Recent Experience in In-Situ Dewatering of Coal Combustion Residuals: A Practical Approach

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INTRODUCTION

Although wet ash impoundments have been regularly maintained, cleaned, and improved over their service lives, efforts to close ponds have been sporadic over the years.¹ However, the publication of new EPA rules requiring the closure of CCR impoundments has spurred a recent wave of large scale ash handling activity and attendant attempts measures to improve ash stability and handling characteristics. The purpose of this paper is to describe the tools and methods available for dewatering, current best practices, and lessons learned with respect to in-situ dewatering of fly ash.

The sensitive nature of saturated fly ash is now well understood in the pond closure community. Seemingly stable material, when subject to vibration, will develop excess pore pressure, expel water, lose shear strength, and act as a viscous fluid rather than a solid mass. This results in unsafe working conditions on the pond and inefficient handling of ash. Research, as well as practical field experience have shown that a removal or drainage of the “free” water results in a slightly negative pore pressure within the ash. This imparts apparent cohesion to the material and allows for normal excavation, handling, transportation and disposal, greatly reducing risk and uncertainty in the pond closure process as illustrated in Figure 1.
Figure 1 – Ash dewatered in-situ supports safe and rapid excavation activity.

Removal of the “free” water corresponds to a reduction in moisture content of approximately 8-12% and typically produces the desired result. This finding is consistent with previously published values for soils with similar particle size distributions.\(^2\) Figure 2 shows the specific yield of fly and bottom ash compared to other common materials.
PILOT TESTS

Each fly ash impoundment is unique. Variations in source coal chemistry, method of combustion, method and history of deposition in the pond, and pond maintenance mean that each pond has its own set of characteristics and those characteristics may vary widely within a pond.

Therefore, given the size and complexity of most fly ash pond closure projects it may be advisable to conduct a pilot test or series of pilot tests prior to design and implementation of a full scale dewatering system. Pilot tests can yield valuable design parameters including the hydrogeological properties of the ash, the expected area of influence of a dewatering system, and the practical yield of properly constructed, representative dewatering devices. These parameters are all important variables in determining the spacing and construction details of dewatering devices.

Figure 2 – Specific yields of common soil and ash materials.
Figure 3 – Ash pond dewatering pilot test with wellpoints.

Pilot tests are also excellent opportunities to gain valuable knowledge about the practical aspects of dewatering system installation. For instance, a pilot test is a chance to verify installation techniques in the actual ash conditions and to refine dewatering device construction details such as screen apparent opening size and filter medium gradation. Experience has shown that non-woven geotextile fabrics utilized as the sole filtering mechanism will quickly become plugged with a dramatic reduction in the yield (and effectiveness) of the system. However, traditional granular filter packs consisting of specially graded soil have proven very effective at excluding ash particles while still
allowing satisfactory water flow into the device. Figure 4 shows samples of potential filter packs ready to be tested.

Figure 4 – A pilot test is a good opportunity to determine which filter pack material works best on a given pond.

Most water pumped from ash impoundments will need to be treated prior to discharge. A properly selected filter pack should be considered a vital form of pre-treatment that will reduce treatment costs by excluding most suspended solids from the treatment train. The typical dewatering discharge from properly filtered dewatering devices will have less than 5 NTUs of turbidity.

DITCHES & SUMPS

The traditional approach to dewatering fly ash is to dig drainage ditches leading to sumps. As water flows to the sumps and water levels are lowered, the ditches may be deepened to induce more water flow. This technique has the advantage of being inexpensive to implement and of not needing specialty dewatering contractors.

However, the speed of drainage will depend on the magnitude of the hydraulic gradient between the ash and the ditch. In most cases it will not be possible to dig the ditch more than a few inches below the top of the saturated ash before the ditch collapses. Therefore, the gradient will be low, leading to slow drainage. Furthermore, this method represents a safety concern as it requires heavy equipment to be operated on the ash just above the hazardous saturated zone as shown in Figure 5.
In very low permeability materials, such as some FGD by-products, wellpoints and deep wells (discussed below) may need to be installed so close together to be effective that they become impractical. In this case, careful use of ditches, and sumps may be the only viable alternative for drying the material.

WELLPOINTS

Wellpoints are small tubes, typically 1.5 to 2 inches (38 to 51 mm) in diameter with slotted or perforated screens on the bottom. A series of wellpoints is typically connected to a common header piped and pumped by a pump station on the surface. The pump station vacuumizes the header and wellpoints, drawing water through the screens. Water drawn to the pump station enters a tank where air and water separate. The air is pulled to the vacuum pump while the water makes its way to a water pump and is expelled to the discharge point.

The primary drawback of wellpoints is that they are limited by practical vacuum lift in how far down they can pull water below the intake of the water pump. Drawdowns that
could be reasonably expected in fly ash would be approximately 15 to 18 feet (4.6 to 5.5 meters). Actual results will depend on the specifics of the situation.

Because saturated fly ash is so loose, wellpoints can often be jetted in by hand from temporary work surfaces improved with geogrid or plywood. This eliminates the need to provide safe access for equipment. As the wellpoints are activated they create access by stabilizing the ash.

Because of the drawdown limitation wellpoints are often used to dewater shallow ponds for closure by removal or to stabilize a crust on the surface to create safe equipment access for a cap-in-place closure. The limiting factor for the capacity of the dewatering system will be the length of wellpoint screen in contact with saturated ash.

In a shallow pond each device will have limited wetted length in contact with the ash, necessitating a relatively dense array of devices as shown in Figure 6.

Figure 6 – A dense array of wellpoints installed in a fly ash pond.

This phenomenon leads to the perhaps counterintuitive relationship that shallow ponds may require a greater installation effort to dewater than deeper ponds.

One advantage of a dense array is that it will naturally address variability in the pond by ensuring that a change in pond characteristics is always accompanied by nearby dewatering devices. This is a truism that has been proven over and over again in conventional construction dewatering.
DEEP WELLS

Deep wells are larger in diameter than wellpoints, typically 4 inches (102 mm) in diameter or larger. Like wellpoints they are typically connected to a common header pipe. Unlike wellpoints, deep wells are equipped with individual submersible pumps and they rely on gravity, not vacuum to pull water toward the well. Also unlike wellpoints, deep wells are not inherently limited in drawdown.

Deep wells are typically installed on wide centers when drainage conditions are favorable or when each well can contact a significant thickness of saturated ash. Therefore, many deeper ash ponds are suited for dewatering using deep wells. This is possible because each device will have a large amount of contact area with the ash and the possibility of tapping locally permeable layers, such as bottom ash intermixed with other CCR materials. This principle holds true even if it is desired to only create a shallow stabilized crust, as given sufficient time, pore water near the surface will drain downward to the more permeable pumped layers.

In this scenario, pilot testing and other upfront geotechnical investigations may be critical to identifying strata within the ash where it is advantageous to install a dewatering device. In particular, cone penetrometer testing (CPT) is an efficient way of quickly exploring multiple locations in a pond. Figure 7 is a CPT log from a roughly 150 foot (46 meter) deep valley fill pond.

![CPT log from a valley fill pond.](image-url)
The pore pressure plot (u) in Figure 7 generally tracks above the hydrostatic line (the light blue diagonal line) indicating that the ash is poorly draining. However, one zone between 120 and 130 feet (36.6 and 39.6 meters) had pore pressures on the hydrostatic line. This zone also coincides with a higher tip resistance (qt). The combination of these two phenomena indicates a zone of potentially high permeability and that this would be a good site for a deep well.

A deep well was installed at this location that produced a significant yield and resulted in significant drawdown in outlying observation wells. Figure 8 is a plot of drawdown vs. distance away from the pumping well after four weeks of pumping.

![Figure 8 – Drawdown vs. distance away from a deep pumping well in a mixed ash pond.](image)

The plot shows a theoretical radius of influence of approximately 500 feet (152.4 meters). However, as a practical matter, greatly improved working conditions were observed on the surface of the pond out to a radius of approximately 300 feet (91.4 meters). Approximately 6.5 acres (26,270 square meters) of stable crust was created by pumping from a single well. By contrast, many shallow wellpoints would have been required to create the same result.
CONCLUSIONS, LESSONS LEARNED & FUTURE TRENDS

In-situ CCR dewatering experience over the last several years has yielded several lessons including:

- Traditional ditches and sumps may be necessary in extremely low permeability material. However, safety and speed of drainage should be considered when contemplating this method.
- All fly ash impoundments have different characteristics that must be understood before properly designing and implementing a dewatering system. Therefore, pilot testing, CPTs, and other forms of investigation are essential prior to beginning a project.
- Although dewatering of shallow ponds likely involves pumping less water and dewatering less ash than for deep ponds, greater dewatering effort may be required due to the limited areal influence per device.
- Deeper ponds may be dewatered efficiently with relatively widely spaced devices, particularly when sufficient pumping time is available and relatively permeable conditions exist at depth.
- Dewatering is time dependent. The amount of installation effort required is partly dependent upon available pumping time.

Maximizing pumping time is a good strategy for reducing dewatering installation effort and cost. Therefore, pond owners are exploring the possibility of beginning dewatering during the investigation and design phases of a project. By commencing dewatering prior to mobilization of a pond closure contractor, pumping time is maximized and overall project schedule is improved.

For a pond closure contractor, the biggest risk on a project is the uncertainty of dealing with saturated fly ash. Early dewatering lessens the contractor’s risk regarding excavation, handling, transportation and placement of ash. Therefore, allowing the contractor to rely on a dewatered condition during the project will improve safety, schedule, and cost.

REFERENCES
