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The Dey Street Connector: Underneath Lower Manhattan

Barrier Wall Construction at Wolf Creek Dam

The new concrete cutoff wall at the Wolf Creek Dam is a milestone in barrier wall construction. The dam, on the Cumberland River in Kentucky, is operated and maintained by the Nashville District of the U.S. Army Corps of Engineers (USACE), to provide area flood control, hydropower, recreation and water supply. Lake Cumberland is the Corps' largest reservoir east of the Mississippi River. With a total surface approaching 1,000,000 sq ft, the Wolf Creek barrier wall is unlike any other project in the world.

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The 5,735-ft-long dam combines earthfill and concrete gravity sections. Construction began in 1941 and was completed in 1950. The solution channel intercepted during construction under the upstream face of the embankment and parallel to the dam axis, was used as a cutoff trench, and improved with a single line grout curtain. The sidewalls of the trench are irregularly shaped, with overhangs (see Figure 1). The Catheys Formation and overlying Leipers Formation beneath the dam are both hard, thin to massive layered, argillaceous limestone interbedded with thin, well cemented, calcareous shale with large Karstic solution features (Figure 2).

Dam Timeline

The design of this unique dam began with the design in the late 1930s. Construction was completed in 1950, but by the late 1960s, wet areas were noted and there were some sinkhole collapses. After emergency exploration, and through 1975, about 8,212 cu m of grout were placed in the rock foundation, mostly in the wraparound area. In 1972 a board of consultants had recommended that a concrete diaphragm wall be placed, and this was constructed between 1975 and 1980 along the crest of the embankment, and switchyard diaphragm walls were placed along two thirds of it. There was little reduction of piezometer pressure and more instrumentation was installed. Soil investigations in 2003 encountered soft zones at the top of the rock and in the embankment, and by 2003, river bank instability occurred due to seepage 1,800 ft downstream of the dam. Another panel of consultants in 2004 recommended grouting and/or a concrete wall, and later that year, more settlement occurred and cracks appeared in the crest of the dam between masonry and embankment sections. At that time, a major rehabilitation report was prepared.

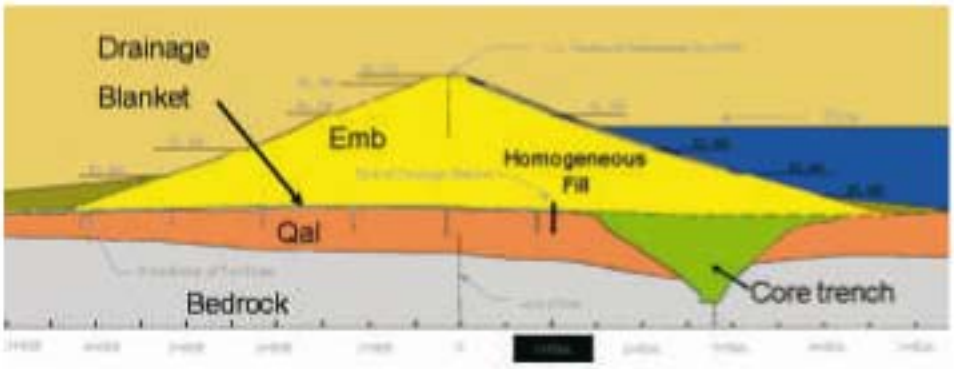

Figure 1: Position of cutoff trench in relation to embankment

Study Conclusions

The report by the Nashville District on the water seepage concluded that a new concrete barrier cutoff wall was necessary. The new wall, with minimum thickness of 24 in, will start immediately upstream of the concrete monoliths and run the length of the embankment, into the right abutment, for about 4,200 ft. The depth will reach 275 ft, well below the zone of solutioning. To reduce dam safety risks, the District proceeded with the rehabilitation efforts in two separate phases, awarded to two contractors with different solicitations.

The first phase (September 2006 to August 2008) involved installing two grout lines below the top of the rock, staggered

Figure 2: Solution channel/cutoff wall

along the alignment of the new barrier wall, mainly to improve the short-term reliability of the foundation and to minimize slurry loss during barrier wall construction.

In December 2007, the District solicited contractors for the second phase of the project, which included completion of the government grouting campaign. The "best value" request for proposal (RFP) method was used for selecting the contractor for this work. Unlike a traditional low-bid procurement, the selection was made considering the soundness of the technical approach and experience of the contractors, along with price.

The $341.4 million contract was awarded to the JV of Treviicos-Soletanche. **Treviicos South** led joint venture with **Soletanche Construction Inc.**, respectively, the North America subsidiaries of Trevi, headquartered in Italy, and Soletanche Bachy, headquartered in France. Dam safety is the primary goal of the JV partners. Their approach included three main steps in the process:

1. Implementing a supplemental probing and grouting campaign to detect and treat soft contact zones between the embankment and rock foundation
2. Installing a Protective Concrete Embankment Wall (PCEW) seated into the top of rock, with a thickness of 6 ft and depths averaging 140 ft, and designed to safeguard the embankment during future construction activities for the barrier wall
3. Installing the permanent barrier wall to the final design depth (up to 275 ft) by a combination of piles and rectangular panels penetrating the underlying rock

Tight Tolerances

The primary difficulties of the job are the extremely tight tolerances required, coupled with the required depth and continuity of the barrier wall.

These requirements would be difficult in normal rock conditions, but at Wolf Creek Dam, the need to cross the solution features and the Karst caves of the trench mainly in the so called "critical areas" pose a further challenge. Finally, the presence of rock reaching 36,000 psi further contributes to the project complexity.

Most of the specialized equipment for the barrier wall is manufactured and customized for the particular project requirements by the equipment manufacturing units of the JV partners' parent companies, Soilmec (part of the Trevi Group) and Soletanche-Bachy itself have been involved since the early stages of the project.

Project Update

The notice to proceed for the 48-month contract was given to the JV in October 2008.

Since then, the JV completed the concrete working platform, which was enlarged and improved with additional thickness and steel reinforcement because of the large and heavy equipment involved in the construction of the walls.

The supplemental probing and grouting campaign started at the same time, while the government foundation grouting was scheduled to be complete by the end of 2009. In the staging area, the JV installed the slurry treatment plant and a large workshop together with the site offices buildings.

Installation of the PCEW began in April 2009 starting from two technical areas, as per contract requirement. This work will continue for approximately 16 months. Currently, minor repair work is underway. Transverse panels are being placed to buttress a few joints of the temporary PCEW.

Installation of secant piles in technical area #1

Barrier wall construction started in July 2009. The two technical areas allow the JV and the Corps personnel to get acquainted with the construction methods together. Currently the work is proceeding well after the initial learning curve, with the pilot holes being drilled ahead of the piles. About 30% of the piles are installed in TA#1. Once the two areas are approved, the remaining work will continue, beginning from the critical areas, where large caves could be encountered, and continuing on the remaining parts of the anticipated alignment. Project completion is on schedule for the last quarter of 2010.

Dam Features

The concrete portion of Wolf Creek Dam consists of 37 gravity monoliths that extend 547 m across the original river channel. Top of the dam is at elevation 773 ft, with a maximum height of 79 m above the founding level. The spillway section has ten 15 m x 11 m tainter gates and six 1.2 m x 1.8 m low level sluice gates. To the right of the spillway section, the power intake section has penstocks feeding six turbines rated at 45 MW each in the powerhouse downstream. Non-overflow sections on either end complete the concrete portion of the dam. The embankment section extends from the end of the concrete gravity portion 1200 m across the valley to the right abutment, with a maximum height of 65 m above the top of rock. The non-zoned embankment is composed of well-compacted, low plasticity clays, from the valley alluvium.

The critical "wraparound" section is at the point where embankment and the concrete sections tie together.