Creep penetration of particles at geomembrane surfaces

Ömer Bilgin[1*], *Mohammad* Mosawi[2]

[1]University of Dayton, Department of Civil Engineering, Dayton, OH 45469-0243 USA
[2]Kuwait Institute for Scientific Research (KISR), Safat 13109, Kuwait

Abstract. Laboratory tests were conducted to measure polyethylene geomembrane contact surface area change with time under sustained loading. The presentation summarizes the test results and findings. A theoretical model for time-dependent contact area is also assessed using the results obtained from the tests conducted. The results show that the contact areas at the geomembrane surface increase with time as anticipated and the rate of increase in contact area decreases with time. The investigations also showed that the time-dependent soil-geomembrane contact area can be predicted using a theoretical model.

Polyethylene, widely used in geomembranes, is a viscoelastic material and show creep behaviour under sustained loads. Following initial loading and contact at soil-geomembrane interfaces, soil particles would continue penetrating into the geomembrane under sustained loads due to the viscoelastic creep behaviour of polyethylene. The soil-geomembrane interface shear strength is critical for projects where geosynthetics are used because these interfaces usually have the least shear resistance in the system. The change in soil-geomembrane contact areas with time would also affect the interface shear characteristics and strength. This study presents the results of experimental study conducted to model the change of soil-geomembrane interface contact areas with time.

A series of laboratory tests were conducted to measure the initial contact areas of geomembrane interfaces due to instantaneous loading and the change of these contact areas under sustained loading over a period of time to monitor the effect of viscoelastic behaviour of HDPE geomembrane. During the tests, the load was applied vertically using steel rod with semi-spherical head in contact with geomembrane at the interface. Two different loads were used for the tests, and multiple tests were performed at each load to assess repeatability using different loading machines. An initial penetration into the geomembrane under the applied load recorded and the corresponding contact area was calculated based on the penetration measurement and the dimensions of the rod used to apply loading.

The movement of the loading rod penetrating further into the membrane due to creep was monitored over a two-week period for each test. The contact areas with time, $A_c(t)$, due to the continuing penetration of the rod were calculated and assessed in relation to the initial contact area, $A_c(t=1\text{ min})$ using a ratio defined as;

$$\text{Contact Area Ratio} = \frac{A_c(t)}{A_c(t = 1\text{ min})}$$

* Corresponding author: bilgin@udayton.edu

Figure 1(a) shows the increase in contact areas at the geomembrane interfaces over two-week period for the four tests performed. The results showed that the contact areas increased about 80%, on average, over the two-week period. The curve fit to all test data using logarithmic regression is also shown in Figure 1(a).

A time-dependent contact surface area, $A_c(t)$, model taking into account the viscoelastic material behaviour of HDPE geomembranes is given by Bilgin [1] as:

$$A_c(t) = \pi \left(\frac{3WR}{4E'(t)} \right)^{2/3}$$

where; W=applied load, R=mean radius of curvature=$(1/r_1 + 1/r_2)^{-1}$, where r_1 and r_2 are the radii of particles in contact, and E'=composite elastic modulus based the materials in contact at the interface. Figure 1(b) illustrates the variation in contact area over time, as determined from both test results and the theoretical model.

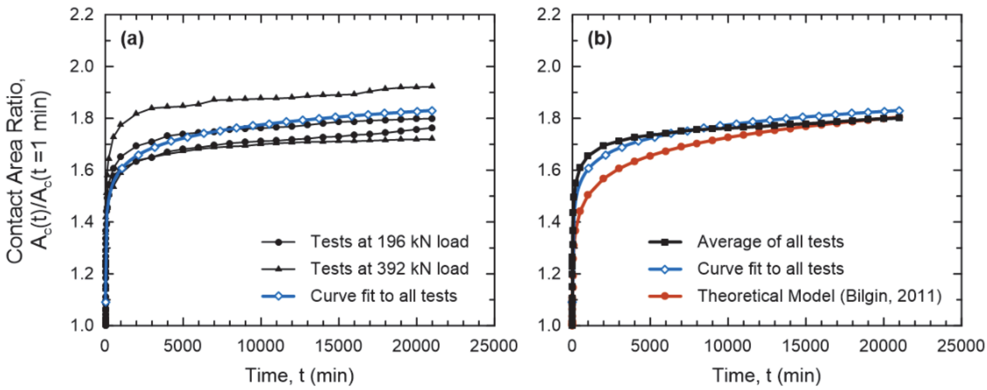

Fig. 1. (a) Creep effect on contact area at geomembrane interface, (b) Contact area changes obtained from tests and theoretical model

The findings of this study show a substantial increase in contact areas at the soil-geomembrane interfaces over time under sustained loads. An approximately 80% increase over a two-week period was observed during the tests. Furthermore, the study demonstrates a high level of agreement between the time-dependent contact areas derived from laboratory test results and the theoretical model proposed by Bilgin [1].

Reference

1. Ö. Bilgin, *Viscoelastic contact characteristics of soil-geomembrane interfaces*, in Proceedings of the Geo-Frontiers 2011: Advances in Geotechnical Engineering (GSP 211), Dallas, Texas, 2092-2100 (2011)