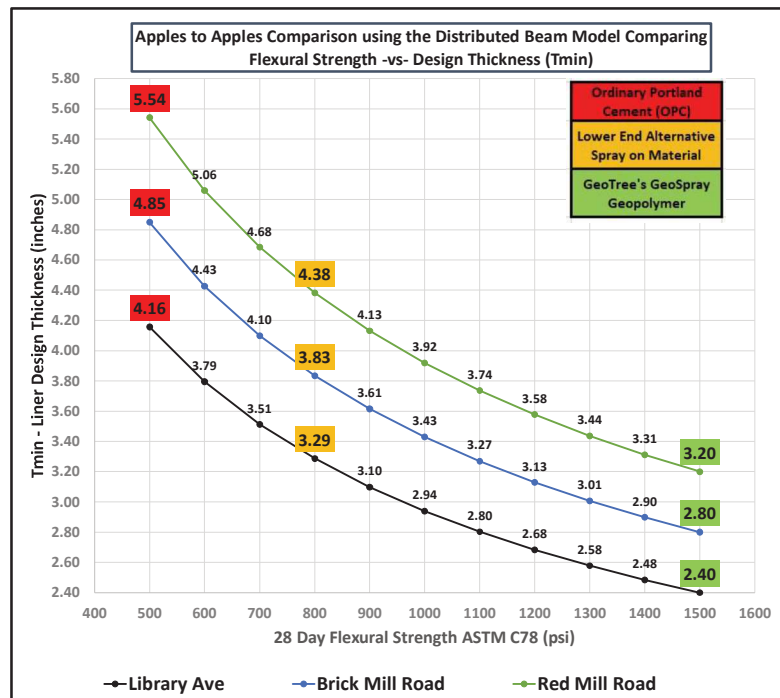
DELAWARE DOT FIRST LARGE DIAMETER METAL PLATE ARCH REHABILITATION WITH UNREINFORCED GEOSPRAY GEOPOLYMER MORTAR

Scott Naiva, P.E.

The Delaware Department of Transportation (DelDOT) has completed its first large scale metal plate arch rehabilitation using GeoTree Solutions' GeoSpray geopolymer spray on mortar. The project included work at three locations with corrugated metal pipe arches ranging from ~7 ft x 10 ft to ~10 ft x 17 ft for a total length of 608 lf. The work included application of a geopolymer structural liner and installation of riprap at the inlet and outlets. The geopolymer liner design assumed the existing pipes were fully deteriorated and utilized the distributed beam liner design method requiring an unreinforced geopolymer mortar liner ranging from 2.4 to 3.2 in. thick (see summary table below). This created a corrosion resistant, unreinforced structurally independent, new pipe inside the old pipe structure with a life expectancy of 70 to 100 years.

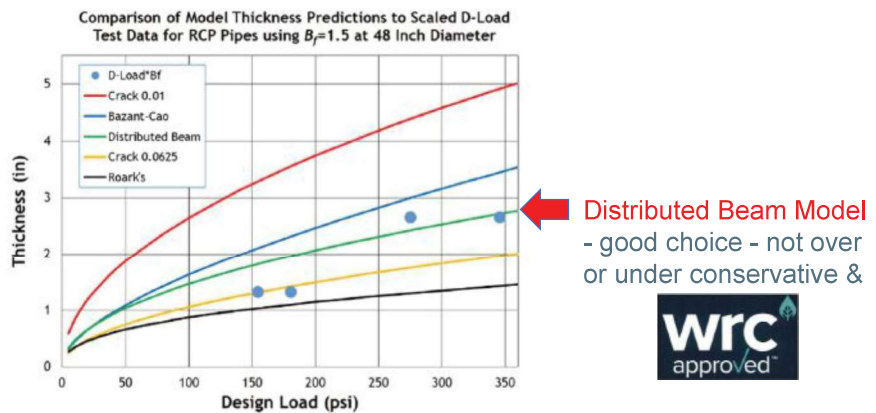
1. Library Ave – a single barrel corrugated metal pipe arch 7 ft 5 in. x 10 ft 2.5 in. pipe at 116 ft = 116 lf at 2.4 in.
 2. Brick Mill Road – a triple barrel steel plate pipe arch 8 ft 11 in. x 14 ft 3 in., three pipes at 92 ft = 276 lf at 2.8 in.
 3. Red Mill Road – a double barrel aluminum plate pipe arch 9 ft 11 in. x 16 ft 8 in., two pipes at 108 ft = 216 lf at 3.2 in.
- Total = 608 lf

The successful construction project was completed during cold weather conditions in January and February 2022 to meet an environmental requirement to be out of the stream by March 1. At DelDOT, any culvert with an opening more than 20 sq ft is considered a bridge. The project



↑ Figure 1

RCP DATA -VS- 5 MODEL PREDICTIONS - 48" PIPE



↑ Figure 2

manager from DelDOT - Jonathan Karam, P.E., estimated that if they had to carry out three full bridge replacements, it would have taken a minimum of six to nine months and had a far greater impact on the environment and the traveling public. Karam said, "By utilizing Accelerated Bridge Construction (ABC) techniques to rehab the existing pipes with a geopolymer liner, the construction duration was reduced to a total of seven weeks and made it possible to be out of the

stream by the March 1 deadline."

Aside from full replacement, Karam indicated that DelDOT also considered several other rehabilitation options. Sliplining was eliminated as it decreased the hydraulic capacity. Cured-in-place pipe (CIPP) was not economically practical at this size and there were concerns about styrene resin getting into the environmentally sensitive streams. Ordinary Portland Cement (OPC) lining was not considered due to challenges with this



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material on other projects and the OPC weaker flexural strength would have required a greater thickness than the GeoSpray geopolymer. See figure 1, which shows the direct relationship between flexural strength and liner thickness using the distributed beam design method.

Scott Naiva, P.E. is the Northeast Region manager for GeoTree Solutions, which manufactures GeoSpray geopolymer mortar. He stated that getting concurrence on selecting and specifying a spray-applied liner design methodology is a challenge as there is not currently a specific ASTM design method that everyone is adhering to. There are easily six or more different design methods that could be picked from, and selecting one is necessary so that all bidders will be providing equivalent load bearing designs for an equal apple to apple bidding scenario. To avoid leaving a gap in the project contract documents, DelDOT in conjunction with its third-party engineering consultant, Houston Brown, P.E., from Pennoni, selected and specified the distributed beam design methodology. This was chosen primarily because it was approved by the Water Research Centre (WRC), based on research performed by the Louisiana Trenchless Technology Center and presented to the Transportation Research Board's 2019 annual meeting. This research paper and presentation can be found at trb.org. Look for: TRB 19-01481 - "Laboratory testing and analysis of geopolymer pipe-lining technology for the rehabilitation of sewer and stormwater conduits." The research shows the distributed beam to be a solid reasonable design method that is not too under or over conservative. See figure 2

The general contractor project manager was Matt Arminger from JJID. Arminger said to meet the March 1 deadline, they had to coordinate working three crews concurrently, one at each



↑ Photo 1



of the three locations. Each location took an average of 17 days to complete. JJID managed the internal and external bypass and their trenchless pipe rehabilitation contractor was Entech Construction. Entech was responsible for shotcrete hand application of the GeoSpray geopolymer mortar. Picture 1 shows a typical internal bypass. Fortunately, JJID only had to manage the normal dry weather flow because when a storm came up, Entech could easily stop its spray application and permit the storm to pass through the pipe

Naiva indicated that in the world of spray on liner systems within corrugated metal pipe (CMP) or plate steel arches, another aspect that is

up for debate is the question of filling the corrugations prior to applying the liner design thickness. Filling the corrugations is not required from a structural standpoint, but it can provide additional strength and improve hydraulics. In this case, DelDOT decided to fill the corrugations and Entech hand-troweled the liner for a smooth finish. This type of approach likely provided a finished manning N somewhere between 0.012 and 0.015. To be conservative, Pennoni used 0.015. The existing and proposed structures were both analyzed to investigate the effects of the liner in-

stallation on hydraulic performance. The proposed pipes are considered to perform similarly to the existing structures as the reduced hydraulic opening was offset by a smaller manning's number.

Effectively, compared to full replacement, the end result is what looks like a new concrete pipe that extends the life of the assets an estimated 70-plus years at a fraction of the time, cost and environmental impact. Overall, the project was a success and DelDOT will be looking to use this technology again in the future.

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