Driven Sheetpile Wall Seepage Barrier Construction in Deep Ponded CCR

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ABSTRACT

In a hybrid coal combustion residual (CCR) pond closure project, the construction sequence required a cove of the pond, with up to eighty feet (24.4 meters) of sluiced CCR and free water, remain in full operation. Subsequent removal of CCR and free water outside of the cove would lead to a hydraulic gradient through the highly permeable CCR, potentially causing instability of the resulting slope and disruption of the normal operations within the cove. Additionally, the project required an access road across the cove during the closure operation. The subsurface characterization encountered typical ponded CCR material.

Under these constraints, the project needed a 465-foot (142-meter) long seepage barrier. Since an access road was part of the project, typical land-based barrier construction techniques were available: soil-cement-bentonite slurry wall or sheetpiles. It is challenging enough building a road across a CCR pond, but add the potential for liquefaction of the loose, saturated CCR from construction-induced vibration during wall construction.

Keller North America, Inc. (Keller) designed the access road and, once the access road was constructed by the general contractor, installed a driven sheetpile barrier to a maximum depth of 85 feet (25.9 meters) below the access road working grade. A Keller-designed, comprehensive geotechnical instrumentation monitoring program provided real-time information on stability of the access road and underlying ponded CCR during all aspects of construction.

INTRODUCTION

A utility company selected dredge methods for implementing the hybrid closure of an existing CCR pond. An operational characteristic of the dredge operation required depositing the material into a holding pond. Rather than building a separate pond or tank outside of the existing CCR pond, the project elected to isolate (physically and hydraulically) a cove of the CCR pond using a barrier wall. This barrier would allow lowering of the water level within the CCR pond as the dredging proceeded while maintaining the water level within the holding pond. However, the barrier needed to penetrate the CCR material, up to eighty feet (24.4 meters) thick, to intercept flow through highly permeable bottom ash material. The barrier would be centered in a new berm/site access road across the cove for the duration of the hybrid closure project.

Unfortunately, the submerged, very weak CCR material constituted the foundation for the berm, adding to the difficulty for its construction and seepage barrier.

PROJECT OVERVIEW

The utility operated a five-unit, coal-fired power plant. CCR was wet sluiced from the plant and across the river to a CCR pond constructed by damming a valley, Figure 1. After multiple raisings, the dam, at the time of closure, held back a pond with a surface area of about 420 acres (170 hectare) containing an estimate twenty-five million cubic yards (19.1 million cubic meters) within a 1,300-acre (526-hectare) watershed. The plant owner dry-stacked a minor amount of CCR material in the upper reach of the CCR pond.

The closure plan called for removal of CCR by dredge methods and lowering the water level in the lower reach of the pond nearest the dam. The closure contractor received the dredge material from the holding pond and placed it within the upper reaches of the pond. Final closure required decommissioning the dam.

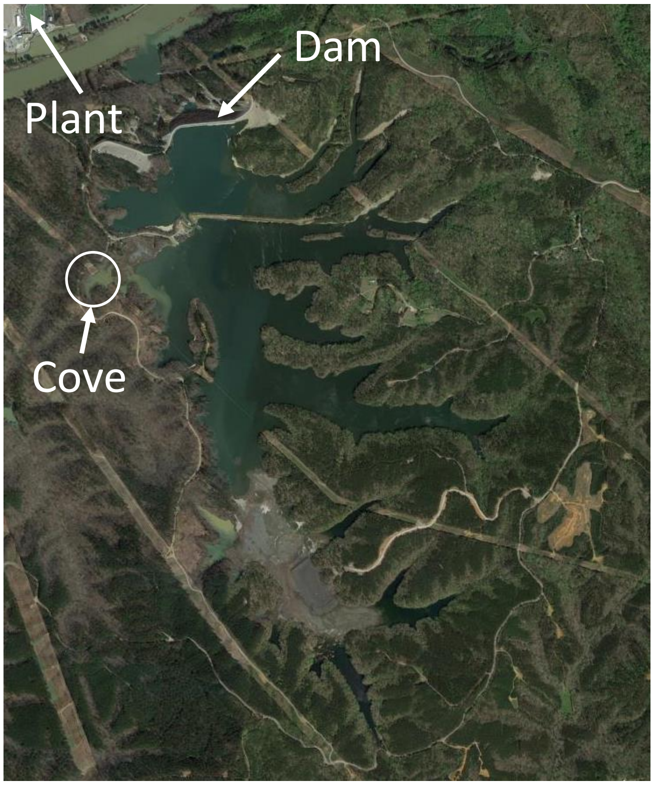

Figure 1. Overhead View of CCR Pond.

Rather than build a separate holding pond, the closure plan isolated a holding pond within a cove of the CCR pond. However, this plan required maintaining the water level in the holding pond at or above the pre-closure water level even as the water level in the CCR pond lowered, necessitating a barrier to control seepage from the holding pond.

SUBSURFACE PROFILE

The foundation of the berm and barrier consisted of a variable profile of fly ash, bottom ash, and a mix of both fly/bottom ash, Figure 2. Standard Penetration Test N-values in the CCR profile ranged from weight of rod/hammer to a maximum of two blows per foot (0.3 meters) [bpf], values typical for sluiced CCR. The CCR was underlain by an estimated 10-foot (3-meter) layer of residual soil with SPT N-values of three to greater than 100 bpf underlain by bedrock.

BERM DESIGN AND CONSTRUCTION

As has been documented in the industry, working on weak CCR can and does present challenges for people and equipment, the primary challenge of work platform stability resulting from CCR liquefaction and slope instability. Therefore, the design and construction must include best practices for working on these unstable materials.

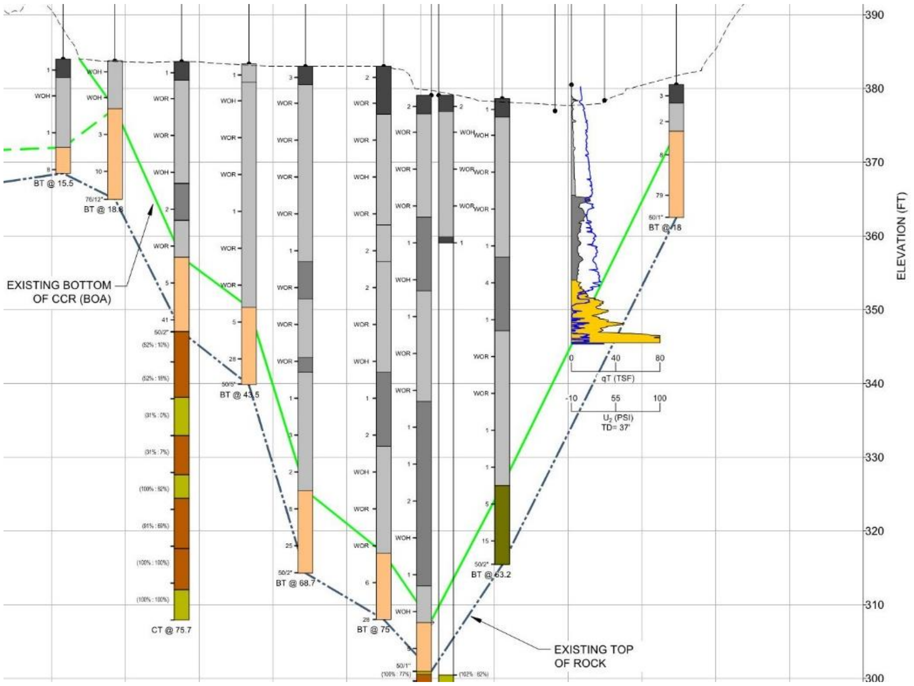

Figure 2. Subsurface Profile along Barrier

Keller designed the berm that was constructed by CCR closure general contractor. It was designed to perform two functions: a stable working platform for subsequent installation of the seepage barrier and “permanent” holding pond berm.

The fill materials consisted of bottom ash obtained from the dry stack area and included three layers of geogrid reinforcement. The design called for bottom ash placed on the existing CCR material up to the grade for three layers of geogrid reinforcement, each layer deployed at 90 degrees to the previous layer. One-eighth inch (3 mm) diameter galvanized wire reinforced the 12-inch (0.3 meter) overlaps. Note the geogrid deployment left a 5-foot (1.5 meter) wide gap centered around the future sheet pile wall alignment.

The berm construction finished at the final grade with a completed crest width of fifty feet (15 meters), Figure 3. A specified rest period allowed dissipation of any excess porewater pressures measured by the geotechnical instrumentation (described later).

After the rest period, removal of the upper four feet (1.3 meters) of the berm brought the berm down to barrier installation working grade; this material functioned as a surcharge load simulating the barrier installation equipment. Once the barrier installation was complete, the general contractor raised the berm back to final grade.

The owner’s quality assurance consultant observed the construction of the berm and certified construction was in accordance with Keller’s design.

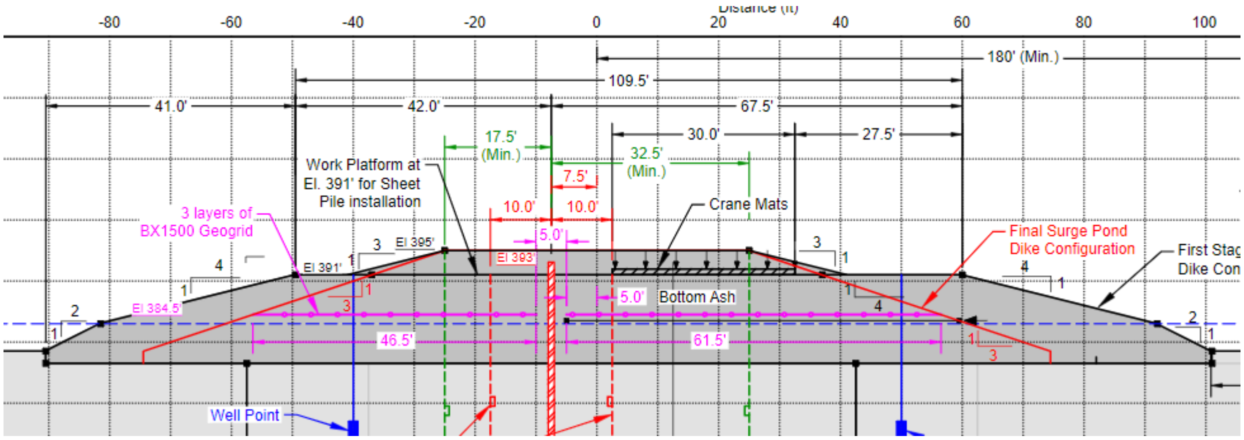

Figure 3. Holding Pond Berm Cross Section

DEWATERING

To aid in the stability of the berm during the barrier wall installation, a dewatering system installed from the working grade lowered the phreatic surface in the berm and the underlying CCR. The system consisted of two parallel rows of drilled well points installed on 10-foot (3-meter) centers and set to 40 feet (12.2 meters) below the working grade. Wellpoints consisted of slotted, two-inch-diameter casing installed inside the temporary drill casing with backfill filter sand placed while retracting the casing. Flexible hose connected the wellpoints to a 6-inch diameter header pipe. One centralized pump station, consisting of primary and backup electric pumps pulled groundwater through the system.

At full operation, the groundwater drawdown from the initial condition measured between 5 and 8 feet (1.5 and 2.4 meters).

GEOTECHNICAL INSTRUMENTATION

The closure design engineer (Engineer) specified and installed an instrumentation system consisting of vibrating wire piezometers and inclinometers for monitoring the berm during the full closure construction period. The data for these elements was available to Keller during the construction process.

Keller supplemented this system with additional vibrating wire piezometers and surface settlement monitoring points set on the barrier working grade and monitored with an automated monitoring total station. These installations specifically operated for berm and barrier construction.

The Engineer’s system tied into Keller’s monitoring system which provided real-time alarm notification of site conditions as work progressed. When monitoring data exceeded preset, site specific, levels, Keller’s system notified the equipment operators and ground personnel, promoting predetermined responses, up to and including work stoppage. The optical survey measured up to three inches (75 millimeters) of berm settlement.

BARRIER WALL DESIGN

Keller collaborated with the Engineer and general contractor to evaluate the best construction technique for installation of the barrier wall. While the intent of the barrier was limiting seepage, the design engineer did not require that the barrier be watertight. The leading candidates were a conventional, excavated slurry trench and sheetpiles. The team selected sheetpiles due to concerns with trench stability in the sluiced CCR while excavating a slurry trench.

The Engineer selected the alignment and provided the design profile for the barrier wall, see Figure 4. The final design had a total barrier length of 465 feet (141.7 meters) and a 2-foot (0.6-meter) penetration into the residual soil material underlying the CCR.

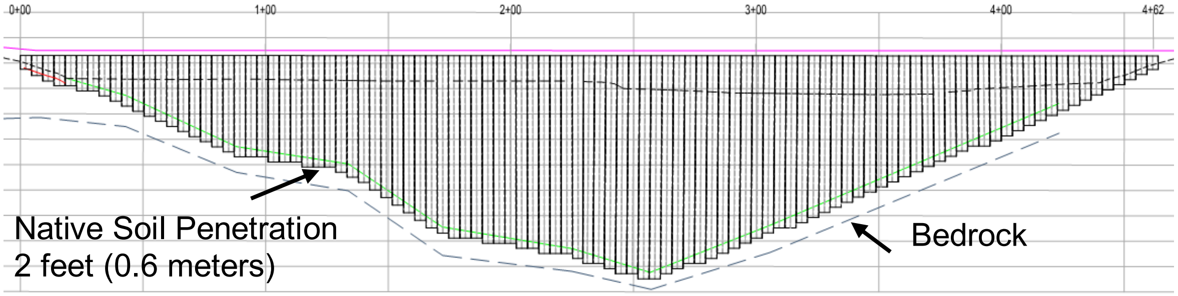

Figure 4. Design Engineer's Barrier Profile

SHEETPILE BARRIER INSTALLATION

With a stable working platform in place, Keller mobilized a 165-ton capacity crane, which would sit on crane matting, and ESZ19-700 steel sheetpiles to the site. The maximum sheetpile design length was about eighty-five feet (25.9 meters). But the site access restricted the delivery of sheetpiles to a maximum length of forty feet (12.2 meters), which required a significant quantity of splicing and the necessary production sequencing that this activity entails.

Even for a temporary barrier such as this, the location tolerances were strict, with a 6-inch maximum alignment deviation along the two ends and a 2% plumbness specification. Working from one end of the wall to the other, Keller used guide beams to control the barrier layout. Keller drove the sheetpiles with both diesel and vibratory pile hammers to the design grade provided by the Engineer or to practical refusal.

For the middle portion of the barrier Keller drove the first 40-foot (12.2 meter) pile segment just above the work platform then spliced and welded an additional pile segment before driving to final grade, Figure 5.

During driving, exceedances in the preset trigger levels occurred which necessitated stopping production, with a maximum stoppage of 4 hours, however there were no indication of a global stability issue that jeopardized the berm or the crew/equipment operating on it. Keller did observe instances of localized ground subsidence during sheetpile driving. Due to the swing radius of the crane, as compared to a fixed mast pile driver, this did not impact the safe operation of the pile installation.

Figure 5. Face View of a Completed Splice on a Sheetpile Pair.

Production pile driving proceeded smoothly, Figure 6. However, there were two occasions where the Engineer indicated there were problems. The first was due to what Keller deemed pile refusal but the Engineer felt the interlocks between individual sheets had welded together, inhibiting further driving. The design engineer required that Keller pull these suspect sheets to prove they had not in fact welded together, then redrive them. This work required a separate submission and approval of an extraction work plan. The interlocks had not welded together, and the piles driven again to refusal, to final elevation.

Figure 6. Sheetpile Installation. Note Dewatering Header on the Lower Left Side of the Photo.

The second instance had to do with the design sheetpile toe elevation. Even though the Engineer had provided the toe elevation in their design drawings, the Engineer was not satisfied that the piles had penetrated the two feet into the underlying residual soil. The Engineer quickly mobilized a geotechnical exploration rig to the site and proceeded to conduct cone penetration testing (CPT - hydraulicly pushing an instrumented cone and connecting rods into the ground at a constant rate) at discrete points along the length of the wall. Keller's crew and equipment were on standby, as the Engineer conducted the testing and evaluated the data. The Engineer concluded over half of the sheet pile pairs required additional driving, as shown in Figure 7. Many of these piles needed splices added before the additional driving could proceed.

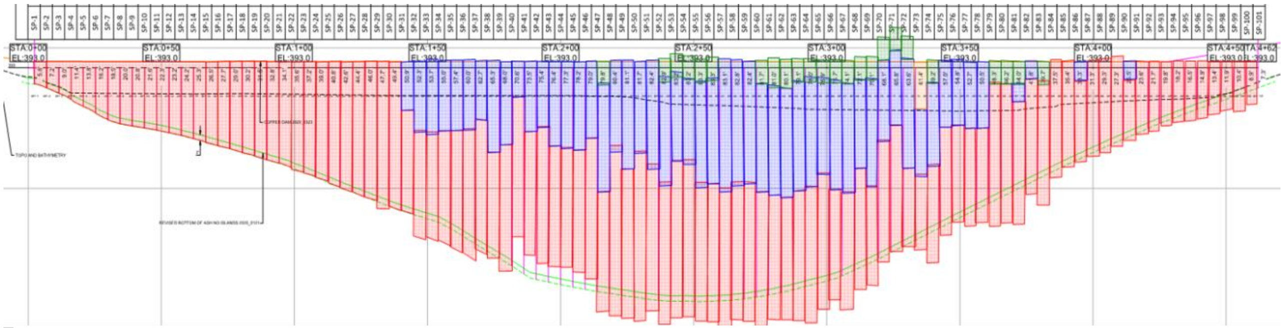

Figure 7. Finished Barrier Profile

CONCLUSIONS

Construction on a CCR pond presents its own set of challenges. Building a berm on a deep deposit of sluiced CCR is one thing, then driving steel sheetpiles through both the berm and underlying CCR is another, all without causing stability issues to the working surface that can impact the safety of the crew and equipment.

Combine Keller’s geotechnical design and construction skills with a capable closure general contractor. Have them both operate under a robust geotechnical instrumentation system providing real-time alerts to on-site crew. Then installing a seepage barrier to facilitate a hybrid CCR pond closure results in challenge met and overcome.