Complete transformation for the Cameron culverts

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ABSTRACT

Rehabilitation work at the Cameron Run Tunnels entailed the restoration of seven heavily deformed, steel liner plate supported, twenty-foot diameter culverts through a CSX railroad embankment near Alexandria, Virginia. A custom fabricated expander, equipped with four 200 ton hydraulic jacks on two expansion arms was used to push back the liner plates encroaching into the proposed tunnel profile and install the steel set support. In a second phase the tunnels were then lined with six inches of fiber reinforced shotcrete. The rehabilitation work was carried out in two stages, where three of the seven tunnels had to remain open at all times. The operation entailed flood monitors to warn construction crews of rising water levels in the Cameron Run and prepare for timely evacuation. Geotechnical instruments both in the tunnels and the railroad embankment were used to monitor the effect of the rehabilitation work on the two CSX Railroad tracks above the tunnels. Freight and passenger trains were to run uninterrupted and at maximum speeds throughout construction. The project was finished for the City of Alexandria within budget and in time despite the use of an innovative technique.

COMPLETE TRANSFORMATION FOR THE CAMERON RUN CULVERTS

Work is almost complete at the Cameron Run Tunnels, in Alexandria, Virginia. where Merco of Lebanon, New Jersey, is currently placing shotcrete in the last of the seven tins 6 m (20 ft) diameter storm water tunnels. Rehabilitation of the 69m (230ft) long steel liner plate supported culverts through a CSX (Chessie Seaboard Express) railroad embankment in the Cameron Run Regional Park, started in February 2000 and will be completed by June 2001. Rehabilitation of the deformed and deteriorating 25 year old tunnels was designed by DSC (the Dr Sauer Corporation) of Herndon. Virginia, as its fourth tunnel rehabilitation project following the old Lehigh road tunnel the Berry Street bus tunnel. (both in Pennsylvania), and work on the Bergen rail tunnel in New Jersey.
After removing the existing invert concrete and remedial timber prop supports in the Cameron Run culverts, the sequence of operations involved installation of W6 x 20 steel sets inside the tunnels; reshaping of the deformed finer plates to accommodate the ovoid geometry; and application of 27.6 N/mm² (4,000psi) fiber-reinforced shotcrete to a minimum 160mm (6,25in) thickness.

Figure 1: Props supported the liner plates of the old culverts.

Work is staged to allow water flow through at least three tunnels at all times. Upstream and downstream crib walls and cofferdams protect the tunnels and monitors trigger a potential flood-alert alarm to allow for evacuation of the crew and equipment relocation if necessary.

Crucial to the entire project was monitoring the effect of the rehabilitation work on the two CSX railroad tracks above. Freight and passenger trains were to run uninterrupted and at maximum speeds throughout construction, and the maximum settlement set by CSX Railroad Engineering Department is 25.4 mm (l in).

A total 115 geotechnical instruments were installed both within the tunnels and on the surface in the railroad embankment to monitor ground movement.

Work on the tunnels was coordinated with CSX railroad from the start and the DSC, construction management learn provides weekly settlement monitoring reports to CSX's Engineering Department. In addition a CSX watchman/flag-plan was assigned to the site for safety purposes and to monitor the rails. Expansion of the deformed culverts was completed successfully within track level tolerance and at no measurable movement inside the tunnels. Only once during construction did (CSX resurface the tracks, lifting the rails and repacking ballast underneath.

After removing the old concrete invert, the steel sets were placed and blocked against the existing liner plates at 1 m (3ft) centers and mainly in deformed sections of the culverts. the sets were installed with temporary filler pieces replaced with longer pieces after expansion to the designed ovoid shape. The transition from pre-expanded to post-expanded sets was accomplished using filler pieces at the spring-line. An expander fabricated for Merco by Elgood Mayo, equipped with four 200 ton hydraulic jacks on two expansion arms and mounted on a loader, was used to install the steel arches and push back liner plates encroaching into the renovated tunnel profile. Metro expanded 230 steel sets in 64 shifts which results in a rate of 3,6 rings/shift, quite an achievement for such an innovative technique. Conditions such as the density of the surrounding material, the presence of grout in the soil, aril tale magnitude and type of deformation influenced the rate of expansion.

Figure 2: Expanded steel sets reshape the tunnel geometry.

The final wet-mix shotcrete lining contains 35kg/ m3 of Novocon Fortex steel fiber and is dosed with MBT Meyco SA 160 accelerator. The mix was field-tested extensively to confirm the required strength and, more importantly synchronize feed of the accelerator into the pumped volume of shotcrete. Shotcrete is being applied using a Reed primp ,with a maximum 24-stroke/h pumping capacity Water reducers keep the water-to-cement ratio at design value to maintain shotcrete strength. During severe cold weather, both portals of the shotcreted tunnel were sealed, and the tunnel heated to near 15°C: (59°F) Cores front the sprayed liner confirmed that 7-day and 28-day strengths met or exceeded requirements. Some 2,300m3 (3,000 yd3)of shotcrete has been applied to date. Shotcreting in each tunnel was kept at least two tunnel diameters behind the expanding activity in the adjacent tunnel to avoid disturbing the curing shotcrete.

Figure 3: Repaired culverts relined with fiber-reinforced shotcrete.

The original $3.56 million 14-month contract was extended by two months and to $3.8 million to complete additional work requested by the City of Alexandria. This was to improve the flow characteristics of the Cameron Run by placing concrete aprons and rip-rap at the tunnel portals. No other changes of any significance were required. Contingency items in the unit price contract are being mainly used to compensate Merco for unforeseen work and weather related delays. Although there is no partnering arrangement set-up between the owner, the construction management team and the contractor, the work is being executed in a cooperative way with frequent discussions between the involved parties to coordinate and solve technical. administrative and fiscal issue.

Figure 4: Finished Cameron Run culverts.