SUCCESSFUL DEWATERING OF ACID MINE DRAINAGE MATERIALS[1]

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Introduction

Many states are faced with the problem of dealing with both old inventories of stock- piled residues, as well as those materials recently excavated in order to provide roads and access to mining areas. The leachate from these tailings produces an iron oxide material that will, if not monitored and controlled, flow into our drinking water, streams, and rivers.

Geosynthetic Products

Proper detection and treatment of the material through state policy and environmental management will prevent this migration. Several attempts have been made to volume-reduce and dewater these residuals, in order to place as little as possible in the storage impoundments for tailings/sludge or to the local landfills. The use of a geosynthetic polypropylene material, which is fabricated into a cylindrical tube called a Geotube® container, has received widespread attention over the past several years. This specially woven fabric membrane allows the filtrate to escape while containing the solids. Volume reductions of 75- to 85% have been achieved with acid mine drainage materials. Several companies are providing experience, engineering, and software for sizing, technical assistance in testing, chemical usage, and field installations.

Project Experience

On a recent project for the PA DOT, the consulting engineer required assistance with an emergency acid mine drainage project for the Highway 99 construction. Excavated material for the highway construction had been stacked nearby for further use by the contractors until the presence of pyretic materials was determined, which would cause drainage of contaminated materials from this large volume of sludge/slurry. The slurry material was concentrated in several holding areas or storage lagoons.

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ARD Formation

Pyrite/Marcasite + Oxygen + Water + Bacteria = ARD

ARD = Acid + Heavy Metals + Sulfates. Heavy Metals of Concern = Fe, Al, Mn, and Zn. ARD Formation--Wet/dry cycles associated with intermittent rainfall caused oxidation and dissolution of sulfides and their oxidation products. During the dry phase the sulfide minerals formed soluble sulfate salts. These salts, when exposed to water, form highly acidic drainage (pH < 3), containing high levels of dissolved Fe, Al, and SO_4 with lower levels of Zn, As, Co, Cu, and Ni. Interim ARD Treatment Measures--ARD + Alkalinity +

Oxygen + Bacteria = Metal Precipitates and Treated Water. Interim ARD Treatment Measures Utilized existing E & S basins along with ChemTreat 252 (sodium hydroxide with a coagulant aid – $KMnO_4$) addition for ARD Treatment.

Bench-Scale Testing

Samples of the residue were sent to several local manufacturers for detailed dewatering testing utilizing (e.g., Fig.1) various mechanical and non-mechanical dewatering devices.

Figure 1. Rapid Dewatering Test Unit

The Geotube® container bench-scale unit-Rapid Dewatering Test Unit (RDT) clearly showed this method was economical and the containers would be safe, efficient and easy to use. They would provide high volume reduction and a product that could be transported and pass the paint filter test. Several chemicals were found to condition the material; however, working with the consultant and their chemical supplier and considering the availability of materials on-site, anionic polymer was selected. The dosages and rates of application were calculated along with the flow rate of the slurry into the geosynthetic unit. The selected supplier was Miratech®. Miratech® is a division of Ten Cate Nicolon. The Rapid Dewatering Test Cell consists of a 10 cm (4") diameter piece of Geotube GT500 geo textile, at the bottom of a cylinder that can hold about 1300 ml of liquid.

A one-liter sample is poured into the RDT, and the time it takes for the liquid to drain through the geo textile is measured. It typically takes 12 to 15 seconds for pure water to pass through the cell. Two candidates were selected from the Hychem Dewatering Guide list of polymers, AE-853, and AE-873. 100 ml of dilution water was measured into a 9 oz. plastic cup. 0.25 ml of neat polymer was added to each cup. The 0.25% polymer solution was then mixed for 30 seconds in a low shear 450 ml beverage mixer. The mixer was thoroughly cleaned between each batch. The polymer preparation equipment (e.g., Fig. 2) and RDT unit are shown below.

Figure 2. The Rapid Dewatering Test

Product Selection

The supplier evaluated the need of the site and based on the bench testing provided the Geotube® containers manufactured of high tenacity polypropylene yarns, which are woven into a network so that the yarns retain their relative position. GT-500 is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids. Several mechanical properties include: Tensile strength (at ultimate) in accordance with ASTM 4595 70.0 kN/m (4800 lbs/ft) in MD and 96.3 kN/M (6600lbs/ft) in the CD. The Flow Rate is 813 l/min (20 gpm/sq ft) with the Apparent Opening Size (AOS) of 0.425MM (40 US Sieve).

These units were shipped to the site where the consultant Skelly & Loy of Harrisburg, PA and the PA-DOT crews assembled the initial system (e.g., Fig. 3) consisting of: Slurry holding (frac) tank, polymer storage, polymer feed, slurry pumping, Geotube® containers, and polymer injection/mixing equipment.

Full-Scale System Design

Technical service personnel from the dewatering membrane as well as the chemical supplier were on site for the start-up. As was performed in the bench testing, attempts were made to dewater the slurry with and without polymers. It was determined that in fact polymer was required for good water release and high solids compaction. Chemicals from Hychem and ChemTreat were tested, and anionic liquid emulsion polymers were determined to be the best choice. The major consideration for the emulsion was that dilution water was not available on site.

Figure 3. Initial System configuration

Therefore polymer was delivered to the site in liquid form and pumped into totes at a dilution of 2%. The economics of the polymers selected showed that 11-14 kg per dry ton (20 to 35 lbs.) of product were required resulting in a relatively low cost per dry ton of slurry/sludge processed. Although other methods of handling the material were considered, the geosynthetic membranes were selected due to their ease of operation, low cost, and lower volume when the material was transported off-site. Stabilization and the use of adsorbents were considered; however, this was deemed too costly, as was liquid removal. Stockpiling the liquid slurry on site was not an option.

The system generally processes approximately 94.6 cu m/day (25,000 gallons) of a feed material to the geosynthetic container of 1- to 3% dry solids and produces cake dry solids of 30- to 35% within several days. Operations are maintained with one pump operator and one Geotube® technician during the day shift. The engineer selected tubes of 18.3mm (60 ft) circumference by 30.5 mm (100 ft) long as shown (e.g., Fig. 4).

The site has been reconfigured over the past winter and is now more compact. Slurry is now pumped to the treatment area from five holding areas (instead of the previously utilized vacuum trucks). The mobile holding tank has been replaced with a concrete tank and a portion of the filtrate from the dewatering containers is now recycled to the concrete tanks for dilution water. The balance of the filtrate flows into a polishing pond prior to being discharged. Filtrate has been examined for metals such as iron and manganese and has been found to have levels below 1.0 mg/l. Additional photos and a description of the site will be presented with the poster.

Figure 4.Typical Geotube® Container Installation

Table 1. Comparison of Influent and Effluent Characteristics.

2005 Sludge Slurry Prior to Processing		2004 Dried/Dewatered Sludge From Geotube
Total Iron	38,090 mg/kg (dry)	53,562 mg/kg (dry)
Total Aluminum	17,925 mg/kg (dry)	25,505 mg/kg (dry)
Total Iron		
Total Manganese	1,525 mg/kg (dry)	1,798 mg/kg (dry
Total Solids	1.15%†	35.4%

†May have been influenced by polymer recirculation in the pond sampled

Other AMD Testing Results

Several additional applications have been tested for the use of mechanical and non-mechanical dewatering devices for AMD projects in Pennsylvania and West Virginia. The slurry/sediment materials are similar although not quite the same as the PA DOT Highway 99 project. These other projects required initial study and evaluation (e.g., Fig. 5) of the sediment/sludge to determine if they could be dewatered utilizing the geosynthetic container method.


Figure 5. Untreated slurry on the left

Geotube® BenchTest

A Geotube® Bench Test was conducted using a test cone of the GT-500 fabric from which Geotube® are made. A 1000 ml sample of 1:1 diluted Jenners PTS sludge was treated with the 2.0% anionic polymer solution. The solids flocculated after strong mixing and were then poured into GT-500 test cone. The time for liquid to drain through the cone was measured, along with the quantity of filtrate recovered

Initial testing of 1,000 ml of slurry was conducted with the recommended polymer after five minutes; about 600 ml of liquid had drained from the sample. Within 15 minutes, all visible liquid had drained from the sample. The treated sample produced 650 ml of clear filtrate in 15 minutes. The filter cake was well formed and released easily from the GT500 fabric.

Samples of the original, undiluted sludge (e.g., Fig. 6), and the filter cake were retained for percent solids testing. The sample of the filter cake (e.g., Fig. 7), was allowed to drain in the cone of GT500 fabric at room temperature and humidity for 24, 48, and 72 hours (e.g., Fig. 8), before testing for solids content. The test samples were weighed, and oven dried at 105C for a minimum of 12 hours or until constant weight. A photo of the filtrate (e.g., Fig. 9), shows low suspended solids and high capture.

The Table below presents the results of drying the sludge and filter cake samples.

Table 2.

Jenners Passive Treatment System	Initial	After Geotube Testing
Sample	% Solids	%Solid
Initial Sludge	14.2%%	
Sludge Diluted 1:1	7.1%	
Filter cake-after 24 hours		23%
Filter cake-after 48 hours		25%
Filter cake-after 72 hours		28.5%

Figure 6. Treated 1-liter sludge sample

Figure 8. Filter cake- after72 hours and passes paint filter test

Figure 7. Filter cake- after 24 hours

Figure 9. Recovered filtrate

Results

The Jenners PTS sludge was successfully flocculated and dewatered in the GT 500 test cone. Drainage from the treated and flocculated sludges was typical, with all visible liquid draining rapidly. About 65% of the treated sample's initial liquid was recovered as filtrate within 15 minutes. The resulting filter cake was well formed and achieved percent solids similar to other, iron oxy-hydroxide sludges. With the proper chemical conditioning, typical PTS sludge can be successfully dewatered using Geotube®.

Conclusions

The selection of geosynthetic membrane systems also known as Geotube® container is a superior and economical method for the dewatering and containment of solids in acid mine drainage and passive treatment processes. The careful selection of chemical (polymer), bench-scale testing with the Rapid Dewatering Test Unit (RDT), or a Cone Test are important in order to help with the estimated consolidation rates and tube requirements. The above case studies show the ease of operation, low chemical, low overall capital and operating costs of the geosynthetic membrane systems compared to mechanical dewatering devices.

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