Long term friction behaviour in interfaces with geomembranes

T.G. Lara, D. Vidal
Aeronautics Technology Institute, Geotechnical Department, São José dos Campos, SP, Brazil

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ABSTRACT: Laboratory tests have been accomplished in order to discuss textured geomembranes sliding under long term loads and some results are presented. The textured geomembranes were submitted to sliding at different angles with the horizontal plain and different normal stresses, after the sliding resistance with an inclined plan were tested. Sand was adopted as covering material.

1 INTRODUCTION

The geomembranes application as barrier material on environmental works and slopes coating expands every day. In many cases the friction between the geomembrane and the adjacent materials needs to be considered in the design, as in the case of cover soils on slopes underlain by geosynthetics, for instance.

The sliding of cover soils on slopes underlain by geomembrane have been taking some designers to propose the use of textured geomembranes. These geomembranes were originally conceived to increase the interface friction and to improve the adherence conditions when a concrete coating is foreseen over the geosynthetic.

At the first sight, these geomembranes would be an interesting solution in the covering systems, since, due to the smallest risk of contamination, and in other cases where it is allowable to accept some tensile geomembrane loading. However, the polymeric components of the geomembranes are susceptible to creep, the friction elements of the textured geomembrane could not resist to long term loading, having sliding risks.

Characteristics of the geomembranes as composition and texture strongly affect its behaviour. Several studies about the sliding behaviour of interfaces with geomembranes have been already accomplished (Rollin et al, 1994, Dove et al, 1997, Izgin & Wasti, 1998, Snow et al, 1998, Lee et al, 1998), but always in fast laboratory tests, that don't consider creep effects.

An augmentation of the geomembrane surface roughness usually conduct to a soil/geomembrane interface friction angle increase. The upper bound of interface friction has been observed to be close to the effective stress friction angle of the soil (Dove et al., 1997). Stark et al. (1996), examined the interface strength between textured geomembranes and geotextiles and found that interface strength increased with an increasing degree of texturing.

The geomembranes textured process has a great contribution to the interface sliding behaviour. The variability in geosynthetic material manufacturing can be manifested from roll to roll or within individual rolls (Snow et al, 1998, Dove et al., 1997). Rollin et al. (1994) discuss the large differences of the surface characteristics of produced textured geomembranes, and indicates four types of manufacturing procedures.

The material type that acts in the interface also presents different effects. Izgin and Wasti (1998) observed that interface friction of sand with rounded particles is sensitive to the geomembrane degree of roughness and even to the difference in brands of the same general type of geomembranes when compared to sand with angular particles.

The deep knowledge of the surface roughness becomes a major concern to analyse correct by way the interaction between the geomembrane and the soil or the geotextile interface necessary to design geosynthetics placed on inclined surfaces.

This paper presents laboratory tests results accomplished to study the interface sliding behaviour under long time loading. In order to evaluate properties and behaviour parameters, tests on inclined board were accomplished having sand as cover material.

2 EQUIPMENT

2.1 *Inclined Board*

The apparatus used for determinate the sliding critical angle of a geomembrane interface covered with a granular soil follows the NF P 84-552 (1992) recommendations. It consists of a two metallic boxes articulated system , as shown on Figure 1: a lower box (0.60 x 1.20 x 0.20 m)containing the confined soil or material that represents the bottom system layer, and an upper box (1.00 x 0.50 x 0.20 m) placed on the interface to be studied.
The upper box function is to confine the soil in contact with the geosynthetic representing the covering layer.

The geosynthetics can be clamped to the lower box superior border. The system is lifted by a controlled constant speed of 2.0 cm/min ± 0.5 cm/min.
During the lifting, the displacement values and inclination as a time function are measured, until the sliding of the upper box. The upper box sliding is interrupted when the same slides at least 50 mm.

2.2 *Friction Creep Apparatus*

From the obtained inclined board tests results, the sliding critical angle is determined and the inclinations for the long time tests are defined. The developed equipment for long time tests consists of a support system and box of 0.30 x 0.50 x 0.10m, as it illustrates on Figure 2, with a displacements measure system and a time counter.
The temperature and the relative humidity should be controlled along the tests that could take several months, according to the adopted inclination. Each system is totally isolated to avoid vibrations. The sliding or rupture is considered for a displacement over 3 cm of the initial position.

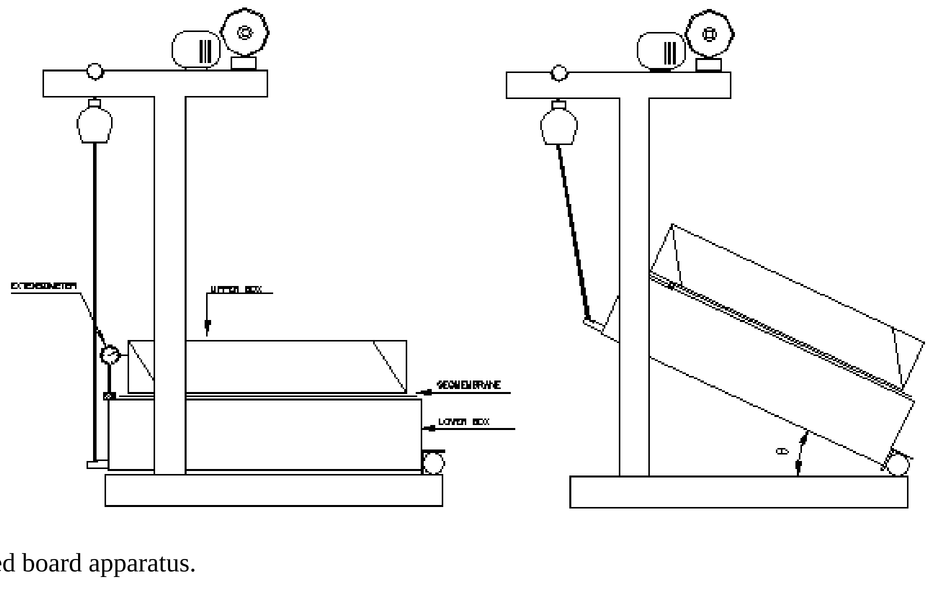

Figure 1. Inclined board apparatus.

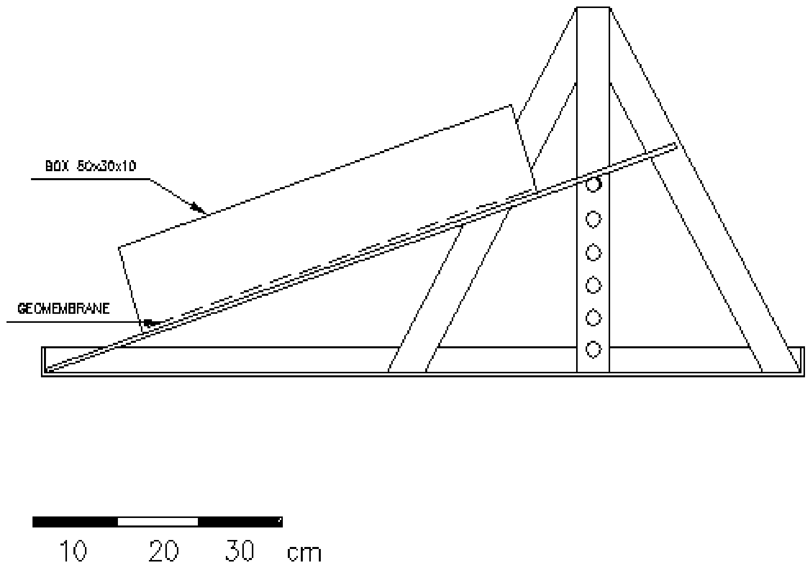

Figure 2. Long time tests apparatus.

3 TESTS AND MATERIALS

3.1 *Geomembrane*

At this stage of the tests, textured HDPE geomembranas were used, with 1 mm functional thickness. The texture is produced “off line” to warranty industrial quality control of the functional thickness, and it is done depositing HPDE fractions over the smooth geomembrane. Figure 3 schematise the type of elements and their distribution.

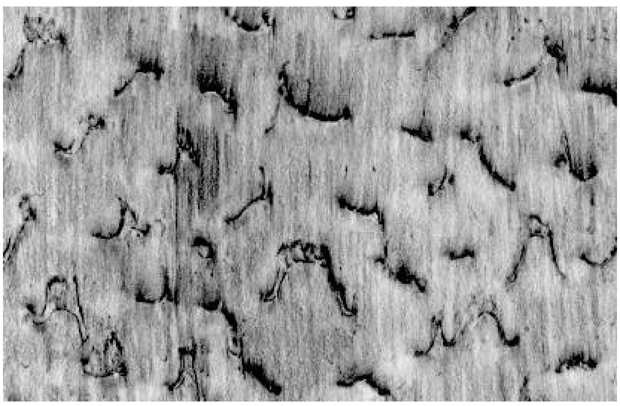

Figure 3. Typical texture elements and their distribution.

The geomembrane specimens for the inclined board tests measured 0.80 x 1.40 m and they were guided in the sense of manufacture texture.

For the long time tests, the specimens measured 0.60 x 0.70m and they obeyed the same orientation considered in inclined board tests.

3.2 *Soil*

A fine sand in the hygroscope humidity was used, whose particle size distribution is suitable in the Table 1. A 33^{o} friction angle for this sand was indicated by direct shear test.

Table 1. Particle size distribution of the sand

d (mm)	% passing
0.71	100
0.42	30
0.145	0

3.3 *Tests*

The tests were accomplished under temperature of (23 ± 1) ^{o}C, monitored by equipment of continuous registration. The geomembrane specimens were always placed on a rigid base and fixed by a clamp system . The soil confined in the upper box was sprinkled at a constant height.
Firstly inclined board tests were accomplished with the box of 50 x 100 cm, according to NF P 84522 (1992), named BA and later these tests were repeated with the 30 x 50 cm box, named BB, to verify the possibility to accomplish the long time tests with the smaller boxes.
Each system was first submitted to a conventional laboratory tests of inclined board, in order to establish the inclinations to be used on long time tests.
The cover material in the upper box applied an interface normal stress of about 1,5 kN/m2 and, to evaluate the normal stress influence, some tests were also accomplished under normal stress of 5 kN/m2

4 RESULTS

Figure 4 presents the results obtained on inclined board tests carried out with the 1.00 x 0.50 x 0.20 m boxes (BA) and the 0.30 x 0.50 x 0.10m box (BB). As it can be observed the values are quite close, making possible the use of the smaller boxes for accomplishment of the long time tests. The rupture surface occurs on the sand, at a slope similar to the sand friction angle

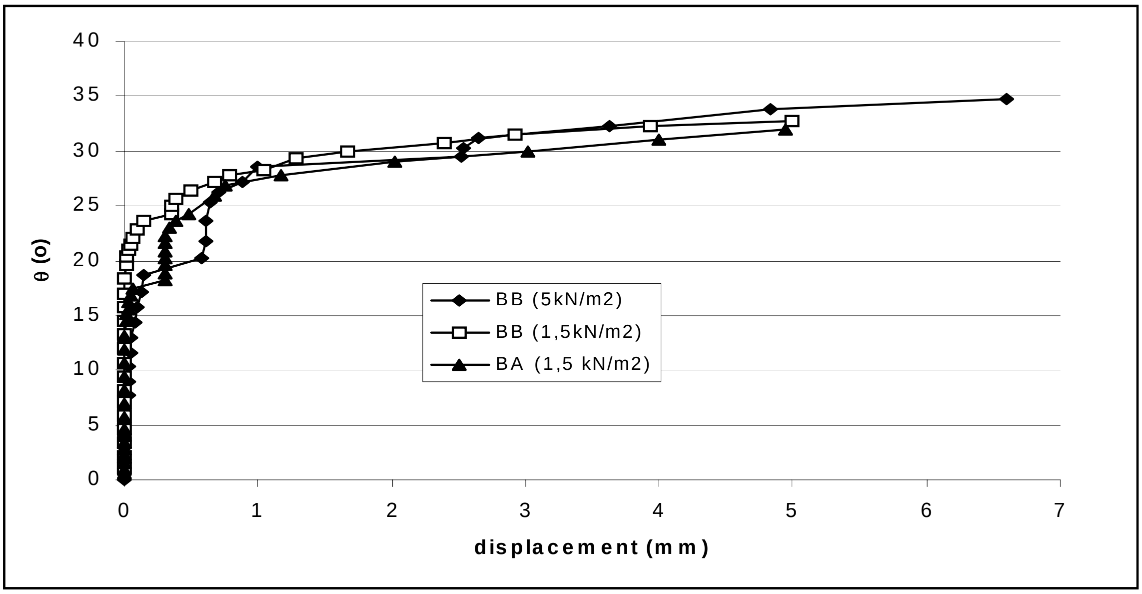

Figure 4. Inclined board tests results.

Figure 5 to 7 present the long time tests observed values. It is verified that the specimen submitted to 1.5 kN/m^2 normal stress a sliding movement slower than that verified for the specimens under normal stress of 5 kN/m^2.

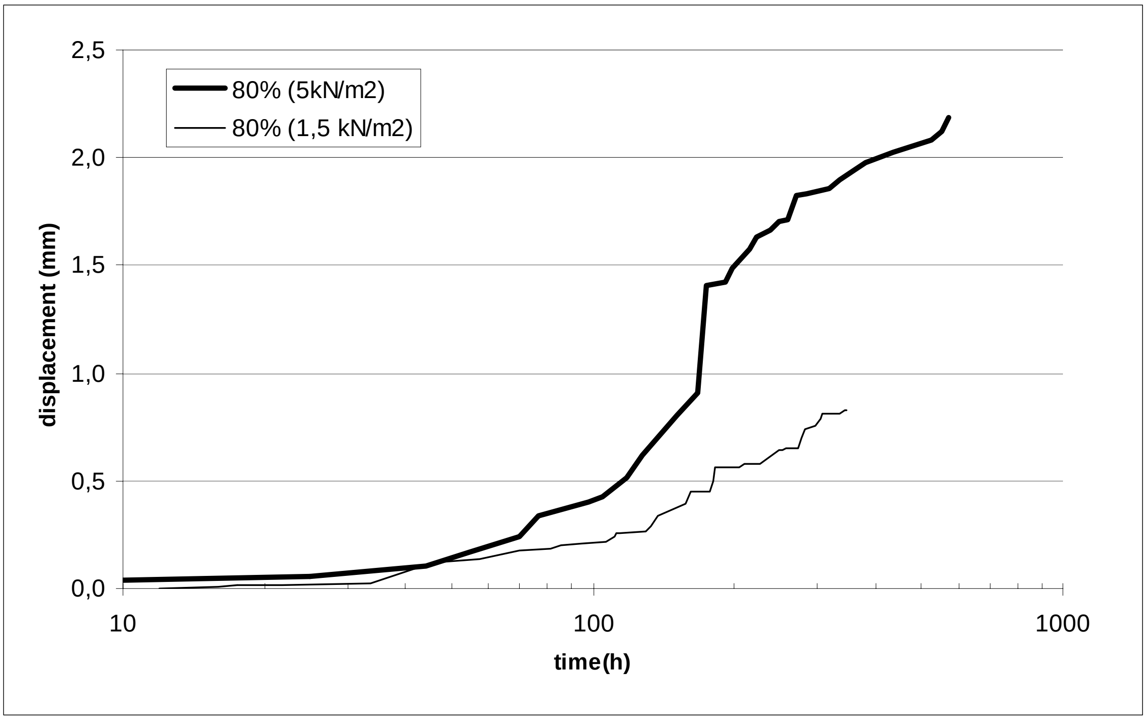

Figure 5. Long time results tests – surcharge effect.

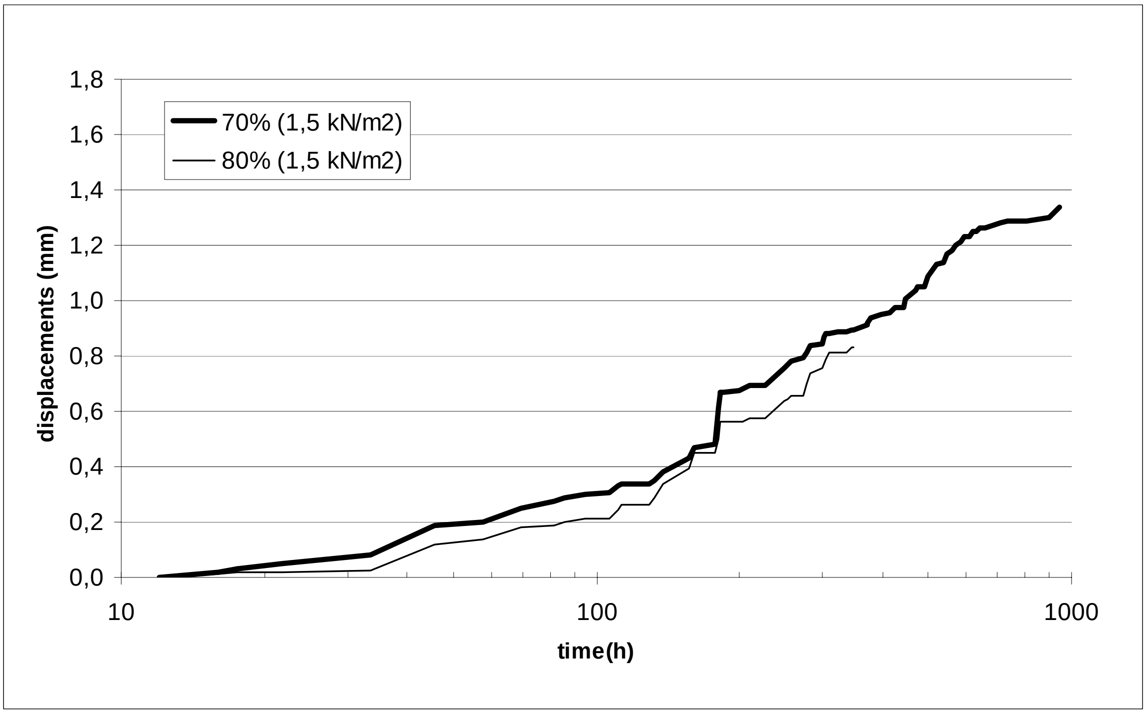

Figure 6. Long time results tests – slope effect (1.5 kN/m^2 surcharge).

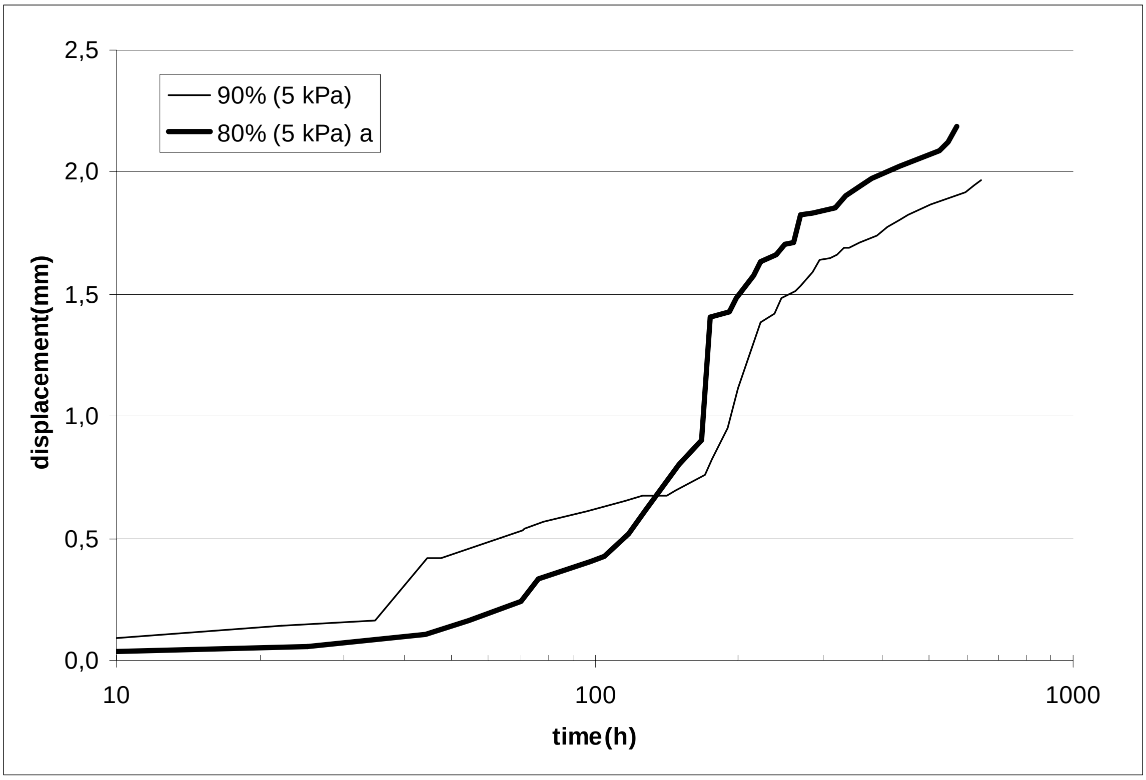

Figure 7 Long time results tests – slope effect (5 kN/m^2 surcharge).

5 COMMENTS

The analysis of the soil/geomembrane interface parameters should consider the long time behaviour, in order to evaluate the reduction factor to be considered for the interface properties.

The interface sliding creeping process is much more complex than the tensile one, because it should take into account the normal stress applied and the interface slope, specially for textured geomembranes, in which this texture supports the load imposed by the soil that tries to slip.

During tests it could be observed that during the test for low levels of normal stress, high percentages of the maximum angle of inclination can be adopted with no short term rupture being observed. However, a continue movement could be observed, that could lead to instability. The normal load has a important effect on the sliding time

6 ACKNOWLEDGEMENTS

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