CAMERON RUN TUNNEL REHABILITATION

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The Cameron Run Flood Tunnels consisted of seven 6.1m diameter drainage tunnels ranging from 52.3m to 67.7m long that were in need of repair (Figure 1). The tunnels, built in the early 70's, have experienced excessive deformation in the liner plates. In some areas above the springline, deformations exceeded 0.3m. Due to this movement, the City of Alexandria had shored the tunnels with 0.3m wood timbers in a crisscrossed configuration to try and prevent further deformation. These timbers however created another problem of preventing steady flow of floodwaters. The average water depth flowing through the tunnels were not more than 76mm, however during heavy rain water depths would reach as high as 3.0m (Figure 2).

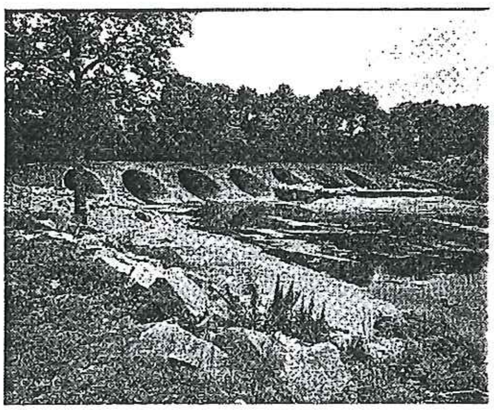

Figure 1.

Figure 2.

The challenges on this project were to repair the deformations in short order while not interrupting the tunnel's ability to handle the drainage of floodwaters. In addition, preventing any settlement of the two active CSX lines running above the tunnels added to that challenge.

The construction parameters of significance were:

- Tunnel repair
- Maintain uninterrupted water flow
- Prevent settlement of active railroad lines above tunnels
- Schedule work during low water flow

The City of Alexandria contracted with the Dr. Sauer Corporation to design the system. Dr. Sauer developed a plan to internally expand the existing liner plates, install steel rings and shotcrete the area between the existing liner and the face of the steel liner. Along with this the contractor would have to design a machine for expanding the steel ribs once in place.

Originally the contract showed a sheet pile cofferdam to divert the river flows. Merco's experience with several projects that included water flow control thought an earth berm would suffice. The berm proved not to be the best solution as several storms caused cresting above the specified elevation of the (cofferdam) berm which deteriorated and washed away. The contractor then designed and built a timber crib wall consisting of 150mm x150mm timbers, filter fabric and Class III Rip Rap. This proved to be very effective even with flows reached 1.0m above the timber wall. The water was temporarily channeled through 3 of the seven tunnels. Upon completion of the four dry tunnels, the timber-cribbing wall was relocated to channel floodwaters through the completed tunnels so completion of the other three remaining tunnels could commence.

The next objective was to design and build a tunnel expander to push out the liner plates and allow for steel rib installation. Coordinated with Elgood Mayo of Lancaster, Pennsylvania, an expander was developed and constructed with four 180 tonne jacks, a hydraulic power pack, and a lifting mechanism to attach to Merco's 966 loader. Initially the expander was only able to rotate 15 degrees. This was originally thought to be the rotation needed to expand and set the steel ribs. Later into the project it was determined that more rotation was required and the Merco/Elgood Mayo team came up with a modification thus allowing 360-degree rotation. Merco was able to expand nearly all the steel ribs with only a few needing modifications due to the tunnel configuration. As the crew became more familiar with the expander, they were expanding as many as 9 rings per shift averaging overall 5 rings per shift throughout the project. The sequence of setting the steel ribs was performed in adjacent tunnels prior to expanding as to not cause any stress to the other tunnels. Careful consideration was giving to when the rib expanding could be performed in order to prevent possible harm to shotcrete in adjacent tunnels, which had not yet developed enough strength to resist such stresses.

Upon completion of the steel rib placement, steel fiber reinforced shotcrete was applied at a 130mm thickness followed by a 25mm non-reinforced smoothing layer. (Figure 3)

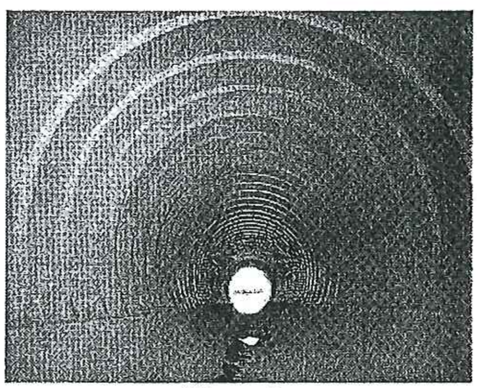

Figure 3.

The shotcrete requirements consisted of compressive strengths of 30 MPa @ 28 days and the use of an alkali-free accelerator. Due to the sequencing of steel rib expansion in adjacent tunnels it was determined that it would benefit the schedule to achieve the design strength in 5-7 days. The shotcrete design was not unlike that of many typical designs, however the high early strength development was enhanced by the use of MEYCO SA 160 as well as a high range water reducer. Since the project did not have large quantities of shotcrete, a site batch plant was not cost effective therefore the local concrete supplier was chosen to deliver the mix. Even with close proximity to the project site, hot summer temperatures as well as delays in traffic precipitated the need for control of the hydration process. DELVO STABILIZER was incorporated into the mix for this purpose. The ability to control the hydration of the shotcrete mix proved to be extremely beneficial to the material logistics while not impeding the early strength development. In fact, the dosage of accelerator was reduced slightly after the incorporation of DELVO STABILIZER. This was due to the MEYCO SA 160 having the more favorable reaction with fresh unhydrated cement. As for ultimate strength some in situ cores exhibited strengths nearly as high as 60 MPa.

This small rehabilitation was carried out successfully by design and construction exceeding the owner's expectations. Total project time was 15 months to completion with no lost time injuries.