ABSTRACT

Mining and mineral processing is vast and complex industry. There are a variety of applications requiring the management of waste streams from the processing of raw coal, removal of tailings and fines from settling ponds, and treatment of thickened wastewater sludge. As in remediation projects, governmental regulations dictate what mines can and cannot do in terms of handling their waste streams. In some areas underground storage of process waste is allowed, in other states there is a moratorium on underground storage. Sometimes in states that allow underground storage, there may be temporary situations that require an alternative storage.

This paper will address how geotextile containers offer a unique high volume, low cost de-watering system to provide a very effective way of dewatering wastewater residuals in mining applications.

1. GEOTEXTILE CONTAINER DEWATERING TECHNOLOGY

Geotextile containers have been used since the 1960’s as shoreline protection in marine and river structures such as breakwaters, dikes, artificial islands, and jetties. Over the years, this technology has transferred into the dewatering of wastewater with the aid of chemical conditioning. There are three basic stages to dewatering with geotextile containers which are confinement, dewatering, and consolidation (See Figure 1). The specially engineered textile which the geotextile containers are fabricated allows confinement of the fine solids inside the container but allows water to filter for dewatering. As the water drains, the solids continue to densify inside the geotextile container and the volume inside the container continues to consolidate over time.

A dewatering cell must be constructed to hold the geotextile containers (See Figure 2). In most cases the available area for construction of a dewatering cell is limited but geotextile containers can be manufactured in many configurations and sizes to maximize the available footprint. Creating a slight grade with the slope in the length direction of the geotextile containers promotes drainage of the filtrate for better collection. An advantage of geotextile containers is that they can be stacked in a pyramid configuration several layers high depending on the consolidated characteristics of the dewatered solids.
Generally this cell has an impermeable membrane installed to help control the volume of effluent which drains through the containers. Typically the effluent is returned back into a body of water, and in some instances can be directly discharged if the filtrate quality meets reporting limits. The wastewater can be dredged or pumped directly into geotextile containers.

If the flow of wastewater is extremely high, a manifold system can be installed which allows multiple containers to be filled at one time to maximize dredging output. The primary feature of a geotextile container is to retain solids and contaminants while permitting effluent to drain through the pores of the woven engineered filtration textile. During all phases of the dewatering process (filling, dewatering and consolidation), the filtration textile must provide excellent tensile properties, efficient effluent drainage, and effective retention of solids to guarantee optimum slurry dewatering. The filtration properties of the engineered textile permit the containers to capture the solids, while water drains out. The moisture will continue to filter out and solids will continue to dry over time promoting more volume consolidation. Using the appropriate polymer for chemical conditioning will allow for the solids in the wastewater stream to create an agglomeration and release free water for drainage. Figure 3 shows typical results of geotextile container dewatering with a depiction of filtered effluent, conditioned slurry, and in-situ slurry.

Figure 2. Geotextile containers inside dewatering cell

Figure 3. Results of dewatering with geotextile containers showing filtrate, conditioned slurry, and in-situ slurry.
Chemical conditioning optimizes the dewatering performance of geotextile containers, increasing the dewatering rate, improving effluent quality, and achieving higher dry mass. The chemical conditioning of the wastewater occurs before the slurry is pumped into geotextile containers to accelerate dewatering.

Once the solids are fully consolidated or have met minimum requirements for transport, several options are available for disposal. Typically after consolidation, the geotextile containers can be cut open and solids transported to landfill or land applied. In some applications, the containers can be buried in place allowing the dewatering area to be reclaimed.

2. PROCESSING OF RAW COAL PROCESSING

Conventional disposal methods of surface impoundment or injection into abandoned underground mine workings is not always possible. Regulatory restrictions, available area, and construction scheduling can create possible interruptions to the primary disposal methods for mining refuse. Geotextile containers can offer an alternative disposal method for wastewater and allow for the coal processing to continue operation without disruption.

A coal processing plant faced an issue where it was facing a possible interruption of its operation which involved a waste stream of almost 1.5 million gallons of slurry per day. Continued production of coal was needed in order to meet shipment demands, and geotextile containers were chosen as an alternative to prevent any shutdown.

The plant’s normal operation created two waste streams from the impurities of processing raw coal, which were composed of rock and fire clay. Both coarse rock and fine rock particles are produced during the process, the coarse rock is sent to a refuse disposal area by conveyor and fine rock particles are slurried and disposed.

Due to the volume of slurry to be processed, the coal mine needed a safe and efficient plan that would allow the containers to be reclaimed in place instead of opening them up and transporting the material to the course refuse disposal area. In order to maximize utilization of the available dewatering area, a stacked pyramid of four layers of geotextile containers was designed for one particular dewatering area. The additional layers were installed and stacked once the consolidated material reached 35% dry weight solids. The complete project required three dewatering cells. Figure 4 is an illustration of the dewatering cell and progression of the stacked containers.

A manifold system, along with a polymer tank and pumps was implemented to fill and manage the flow to multiple containers at once. A swinging ladder 8-inch dredge was placed into the slurry pond to pump the slurry into the containers. The dredge was initially operated on a 24-hour basis with two 12-hour shifts. A crew of five to six men operated the dredge plus managed the filling and dewatering of the containers.

This set-up was capable of pumping 1,750 cubic yards per 24-hour day. The completed project utilized 240 geotextile containers, and a total of 200,000 cubic yards were pumped and dewatered. The average holding capacity of the geotextile containers was 5 cubic yards of solids per linear foot of container.

Once all the containers in the dewatering cell were fully dewatered, the site was then ready for reclamation. Eventually, the containers were covered with earth and then topsoil. Once reclamation was complete, the entire dewatering cell was mulched and seeded. All three dewatering cells were covered and reclaimed. During the reclamation process, a layer of
sand was first applied to cover the containers and provide a filter medium. Next a layer of limestone was installed for drainage, and then containers were covered with earth and topsoil.

3. REMOVAL OF TAILINGS & FINES FROM SETTLING PONDS

Many aggregate plants experience high equipment and manpower costs associated with the handling and removing of tailings and fines from settling ponds. The costs of maintaining pond operations can vary significantly from plant to plant. Not only is valuable space tied up during gravity settling and thickening the materials in the settling ponds, but the ability to calculate the overall costs for mechanical dewatering, removal, and disposal costs of fines can be difficult.

Smaller plants face a more difficult challenge since the capital, maintenance, and operating expense of mechanical dewatering equipment for the removal of clays and fines from plant effluent is beyond their budgetary means. Aggregate plants find it necessary to explore and evaluate other dewatering options.

Several states are revising permits aimed at protecting water quality from the pollution discharged by sand and gravel operations. These facilities can include sand and gravel mines, rock quarries, clay mines, concrete batch plants, and asphalt plants. Federal and state laws require a permit because these operations discharge water that may be polluted, such as sediment from gravel washing, oil and grease from trucks and heavy equipment, and alkaline wastewater from concrete plants. The permit requires companies to take steps to ensure that surface and ground waters are protected and to monitor water quality on a regular basis.

Dewatering with geotextile containers is a cost effective alternative to mechanical processes. Plant effluent can be pumped directly from the process or, if a clarifier/thickener is used, effluent from the underflow can be diverted through a geotextile container, eliminating the requirement for expensive mechanical dewatering units. Table 1 illustrates the effectiveness of dewatering aggregate tailings with geotextile tubes.

<table>
<thead>
<tr>
<th>Material Type</th>
<th>% Solids During Pumping</th>
<th>Dry Solids after 1-Day</th>
<th>Dry Solids after 3-Days</th>
<th>Dry Solids after 15-Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarifier inflow with Polymer</td>
<td>8%</td>
<td>27%</td>
<td>45%</td>
<td>71%</td>
</tr>
<tr>
<td>Clarifier outflow with Polymer</td>
<td>31%</td>
<td>43%</td>
<td>55%</td>
<td>70%</td>
</tr>
<tr>
<td>Aggregate Tailings with Polymer</td>
<td>26%</td>
<td>42%</td>
<td>67%</td>
<td>86%</td>
</tr>
<tr>
<td>Pond Material with no polymer addition</td>
<td>26%</td>
<td>NA</td>
<td>36%</td>
<td>79%</td>
</tr>
<tr>
<td>(high solids in filtrate)</td>
<td></td>
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</tbody>
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Geotextile containers can be used to capture fines, silts, and clays from the tailings effluent prior to discharge into the ponds or directly into streams. The containers will separate and dewater the fines and allow disposal without expensive dredging and transporting operations.

4. DEWATERING OF ACID MINE DRAINAGE

A mining company was faced with a challenge to reopen a pit mine which had been converted into a tailings pond for nearly a decade. The mining company desired to extract zinc from the former pit mine, now a tailings pond since the value of zinc had increased. Restarting the operation also required refurbishment of the waste water treatment plant. Figure 5 shows the condition of the open pit mine at the start of the project.
The challenge of the operation required the removal of 392,000 cubic yards of zinc-contaminated water from the pit mine and dewatering 41,000 cubic yards of sludge. Of the potential options to either dewater the sludge with mechanical systems or build a storage pond on-site; geotextile containers were chosen for dewatering and temporary containment. The project began by adding lime to the tailings pond to raise the pH and precipitate metal ions. The addition of the lime to precipitate zinc created a need to inject CO$_2$ to balance the pH of the water during removal. This process left the need to dewater 41,000 cubic yards of sludge comprised tailings and addition of lime with geotextile containers. The limited area to construct a dewatering cell required two layers of containers in a pyramid stack to maximize the area, see Figure 6.

There was an additional benefit of the geotextile containers which allowed the mine to contain the sludge onsite for transport and disposal at a later time. Filtrate results showed that the geotextile containers in conjunction with proper chemical conditioning produced zinc leachate concentrations below the discharge limit of 250 ppb.

5. TREATMENT OF THICKENED WASTEWATER SLUDGE

Typically, thickened wastewater sludge from underground mines is pumped back underground. West Virginia has discontinued issuing new permits for underground wastewater storage. Geotextile containers can contain and dewater the thickened sludge and provide an efficient alternative to liquid hauling of the sludge to the refuse pile.

A particular coal mine produced approximately 2 million gallons of raw mine water per day which is pumped out of the underground mine. The wastewater containing coal fines, iron, and manganese salts is pumped to a neutralization tank where it is treated with hydrated lime and oxygen. The treated water in the neutralization tank overflows into the thickener. Flocculants are added in the overflow trough and thickened solids settle to the bottom of the tank, allowing clear water to overflow from the top to the discharge.
Rakes direct the solids at the bottom of the tank to a center well pump. From there, the solids at 15% by dry weight are pumped to geotextile containers. A dewatering cell was constructed near the wastewater treatment plant and containers were placed on an aggregate base for good drainage. Clean filtrate is collected in a pond and a submersible pump returns the filtrate to the thickener.

After one week the dewatered solids typically reach 33% dry weight solids and continue to consolidate over additional weeks to 67% dry weight solids.

6. CONCLUSIONS

As in remediation projects, governmental regulations dictate what mines can and cannot do in terms of handling their waste streams. In some areas, underground storage of process waste is allowed but in other states there is a moratorium on underground storage. Sometimes in states that allow underground storage there may be temporary situations that require an alternative storage. Likewise, the mines are accountable for contaminants in their waste streams. Case in point is a metals mine where a pond had to be closed pond. For several years wastewater had been stored in the pond due to nitrate contamination.

Acid mine drainage is heavily regulated in all mining areas and all these issues create opportunities for dewatering in geotextile containers. These opportunities may not have existed if not driven by regulations. Mining and mineral processing offer a variety of applications where geotextile containers offer a unique solution to dewatering of wastewater residuals.

REFERENCES: