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Geotextile tubes to dewater and confine fine gold tailings

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ABSTRACT

The use of geotextile tubes is an alternative to dispose ore tailings, once it is possible to dewater these high humidity materials and stack the geotextile tubes. This paper is intended to present the first level tests results of a full-scale prototype of stacked geotextile tubes installed inside a gold mine company located in the state of Bahia, Brazil. The project was designed for a three-level structure, being 9 geotextile tubes units in the first level, 4 in the second level, and one geotextile tube unit in the third level of stacking. Every geotextile tube unit had 2,0m in width, 6,0m in length and was designed to have a maximum height of 1,0m throughout the filling process. The process to fill the first set of geotextile tubes from the first level is presented as well as the main results regarding volume of confined tailings and solids concentration over time. Based on field observations and geometry, the geotextile tube technology efficiency on dewatering fine tailings was verified.

1. INTRODUCTION

The geotextile tubes technology has been applied to dewater high-humidity materials such as tailings around the world (Yang et al., 2019; Arnau et al., 2017; Timpson, 2017; Assinder et al., 2015; Wilke et al., 2015). Geotextile tubes are made of high-strength, permeable, specially engineered textiles. Hydraulic pressure is applied to the infill material thus forcing the water through the fabric leaving behind the solid particles to gradually stabilize. The solution is an alternative to dewater and confine mining tailings; according to Lawson (2008), tailings produced by large mining facilities are typically disposed of in dams built in isolated locations. However, there are instances in which mining activities are installed in environmentally and socially sensitive locations and generate waste on a relatively smaller scale. For these circumstances, or even to dispose part of the generated tailings, geotextile tubes are a technological alternative to dewater and confine the mining tailings.

For new projects, Lawson (2008) proposes to carry out prototype tests in large or real dimension to confirm or modify the assumptions assumed from the smaller scale tests, such as Geotextile Hanging Bag and Geotextile Dewatering Test (pillow test). These smaller-scale tests allow the quality of dewatering to be assessed but are of little use in estimating the dewatering time required for large-scale tube stabilization. For Yee and Lawson (2012), large-scale prototype testing is the best way to evaluate dewatering and accurately reproduce tube filling phases. This paper presents the process of filing the geotextile tubes

2. MATERIALS

The geotextile tube used in this study was made of a polypropylene woven geotextile. It is 1.8 mm thick and has tensile strength of 100 KN/m. The test property results of the geotextile are given in Table 1.

Table 1. Test results of geotextile properties used in this study

Property	Test Method	Unit	Woven Geotextile
Mass per Unit Area	ABNT NBR ISO 9864	g/m^2	554
Thickness	ABNT NBR ISO 9863 – 1	Mm	1.77

The geotextile tubes were used to dewater gold ore tailings produced in slurry form at a mine district located in the state of Bahia, Brazil. Laboratory tests were conducted to evaluate the tailings before filling the geotextile tubes. The results are presented in Table 2.

Table 2. Test results of physical and mechanical properties of tailings samples

Property	Test Method	Unit	Tailings
Water content (%)[1]	NBR 16097	%	1.27
Natural Water content (%)[2]	NBR 16097	%	100
Specific Gravity	NBR 6458	NA	2.85
Sand	NBR 7181	%	6.6
Silt	NBR 7181	%	71.3
Clay	NBR 7181	%	22.1
Coefficient of Uniformity (CU)		NA	
Coefficient of Concavity (CC)		NA	9
Percent passing #200 sieve	NBR 7181	%	75
Liquid Limit	NBR 6459	%	NA
Plasticity Limit	NBR 7180	%	NA

[1]water content of specimens after preparation for testing. [2]water content of specimens in slurry form as produced in the field

The tailings have a natural water content of 100% in a slurry form right after being disposed of the beneficial mining plant. It corresponds to a solids content, by weight, of 49%. A combined size analysis for the tailings is shown graphically in Figure 1.

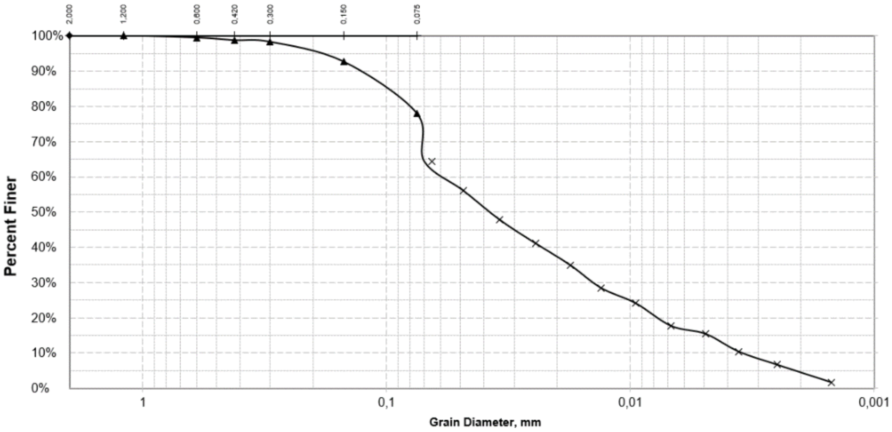

Figure 1. Test results of grain size analysis for the tailings used on this study

Other laboratory tests were conducted prior to filling the geotextile tubes at the field. Those tests were performed to evaluate dewatering efficiency and included the cone test, the jar-test, and the geotextile dewatering test (GDT). Through these dewatering efficiency tests, it was decided that a flocculating agent (polymer) would be required to prevent excessive loss of fines. Nevertheless, this paper focus on presenting the full-scale prototype test procedure and results.

3. TEST PROCEDURE

The model test was constructed inside the mining area, on the top of a tailings pile. There was no scheduled works to be performed in this area in the coming years, so the geotextile tubes were installed over there to be monitored for, at least, two years. The test area had the dimensions of 7m x 9m and a drainage layer was built over a geomembrane layer to collect the fluid along the dewatering process.

Figure 2 is showing the prepared area overview: the system was composed of a 9 m^3 graduated tank directly connected to the mining plant through a valve; two flocculating agent (polymer) tanks.; a box to verify tailings flocculation; a system composed of pumps to mix tailings and the flocculating polymer and fill the geotextile tubes. Details of each of the system components are shown in the Figure 3.

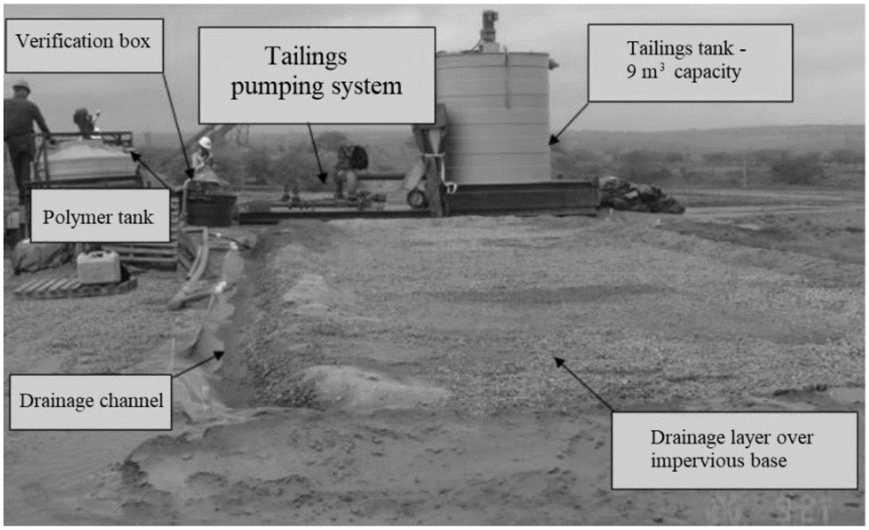

Figure 2. Overview of full-scale prototype area

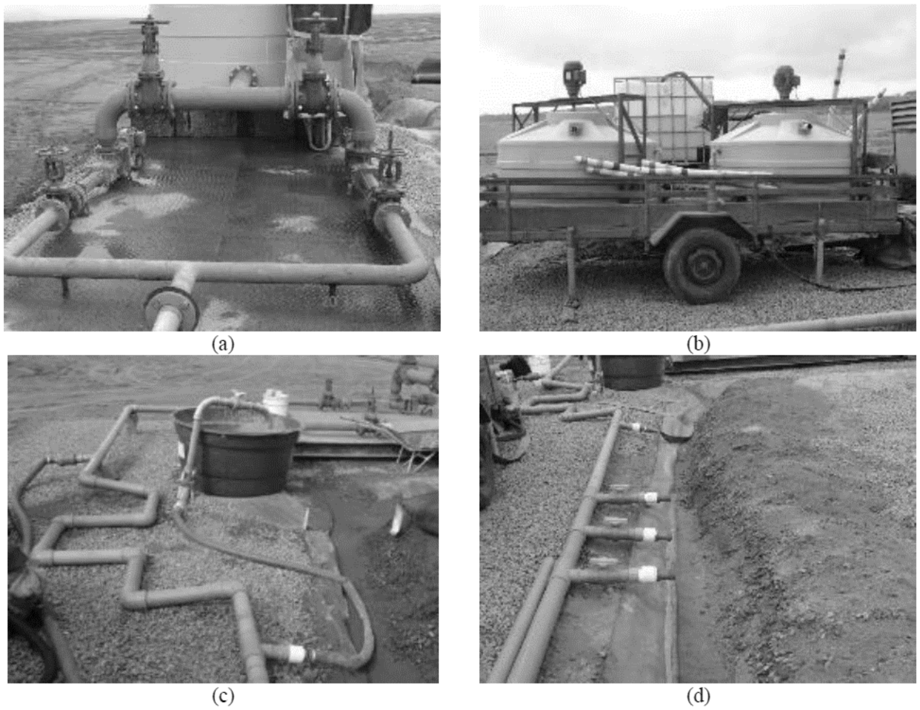

Figure 3. (a) pumping system composed of two pumps and a tank to store tailings; (b) two polymer tanks; (c) verification box and pipes to mixture tailings and the flocculating polymer; (d) pipes and connections to fill the geotextile tubes

The following variables were observed throughout the filling process: volume of pumped tailings over a specific period of time; frequency of polymer and tailings pump; visual aspects of flocculated tailings; tailings distribution over the geotextile tube length; visual aspect of the fluid that came out of the tube; the flow output rate, and also the shape of geotextile tubes transversal area.

Regarding the geotextile tubes geometry, vertical and horizontal displacements were monitored over the operation and tailings pumping. These data were obtained through the installation of monitoring elements that included topographic laser control to ensure that measurements were taken at the same level, and a scale gantry for vertical and horizontal direct measurements. The gantry ruler used to collect horizontal and vertical displacements was 8.0 m long and 3.0 m high and was graduated to enable millimeter-precision measurements. It was designed so the structure could be monitored to the most critical condition of the last tube to be stacked, as can be seen in Figure 4. The horizontal ruler was able to move up and down as the geotextile tube height increased/decreased.

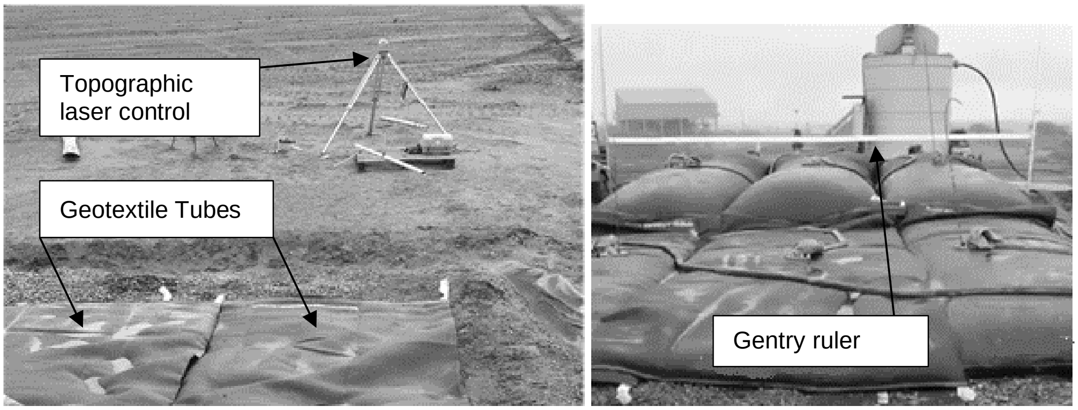

Figure 4: Equipment used to monitor the geotextile tube filling process

There was no device to control the outflow rate of the tailings tank. To solve this issue, the gradation marks at the tailings tank were used check the volume of tailings pumped over time. The steps to fill the geotextile tubes are presented below:

1) Fill the tailings tank to its maximum capacity of 9 m^3 by opening the valve that connected the tank to the mining plant tailings pipe;
2) Continuously stir the tailings stored at the tank by the electric agitator to ensure an even mixture;
3) Collect a sample of slurry to calculate the tailings initial solid concentration;
4) Turn on the tailings pump and the flocculant pump to fill the geotextile tubes.

Once the tailings pump was started, a timer was set so the tubes height was measured at each 10-minute interval by the topographic laser; also, the tailings tank level was checked to calculate the amount of pumped tailings.

The tailings pump and the flocculant agent (polymer) pump system needed to work in coordination to ensure a proper filling. When filling the first geotextile tubes layer, none of those had a pressure gauge to control pumping pressures so the tailings tank pump frequency was recorded and used as a control variable. Therefore, the polymer tank pump frequency was set to allow flocculant dosing at a concentration of 0.2% by weight within the system (Figure 5 – c). Setting the power and rotation frequency between the two pumps was important to insert the polymer in the system with enough energy to flocculate the tailings. However, inserting a larger volume of polymer than is needed for flocculation (Figure 5 – a) would lead to an uneconomical condition of the process. In order to monitor the flocculation, random samples were taken at the verification box for qualitative analysis, as shown in Figure 5.

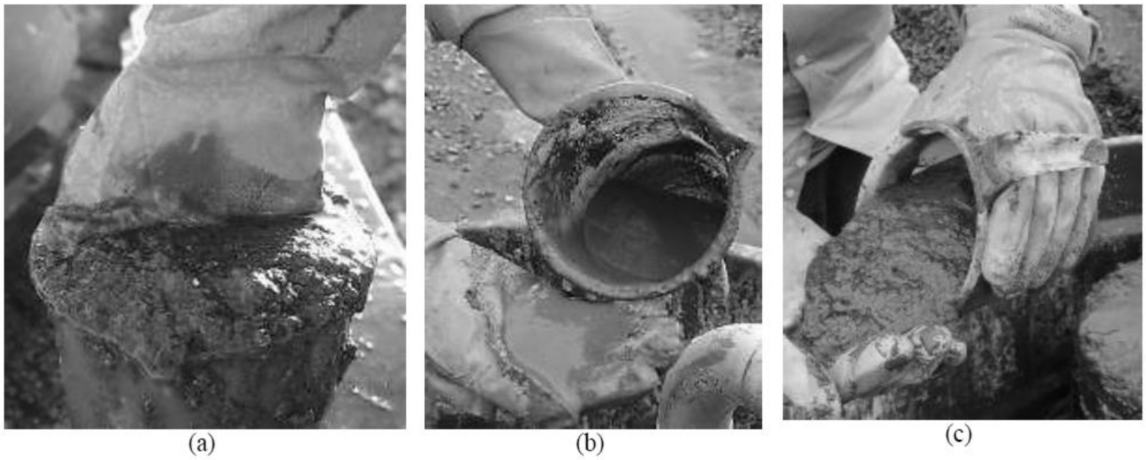

Figure 5: Flocculated tailings appearance: (a) excess polymer-tailings mixture, (b) inefficient flocculation, (c) proper polymer dosage (0,2%).

4. TEST RESULTS AND DISCUSSION

After setting the pumps frequency for proper tailings flocculation, the filling process was started. Three geotextile tubes were filled at a time by alternating pumping stages to obtain intermediate dimensions. A filling cycle of 10-15 minutes in each tube was estimated for testing. After this 10-minute filling period, the next geotextile tube should be filled for the next 10 minutes and so on. From the input data, the tailings had a solids content by weight of 50% and were pumped at a flow rate of approximately 0.16 L / s over a time period of 75 minutes. From this information, each geotextile tube instantly retained about of 1.8 m³ of tailings, making a total volume of 5.4 m³ of confined tailings. Given these numbers and initial pumped volume, about 13% of the total amount pumped tailings was instantly dewatered. Figure 6 is showing graphically the filling (circled) and dewatering stages over time for the first set of filled geotextile tubes. The filling process for the first set of three geotextile tubes took place in six stages. The first stage had to be interrupted due to technical issues at the mining company, so it was only possible to fill the tubes up to 17 cm in height. Three more steps were performed on the following two days and the geotextile tubes were left over the weekend. After 48 hours, the geotextile tubes height decreased by 10 cm, so two more fillings were performed. Once filled, the tubes had a final height ranging from 0.98 m to 1.0 m.

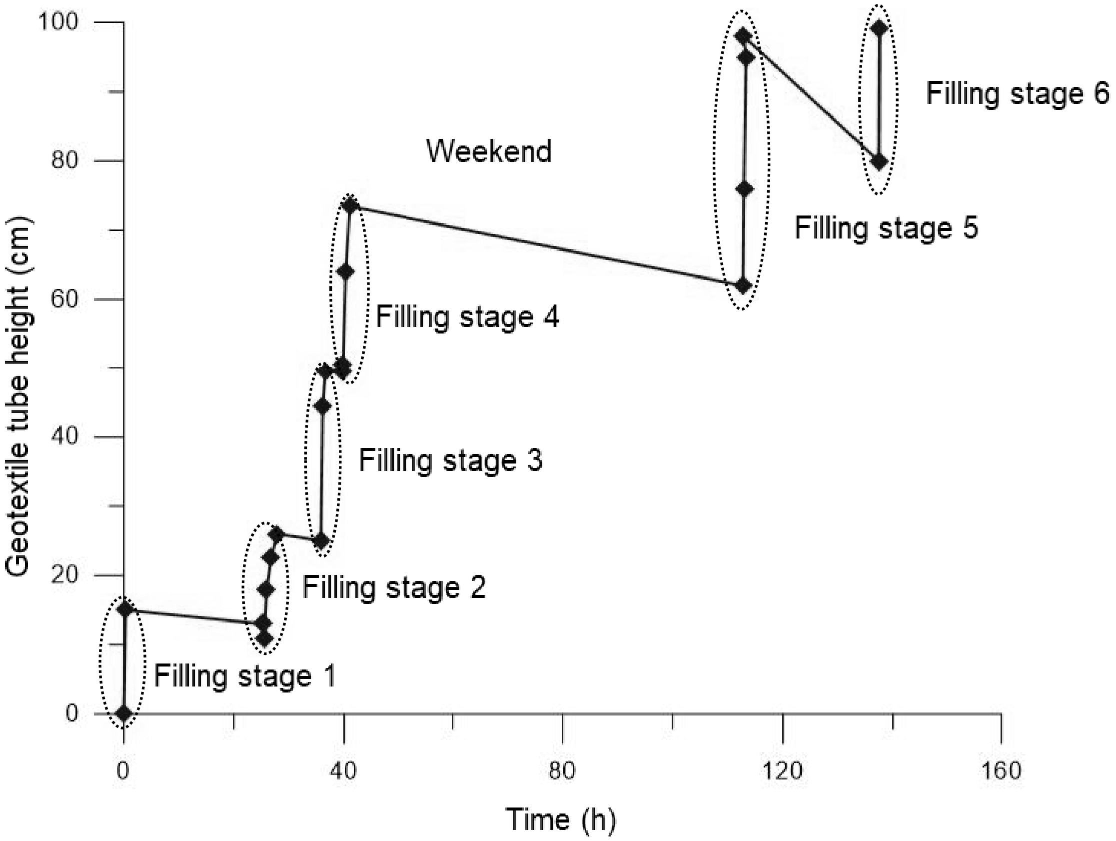

Figure 6: Geotextile tube height over filling and dewatering stages

Tailings confined within the geotextile tubes had its solids concentration evaluated by taking samples close to the tube filing port. After the last filling stage, samples were taken after 24h, 48h, 72h, 7 days, 21 days and 28 days. Figure 7 is showing the solids concentration over time. The greatest increase in solids content occurs in the first 24 hours, when the solids concentration goes from 53% to 75%. This data corresponds to a water content of 100% decreasing to 25% in a day. After the first 24 hours, the desiccation rate decreases and the increase in solids content is about 10% in 13 days.

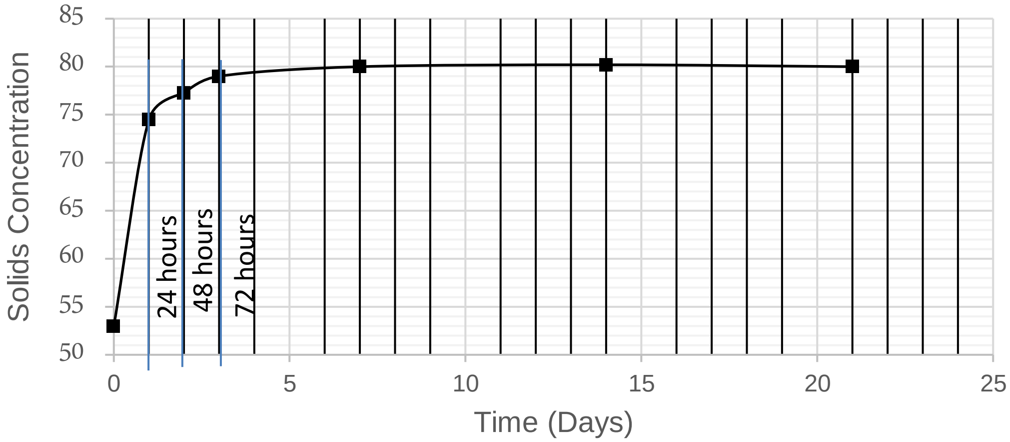

Figure 7: Confined tailings concentration over time within the geotextile tubes

5. SUMMARY AND CONCLUSIONS

This paper presented test procedures of a full-scale geotextile tube prototype constructed inside a mine company to dewater and confine fine tailings. Every geotextile tube unit was able to dewater and confine an amount of 5.4 m^3 of tailings. It corresponded of decreasing the water content from 100% to 25% in 24 hours. The water content tended to stabilize after 48 hours. The authors plan to present in a future paper the stack stability evaluation of geotextile tubes filled with fine mine tailings. As indicated by Timpson (2017) the geotextile tube technology can allow the use of tailings to create a structure by stacking the tubes, using the tubes as road base, or increase the berms around dams to raise storage capacity. The use of geotextile tubes provides a flexible technology to dewater and contain mine tailings.

6. ACKNOWLEDGEMENTS

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