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Methodological aspects in the experimental measurement of the interface friction between geosynthetics

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Abstract

The evaluation of the interface friction at the contact between geosynthetics is a very important feature in a safe design of landfills and similar earth structures. Coupling different geosynthetics to fulfil multiple functions may be a critical point, due to the low frictional properties of such products. As a consequence, the assessment of the degree of safety of earth structures including geosynthetics requires a characterization of the interface strength and of its evolution with displacements. Some results obtained at the University of Padua will be presented with reference to experimental measurements of the interface friction between geosynthetics, in different conditions, to highlight the complexity of the friction phenomena and their dependence on experimental conditions.

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1. Introduction

The development of geosynthetics has provided a whole range of materials specifically designed for the resolution of typical problems of the earth works, such as reinforcement, separation, drainage or waterproofing. Often, such materials are coupled together to accomplish different functions: a typical example is represented by the lining systems of landfills were different geosynthetics are disposed on the bottom, sides and cover in order to isolate

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the mass of waste from the surrounding environment. The stability of a geosynthetic landfill lining mainly depends on the shear strength available along interfaces, between geosynthetic and soil and between geosynthetic and geosynthetic. It is clear that an erroneous assessment of the interface shear strength can have severe consequences, as occurred in March 1988 at Kettleman Hills (USA). As result of following studies and tests, it was pointed out how the interface strength between geosynthetics may be very low, with friction angles that may reach values as low as 8° [1]. Despite the elapse of several years, in which the research has made considerable progress in understanding the behaviour of these materials, landfill failure events still occur due to the wrong design of lining systems, like in the case of the instability of the Chrin Brothers Inc. Landfill in Williams Township (USA) occurred in March 2013, where approximately 49400 m^2 of the landfill slope move downward, involving a sliding mass of waste of about 590000 m^3 [2]. Therefore, the correct evaluation of the available interface shear strength is yet a topic of interest. In the following, after a short outline of the methods for the evaluation of interface shear strength, a discussion of typical inclined plane test results is presented.

2. The measurement of geosynthetic interface shear strength

The measurement of geosynthetic interface shear strength may be carried out in laboratory in static conditions by means of the direct shear test, the annular/cylindrical shear test and the inclined plane test. The direct shear test is widely used: for testing geosynthetic interfaces, the use of large dimension specimens is required, with shear boxes at least 30 cm × 30 cm wide [3]. One limit of this device is the difficult to study the shear strength reduction at large displacement: indeed, the maximum allowable displacement (about 100 mm) may not be sufficient. For increasing the relative displacement, many tests, or several cycles of reversed displacement, may be performed on the same specimen. To study the residual shear strength, the annular shear device is more suitable [4,5] because it enables unlimited relative displacements: this equipment is similar to the Bromhead apparatus but modified to allow testing large dimensions specimens. Even though this device allows a continuous and unlimited displacement on the same contact area, the sliding direction changes continuously, with respect to the direction of the geosynthetic fabric and also the displacement is non-uniform across the shear surface. To overcome some limits of the annular shear device, Moss and Anderson [6] developed the cylindrical shear apparatus. In this device, the first specimen is wrapped around an inner cylinder while the second specimen is anchored to the non-rotating base and top. The test is performed by rotating the inner cylinder while the outer geosynthetic is fixed.

Finally, the shear strength may be measured by means of the inclined plane test [7,8,9]. This device is composed by an inclinable table, above which a block is placed, free to slide: one geosynthetic is fixed to the table, tilting at constant rate of rotation, while the second is bound to the sliding block. This kind of test, generally used in Europe and subjected to a specific standardization [10], may be more accurate in determining the shear strength of geosynthetic interfaces at normal stress lower than 20 kPa [11]: the direct shear test is widely used to estimate the interface shear strength at high pressure conditions (like in the cases of bottom and lateral barriers) but, for the limits of the device, it is difficult to test very low pressure conditions (such as in landfill cover) and for this type of problems the inclined plane test is more suitable.

3. The inclined plane test procedure

The experimentation on the interface friction, carried out at the geotechnical laboratory of the University of Padua, was conducted by means of an inclined plane device [12]. The inclined plane has length of 1.10 m and width of 0.25 m while the block has length of 0.35 m and width of 0.20 m. The inclination of the plane can be varied between 0° and about 45°. The block is constrained to slide straight by lateral guides, without this leading a significant additional friction (Fig. 1). In the following, for each interface, the first listed geosynthetic is fixed to the table while the second one is linked to the block. The adopted test procedure allowed the measurement of the friction angle according to three different modes, as described below. The test begins with an initial horizontal configuration of the table; the table inclination is increased at a constant speed of 3 ± 0.5 °/min and the angle of inclination, β_0, for which the block starts to slide, is checked. From static equilibrium $\varphi_0 = \beta_0$, being φ_0 the "first movement" angle of friction.

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