Design Considerations for Closure of Coal Combustion Residuals (CCR) Ash Ponds

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INTRODUCTION

Coal ash pond closures have several site-specific design considerations to account for including: location, size and number of impoundments, site acreage, type of ash, placement methods of ash, nearby facilities, hydrogeology, and regulations. These and other design conditions limit the options for how to efficiently move forward to closure of coal combustion residual (CCR) ponds. This paper summarizes several specific design challenges for CCR pond closures using a structured geomembrane/turf material as a closure cap for closed in-place ash ponds.

Though the following design considerations are written with the context of a CCR pond, they also apply to CCR landfills. Typically, CCR landfill closures will also address steeper slopes within the closure system than a CCR pond.

DESIGN CONSIDERATIONS

Prior to the design of any cap or closure system, understanding the client's concerns and expectations, site characteristics, regulatory standards and requirements, and having a fundamental knowledge of construction materials are needed for a successful project. An overall feasibility analysis on the type of closure (clean closure, in-place closure, or hybrid) and the cap materials (membrane/soil cap or structured membrane/turf cap) will occur prior to the following design components. The design features discussed in this paper include site grading and stormwater collection, active utilities and pipelines, active roadways, third-party access to their facilities, and flooding. This paper is using an Illinois hybrid CCR pond closure with a structured membrane/turf cap (ClosureTurf™) for illustrative purposes.

Site Grading and Stormwater Collection

The maximum grades for the site depend on the volume of CCR to cap in-place, storm events for the area, the type of cap, and seismic considerations. Both cross slopes and longitudinal slopes of the cap and the stormwater collections channels need to be considered. Though the cap slopes can typically be constructed up to a 4:1 or 3:1 slope, ash ponds are generally flat or have negative slopes because of the embankments to hold back the water while sluicing the ash to the pond. Therefore, positive slopes to drain stormwater must be created, often with material from a clean closure from other locations on site. The earthwork balancing work often requires many iterations during the design process and updates as more or less CCR is discovered through the construction of the cap. This ash consolidation into a smaller acreage has many advantages including the reduction of long- and short-term environmental impacts, reduction of long-term maintenance, reduction of impacts to the neighboring communities and infrastructure, and cost savings.

The cross slopes at CCR ponds typically range between 2%-5% so the stormwater drains off the cap effectively. The storm collection channels typically require a longitudinal slope between 1%-5%, dependent upon the designed size and length of the perimeter ditch channel (Figure 1). The sizing of storm collection channels must maintain an appropriate flow capacity, which is based on each channel's receiving drainage area and channel width. Generally, a maximum flow velocity of 5 ft/s (1.52 m/s) within perimeter channels is suggested unless a geotextile/rock or other significant armoring of the storm channels are included in the design. Lower flow velocities may be required on soil-based cap systems due to erosion.

Storm flow exits the perimeter channels into downslope discharge channels of varying slopes. The downslope channels need to be spaced properly with energy dissipators installed at the outlets (Figure 2). The external side slopes should not be any steeper than 2 feet (0.60 m) horizontal to 1 foot (0.30 m) vertical for unarmored structured geomembrane/turf systems. Geomembrane/soil caps typically have shallower slopes and additional armoring on the downslope channels.

Figure 1: Perimeter ditch channel with ClosureTurf™.

Figure 2: Energy dissipator at end of downslope channel.

Utilities and Active Pipelines

Utilities are a major concern and need to be considered during the design process. The avoidance of utility impact is preferred, but not always practical. Potential conflicts with the closure of CCR ponds during design or construction can impact project safety, project schedules, or environmental regulations.

If you need to leave a utility pole or other foundation in place and in operation on a closure, a boot or extra geomembrane will be needed to make a watertight seal and preserve the integrity of the closure. If a ready-made geomembrane boot does not fit the utility structure, one can be constructed to fit. The geomembrane is wrapped up the sides of foundations, pipes, and/or poles, affixed with mastic glue, and bolted or banded with metal plates around the top. The battened geomembrane is then extrusion welded to the geomembrane cap covering the CCR ash material. Using geomembrane battening will assure operations of utilities and inhibit water from infiltrating around tricky foundations or poles (Figure 3) situated in capped areas.

Figure 3: Geomembrane batten around utility pole.

In the case study, a third party operated an active petroleum pipeline on a CCR filled embankment. Due to flooding considerations at the site, the pipeline could not be removed and placed on the ground surface after a clean closure. The third party also required that closures of the pipeline were minimal and any closure in place option could not include burying the pipeline. The same general process was used on the pipeline foundations as for utility poles for sealing the cap (Figure 4).

Figure 4: Geomembrane batten around pipeline foundation.

Roadways and Third-Party Access

Generally, third-party access to easements on the property require notification of changes in the easement area and scheduling to avoid conflicts. Many easements are not regularly used or do not go through a CCR area, so they are a simple matter of taking care of the closure then fixing ruts or other minor impacts in the easement area.

Some easements are not that simple. In the case study, an existing access road to an active river dock facility used by a third-party needed to be preserved above the 100-year flood level. The existing access road was built upon an ash pond containment berm that was constructed of bottom ash. Since the existing containment berm consisted of CCR material and removing then replacing the road with clean fill was unacceptable to the use of the facility, it was decided to cap the ash in place and add a specialized road section over the cap. The roadway was originally a one-way road going around the entire CCR pond, so the configuration was changed so that the pond could be primarily clean closed, and part of the bottom ash material removed was used to construct a turnaround for the trucks.

The dock facility access road was capped with the same structured geomembrane material/turf product (Figure 5) as the other closed in-place pond on site. A specialized roadway section was developed and constructed over the geomembrane so wheel axle loading would not damage the cap integrity. First, the contractor shaped the CCR material of the proposed access road according to plans, which included a 20-foot (6.09 m) roadway width and a semi-trailer turnaround cul-de-sac. Then the geomembrane was installed along the side-slopes and over the roadway embankment (aka CCR containment berm). The roadway section was placed overtop the geomembrane with a 12-inch (30 cm) protective soil, geotextile filter, and 24-inch (60 cm) roadway surface aggregate (Figure 6). The proposed roadway section provided a stable, yet cushioned driving surface for semi-trailers and other vehicular traffic.

Figure 5: Dock facility access road (built upon CCR containment berm) during construction.

Figure 6: Completed dock facility access road

Flooding

Many historic ash ponds are located near or adjacent to rivers or lakes. The design of the CCR cap needs to include considerations for 100-year floods and resulting impacts from river debris (Figure 7). Rock blanket or riprap are commonly laid along the base of slopes adjacent to waterways to provide additional anchoring of the closure system at the toe and to protect the system from flood waters or debris impacts. Thick layers of rock blanket positioned at toe of slope will act as an armored barrier from undercutting occurring from flooding. Soil based closure systems need to have a maintenance plan for how to measure and address flood damages.

Figure 7: Flood waters on completed cap.

CONCLUSION

Closure of CCR ponds have many design, regulation, and construction considerations that, when appropriately thought out in advance, can help your client, and reduce change orders during construction. This white paper does not address all the concerns for a site, rather only a few considerations. In-place CCR closure systems have been effective in providing environmentally safe conditions, maintaining current business ventures, sustaining natural habitats, and creating opportunities for future reuse.