Available online at www.sciencedirect.com

ScienceDirect

Geotextiles and Geomembranes 26 (2008) 82–90

Geotextiles and Geomembranes

www.elsevier.com/locate/geotexmem

Technical note

The influence of bentonite extrusion on shear strength of GCL/geomembrane interface

Ana Vukelić[a,*], Antun Szavits-Nossan[b], Predrag Kvasnička[c]

[a]Civil Engineering Institute of Croatia, Janka Rakuše 1, 10000 Zagreb, Croatia
[b]Faculty of Civil Engineering, Fra Andrije Kačića-Miošića 26, 10000 Zagreb, Croatia
[c]Faculty of Mining, Geology and Petroleum Engineering, University of Zagreb, Pierottijeva 6, 10000 Zagreb, Croatia

Received 23 January 2006; received in revised form 5 April 2007; accepted 6 April 2007
Available online 29 May 2007

Abstract

A series of shear strength tests of needle-punched geosynthetic clay liner (GCL)/textured geomembrane interface were conducted at normal stresses ranging from 10 to 400 kPa. The geomembrane was in contact with the woven geotextile of GCL. One half of the tests were carried out on prehydrated GCL samples at low normal stress (about 1 kPa), whereas the other half on non-prehydrated samples. The prehydrated samples exposed during shearing to normal stresses of 100 kPa and above demonstrated bentonite extrusion to the area in contact with geomembrane, which was visible to the naked eye. The bentonite extruded was quantified by introducing an extrusion coefficient. The quantity of the bentonite extruded increased with an increase in normal stress, and lubrication of the contact area with bentonite resulted in reduced shear strength. Finally, the testing showed that for tests carried out on prehydrated samples at lower shear rates, lower contact shear strengths were obtained and more extensive bentonite extrusion to the contact area was observed.
© 2007 Elsevier Ltd. All rights reserved.

Keywords: GCL; Geomembrane; Shear strength; Bentonite extrusion

1. Introduction

Geosynthetic clay liners (GCLs) are installed as liners. In landfills, they are installed (1) in a landfill bottom lining to reduce the permeation of contaminated leachate into the ground, and (2) in cover systems, to minimize infiltration of precipitation water into the deposited waste and thus the resulting leachate as well.

Geosynthetic clay liners represent a composite material consisting primarily of bentonite (either powdered or granular) and geosynthetics (either geotextiles or geomembranes) (Bouazza and Vangpaisal, 2003). They are being investigated intensively, especially in regard to their hydraulic and diffusion characteristics, chemical compatibility, and mechanical behavior (Bouazza and Vangpaisal, 2003). In the last few years, special attention was given to their hydraulic performance (Barroso et al., 2006; Lorenzetti et al., 2005; Rowe et al., 2007; Shan and Chen, 2003; Southen and Rowe, 2007; Touze-Foltz et al., 2006), cation exchange (Bouazza et al., 2006; Touze-Foltz et al., 2006), thermally induced desiccation (Southen and Rowe, 2005), internal erosion (Rowe and Orsini, 2003), volatile organic compound sorption (Lake and Rowe, 2005), deformation (Dickinson and Brachman, 2006), internal strength (Hurst and Rowe, 2006; Koerner et al., 2001), interface shear strength (Bergado et al., 2006), and gas migration through them (Bouazza and Vangpaisal, 2003, 2006). This paper investigates the interface shear strength of GCL.

For the bottom lining of a municipal waste landfill and of a hazardous waste landfill, very often a composite liner is used consisting of a geomembrane placed on the GCL. Such liner systems are installed to enhance safety with respect to leachate percolation or water inflow through waste as specified by The council of the European Union (1999) and by the United States Environmental Protection Agency (EPA). The Agency also recommends that composite liner should be installed in municipal waste covering. In such a composite liner, one layer is always a geomembrane, whereas the other is either a natural

*Corresponding author. Tel.: +385 1 6125 491; fax: +385 1 6125 481.
E-mail address: ana.vukelic@igh.hr (A. Vukelić).

0266-1144/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geotexmem.2007.04.001

hydraulic liner or an adequate replacement material such as GCL, which is quite often used.

For the purpose of stability calculation, shear strength of the GCL and geomembrane has to be determined. Geosynthetic material interface shear strength is determined in accordance with standards (ASTM D 5321, 2002; ASTM D 6243, 1998; (the only standard for testing GCL specifically); EN ISO 12957-1, 2005) in laboratory direct shear tests. Considering that there is the whole gamut of different types of GCLs and geomembranes and that the conditions in which these materials are to perform after installation are different, tests are best conducted on particular products, which will be used on the site, and under conditions that closely simulate the in situ conditions (Bouazza, 2002; Koerner, 1997; Koerner et al., 1998b).

Testing of GCL/geomembrane interface shear strength in a laboratory and in situ conducted so far showed that bentonite extrusion to the contact area with geomembrane may occur, which results in a reduction in interface shear strength (Daniel et al., 1998; Gilbert et al., 1996; Koerner et al., 1998a, b; Richardson and Thiel, 2001; Triplett and Fox, 2001). Bentonite was primarily extruded through woven geotextiles and thin non-woven geotextiles, having a mass of up to 220 g/m^2 (Bouazza, 2002; Gilbert et al., 1997). Extrusion of bentonite was considered to have occurred when bentonite was wet and mobile (Hewitt et al., 1997; Koerner, 1998a, 1998b) to the extent equal to that of hydrated bentonite; thus, its extrusion was more extensive when bentonite was prehydrated at a lower normal stress than that applied in direct shear test (Gilbert et al., 1997). Finally, bentonite extrusion was found directly dependent on a normal stress applied during shearing, i.e. the higher the normal stress during shearing, the higher the extrusion (Triplett and Fox, 2001).

2. Aim and description of the research

2.1. Aim of the research

Bouazza (2002) stated that ‘‘Laboratory interface shear tests are routinely conducted to evaluate interface friction between GCLs and soils or geosynthetics under operating conditions. As a result, a more extensive database is now available’’, and then emphasized that ‘‘Probably, the major findings worth noting are the possible reduction in frictional resistance between a geomembrane and a GCL due to bentonite extrusion through woven geotextiles’’.

The aim of this research was to establish in laboratory direct shear tests the extent of bentonite extrusion through the woven geotextile of a needle-punched GCL under specific conditions and the extent to which this occurrence influences a reduction in shear strength of needle-punched GCL/textured geomembrane interface.

Considering the above aim, tests were carried out in two different ways, the selection of the method of sample preparation being the main consideration. Therefore, the first procedure was designed to achieve the most extensive bentonite extrusion possible (therefore GCL samples were prehydrated under normal stress of only 1 kPa, and test normal stresses were applied all at once), whereas the second procedure was designed to achieve the least extensive extrusion (without prehydration of GCL samples). The comparison of the shear results and the amount of bentonite observed on the contact area after testing made it possible to determine the influence of bentonite extrusion on GCL/geomembrane interface shear strength.

2.2. Testing program

The material tested was a reinforced BENTOMAT AS 100 GCL, consisting of a layer of a geotextile with a mass per unit area of 105 g/m^2, a layer of non-woven geotextile of 200 g/m^2 mass per area, and an intermediate layer of granular sodium bentonite with a mass per area of 4500 g/m^2. A second element of the composite liner was sprayed-on textured geomembrane made of high density polyethylene (HDPE) of 2.5 mm in thickness, type T/T (the smooth geomembrane surface is sprayed-on on both sides with a material identical to that of which the geomembrane is made). The geomembrane was in contact with the polypropylene, slit-film woven geotextile of GCL.

One half of the tests were carried out on non-prehydrated samples (Series marked A), and the other half on prehydrated samples at a low normal stress (Series marked B).

The samples in Series A were not specially prepared; that is, ‘‘dry’’ samples were installed in a shear device (initial water content of the samples was between 11% and 13%, as obtained in laboratory tests carried out, which were also in accordance with the manufacturer's technical data sheet). After installation, the samples were exposed to test normal stresses all at once; they were then submerged (tap water was used) for about 18 h. Following this, the samples were sheared.

Before their installation in the shear device, the samples in Series B were hydrated on both sides with tap water at a very low normal stress (about 1 kPa—the weight of the top shear device platen). Hydration duration was 17 days (Series B.1) and seven days (Series B.2, B.3, and B.4). After hydration, the samples were placed in the shear device and exposed to test normal stresses all at once; they were then submerged (tap water was used) to remain in such conditions for 24 h. After that, the samples were sheared.

The time required for hydration of the samples in Series B was determined in the GCL swelling tests conducted according to ASTM D 4546 (2003) (Fig. 1). Based on the tests carried out, primary hydration of GCL samples was found to take about 8000 min (about 5.5 days) at normal stress of about 1 kPa.

A summary of the tests performed is given in Table 1.

2.3. Shear device

The shear device used in this research is illustrated in Fig. 2. The textured geomembrane was placed on and

Download English Version:

https://daneshyari.com/en/article/274454

Download Persian Version:

https://daneshyari.com/article/274454

Daneshyari.com