Investigations on geotextile specimens exhumed from a mining tailings dams
Enquêtes sur géotextile spécimens exhumés d'un des barrages de résidus miniers

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ABSTRACT

The filtration behaviour of geotextiles has been extensively studied in the laboratory. Different conditions of loading and flow regimes have been analysed. However, little have been investigated under field conditions. Geotextile specimens exhumed from real filtration and drainage systems are important for the evaluation of the behaviour of geotextile filters. In this paper, a geotextile specimen exhumed from an iron ore tailings dam is studied in order to improve the understanding on the geotextile filtration behaviour in this type of work.

RÉSUMÉ

Le comportement de la filtration des géotextiles ont été largement étudiés dans le laboratoire. Les différentes conditions de chargement et de régimes d'écoulement ont été analysées. Cependant, très peu ont été étudiés en conditions de terrain. Geotextile spécimens exhumés de véritables systèmes de filtration et de drainage sont importantes pour l'évaluation du comportement des géotextiles filtres. Dans ce document, un spécimen géotextile exhumés d'un barrage de résidus de minerai de fer est étudié en vue d'améliorer la compréhension sur le géotextile de filtration de comportement dans ce type de travail.

Keywords : geotextile, exhumation, filtration, drainage, tailings dams

1 INTRODUCTION

Geotextiles have been employed in several types of engineering works for the last decades. The non-woven geotextiles in particular have a quite extensive application in drainage and filtration systems (Giroud 1996, Palmeira et al., 1996, Gardoni, 2000, Lafleur et al., 2002 and Bessa da Luz, 2004). The use of geotextiles as filters of mining tailing dams still demand significant studies in order to evaluate the performance of these materials under severe conditions. Considering these aspects, this study presents results on the characterisation of non-woven geotextiles specimens exhumed from a tailings dam drainage and filtration system.

In order to take advantage of the benefits that a field investigation can bring to the research, non-woven needle punched geotextile samples were exhumed from the drying bay of the Germano dam at Samarco Mineracao S.A, state of Minas Gerais, Brazil. The technique for tailings disposal used in this plant is the process of desiccation. More information is reported by Beirigo (2005). Figure 1 presents a typical drainage structure from were geotextile specimens were exhumed.

The field sampling methodology allowed testing smaller specimens in the laboratory (Gardoni, 2000). These specimens permitted the investigation of the clogging phenomenon that took place in the real filtration and drainage system under field conditions. Investigation techniques in the laboratory such as x-ray difractometry, laser beam grain size analysis of the tailings and electronic microscopy were carried out.

2 METHODOLOGY

2.1 *Geotextile Exhumation*

Several materials involved in the filtration process were identified in the field. Samples of the protected tailings were also collected. In the laboratory, the tailings samples were submitted to conventional characterisation and difractometry tests. Regarding the geotextile, after the physical integrity evaluation of the exhumed sample, a simple random statistical procedure was adopted in order to obtain the specimens to be used for the evaluation of the spatial variability of the geotextile mass per unit area and level of impregnation by tailings particles. In addition, optical and scanning electronic microscopy studies were carried out in order to analyse the interaction between the tailings particles and the synthetic filter. The x-ray difractometry was also utilised to identify the main constituent minerals of the particles impregnating the geotextile pore space. The grain size distribution of the particles that impregnated the geotextile samples were also obtained using a laser beam particle size analyser.

Considering the difficulties imposed by the field conditions in the tailings dam site, it was possible to exhume only one large geotextile sample from the dam drying bay BS1. It was necessary to use an excavating tool in this procedure (Fig. 2), which caused some damages to the sample, such as perforations and cuts. Nevertheless, the sample was considered a good representation of the material utilised in the field, once these damages were localized in a few places of the sample layer.

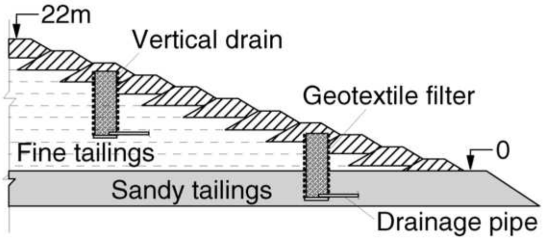

Figure 1. Vertical drains – Drying bays of the Germano Dam.

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Figure 2: Exhumation of the geotextile sample.

3 METHODOLOGY

3.1 *Laboratory Investigations*

First, the physical conditions of the geotextile were visually evaluated. It was attempted to identify the damages caused by the constituent materials of the bay drainage system and by the sampling procedure utilized in the field.

The studies concerning the interaction mechanisms between the geotextile and the adjacent materials involved the use of electronic microscopy. In addition, determinations of the geotextile mass per unit area, the level of the geotextile impregnation and the grain size distribution of the particles retained in the geotextile were performed. It is important to point out that the regions that showed any kind of mechanic damage were excluded from these tests.

The level of impregnation (λ) of the geotextile by tailings particles can be determined by the ratio between the mass of the particles entrapped in the geotextile and the mass of geotextile fibres. The mass of geotextile fibres was obtained after the removal of the entrapped particles. This also allowed obtaining the mass of geotextile fibres per unit area.

4 RESULTS OBTAINED

The visual examination showed that the exhumed geotextile sample presented mechanic damages possibly caused by the perforating ends of the materials adjacent to it, like the metallic net of the drainage system and the core rock fill material, as well as by the sampling procedure used.

There were also regions with higher concentrations of particles attached to the geotextile, as shown in Figure 3. In order to quantify and qualify this occurrence and to verify the influence of the spatial variability of the fabric characteristics, selected specimens were taken. These specimens were subjected to microscopic analysis and to the evaluation of geotextile impregnation levels.

Table 1 presents the results obtained for the geotextile mass per unit area and geotextile levels of impregnation in the exhumed sample. It can be noticed that the average mass per unit area is equal to 400g/m^2. Regarding the level of impregnation, a significant scatter of results was observed, which is reasonable, bearing in mind the variability of several relevant parameters to that effect, such as tailings particles sizes and geotextile opening dimensions and special distribution, for instance

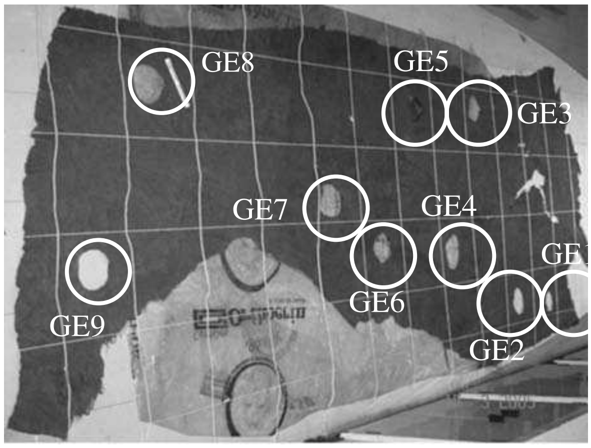


Figure 3: View of the geotextile sample exhumed from drying bay BS1 (UIG)

Figures 4, 5 and 6 present some images obtained by microscopy. It can be observed the occurrence of particle clusters close to the geotextile surface (Figure 4) and inside of the geotextile, characterizing some level of internal clogging (Figure 5). This impregnation causes reductions on the geotextile pore space and consequently increases geotextile retention capacity. Figure 6 shows that large particles were entrapped in the geotextile pores. The presence of larger particles in the geotextile pore space was a consequence of the tailings deposition process or due to seepage forces, which can push some large particles further in the geotextile pore volume.

Table 1: Characterization of the exhumed geotextile sample.

Specimen	E1	E2	E3	E4	E5	
λ	4.6	4.0	2.0	6.6	2.2	
M_A	392	412	416	414	415	
Specimen	E6	E7	E8	E9	$\bar{x}$	σ
λ	3.4	10.0	5.6	2.5	4.5	2.4
M_A	385	393	461	426	413	21

Notes: λ is the geotextile level of impregnation and M_A is the mass per unit area of the geotextile specimen (g/m²), x is the average value, σ is the standard deviation and E1to E9 are the specimen codes.

Figure 4 - Particles clusters close to the geotextile surface.

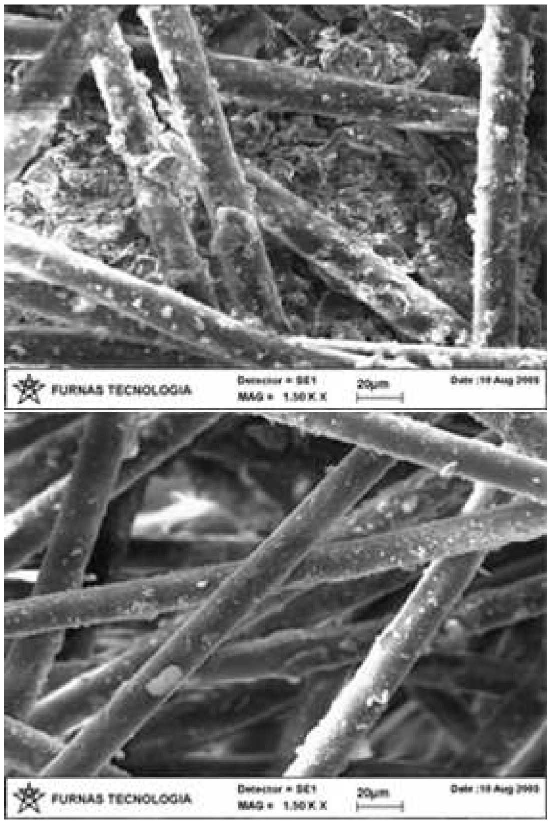


Figure 5 – Particle clusters inside the geotextile.

Figure 7 shows that there is no clear correlation between the specimen mass per unit area and its impregnation level.

Table 2 presents data on the sizes of particles entrapped in the geotextile as well as particle sizes of the tailings adjacent to the drainage system. Figure 8 depicts the grain size distribution curves obtained in the grain size analysis. It can be verified the occurrence of a small amount of grains larger than the filtration opening size of the geotextile (= 0.125mm, according to the manufacturer's catalogue). This has been confirmed by the microscopic analyses (Fig. 6), as commented before, and should be expected, as some openings at the geotextile surface can be greater than the geotextile opening size, which facilitates the intrusion of large particles.

5 CONCLUSIONS

Laboratory tests were carried out on geotextile samples exhumed from the drainage system of a tailings dam in Brazil. Mechanical damages were observed in these samples, as well as different levels of geotextile impregnation by tailings particles. As expected, the impregnation of the geotextile did not occur in a uniform manner. Local blinding and internal clogging mechanisms were identified in the microscopic analyses. Tailings particles attached to the geotextile fibres were also observed. These mechanisms may have some effect on the filter behaviour in the field. Further investigations are required for a better understanding on the behaviour of geotextile filters under such severe conditions.

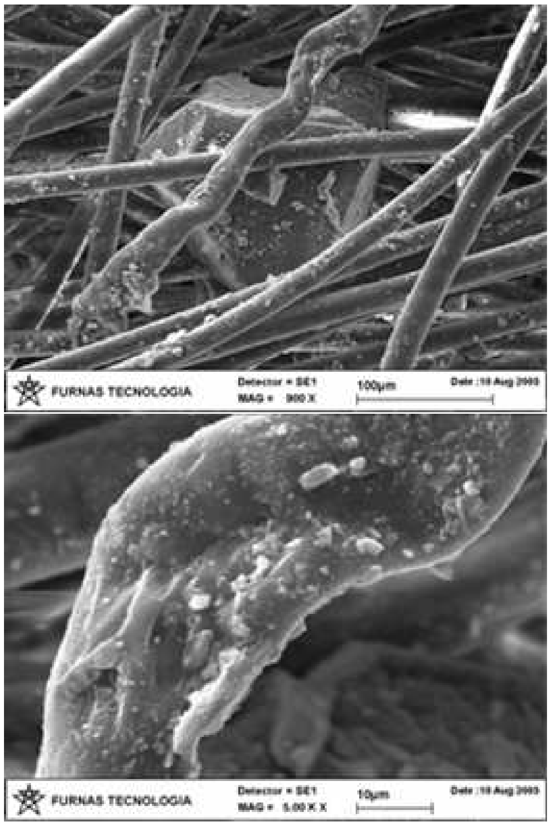


Figure 6: Large entrapped tailings particles in the geotextile pores.

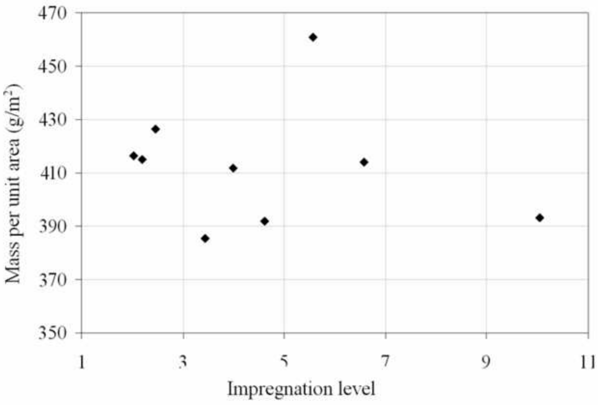
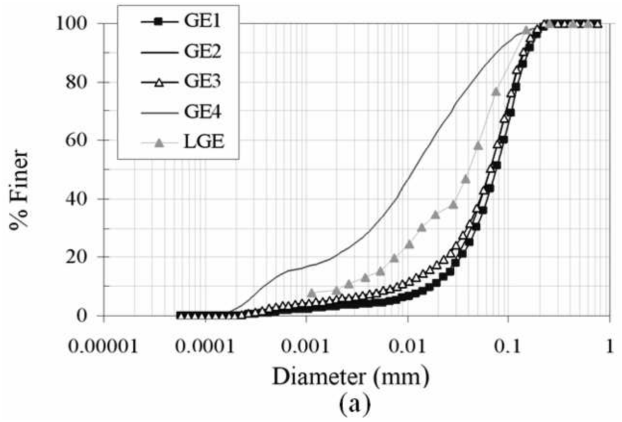
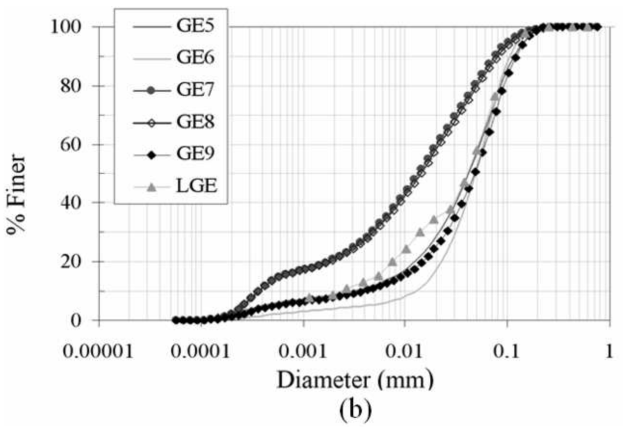


Figure 7: Level of impregnation versus mass per unit area for the exhumed geotextile sample.



(a)



(b)

Figure 8: Grain size distribution curves of particles entrapped in the geotextile: (a) GE1 to GE4 and LGE; (b) GE5 to GE9 and LGE.

Table 2: Characterization of the particles retained inside the exhumed geotexile.

Specimen	d_{15} (mm)	d_{50} (mm)	d_{85} (mm)
E1	0.026	0.075	0.140
E2	0.026	0.065	0.126
E3	0.016	0.065	0.121
E4	0.001	0.012	0.056
E5	0.008	0.041	0.098
E6	0.018	0.048	0.094
E7	0.000	0.013	0.060
E8	0.000	0.014	0.065
E9	0.009	0.048	0.066
LGE	0.006	0.041	0.105

Notes: $\mathbf{d_i}$ is the diameter for which **i** per cent in mass of the remaining particles are smaller than that diameter, LGE – results obtained for the tailings particles.

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