Geotextiles and Geomembranes 35 (2012) 87–99

Contents lists available at SciVerse ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

Development of a methodology for the evaluation of geomembrane strain and relative performance of cushion geotextiles

W.P. Hornsey*, D.M. Wishaw

Geofabrics Australasia (Pty) Ltd, Gold Coast, Australia

ARTICLE INFO

Article history:
Received 24 November 2011
Received in revised form
24 April 2012
Accepted 22 May 2012
Available online 10 August 2012

Keywords:
Geomembrane strain
Geotextile protection
Puncture
Drainage gravel
Landfill

ABSTRACT

The protection of liners in landfill sites is of the utmost importance in the calculation of the usable design life of a landfill system. This research presents the establishment of an improved method for analysing the strain induced on a geomembrane using laser scanning technology to better determine the design life of the geomembrane. The ability to reproduce results with a high degree of accuracy under a range of test conditions was investigated. The results of this research showed that the use of high-definition laser scanning techniques produces repeatable and highly accurate results allowing precise indication of potential stress crack failure while providing a realistic comparison of cushion geotextile performance.
© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Typical design for landfill drainage and containment uses a coarse gravel drainage layer over a geomembrane liner, with a cushion geotextile separating the two. The uneven surface of the drainage layer creates localised stress points on the geomembrane, these stress points can lead to long-term stress cracking of the geomembrane and increased leakage from the landfill. The cushion geotextile plays a crucial role in limiting the development of local stresses within the liner. Understanding the performance of the geotextile protection relative to drainage gravel size and angularity and imposed load is considered critical in determining the suitability of any given protection layer. Current test methods provide some indication of performance, however the test methods do have limitations, primarily with regard to the assessment/measurement of the strain placed on the liner.

The long-term stress crack resistance of the geomembranes can vary depending on the method of manufacture, base resin used, etc. and no internationally accepted limit has been placed on the extent to which the various geomembranes can be stressed before they fail due to long-term stress cracking. This problem is further compounded by the fact that the current methods used to calculate the induced strain on the geomembrane are somewhat limited (Brachman and Gudina, 2008; Seeger and Müller, 1996; Tognon et al., 2000). Elton and Peggs (2002) identified the need to develop a better method of evaluation of geomembrane damage using ASTM D5514-06 (2011).

Protection layers in the form of sand, compacted clay, rubber tyre shreds, geotextiles and composites have been proposed and used as geomembrane protection layers. Their effectiveness was examined by Dickinson and Brachman (2008) and the results showed the sand and compacted clay (in 150 mm layers) was most effective, while rubber tyre shreds, geocomposites and finally, single-layered geotextiles produced less effective protection. Despite their good protection capabilities the sand and clay options are rarely used due to construction difficulties, loss of landfill volume, reduction in drainage effectiveness through encroachment of fines into the drainage layer (McIsaac and Rowe, 2007) or cementation of the sand layer exposed to landfill leachates (McIsaac and Rowe, 2006). Rubber tyre shreds present problems with geomembrane puncture caused by steel belting in tyres. Consequently nonwoven geotextiles are often used to limit or reduce the stresses placed on the geomembrane by either the mineral drainage layer or the prepared subgrade.

The selection of an appropriate geotextile protection layer is difficult however, as full understanding of geotextile performance in relation to stress absorption is yet to be defined and many of the questions raised regarding the relative performance of various

* Corresponding Author. Tel.: +61 7 5594 8600, +61 7 55638600; fax: +61 7 5563 3727.
E-mail address: w.hornsey@geofabrics.com.au (W.P. Hornsey).

0266-1144/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geotexmem.2012.05.002

Nomenclature

$\in$	arch elongation (%)
h	depth of the indentation (mm)
a	width of the indentation. (mm)
ε	strain (%)
L	original length (mm)
ΔL	deformed length post testing (mm)
ZL	original height (mm)
$Z\Delta L$	height post testing (mm)
Δz	difference between the original and post testing height (mm)

geotextile protection layers can be attributed to the methods used to assess the strain on the geomembrane.

This paper identifies the limitations of the existing tests methods (LFE-2; DIN EN 13719, 2002 and ASTM D5514-06, 2011) and proposes that the methods of strain measurement be altered to accommodate the advances in technology thereby allowing accurate and repeatable reporting. The use of high-resolution laser scanning devices with specific software to calculate strain is investigated for this purpose. The concept was developed based on work by Zanzinger (1999). Lichti et al. (2002) and Boehler et al. (2003) identified possible inaccuracies with the technology if care is not taken during the scanning process. Accordingly, the analysis process was carefully controlled to verify high levels of accuracy.

As early as 1993, Sehrbrock and Rodatz (1993) showed that computer-generated results provided a level of accuracy far higher than those that could be achieved with random manual measurement methods. At the time the cost of the scanning and software required to carry out the analysis was prohibitive. Fortunately advances in scanning and computer technology have resulted in a significant cost reduction in the analysis process. The cost of laser scanning analysis is now similar to current manual strain analysis methods yet overcomes many of the limitations associated with those methods.

The laser scanner technology allows analysis to a very high level of accuracy over the full surface area analysed, rather than relying on randomly selected points or areas to define the protection capabilities of the protection system.

2. Current test methods

There are currently three main test methods for determining the proficiency of geotextiles in cushioning/protection applications. These test methods are:

1. LFE-2: cylinder testing for geomembranes and their protective materials (Environmental Agency, UK).
2. DIN EN 13719 (2002): geotextiles and geotextile related products—determination of the long term protection efficiency of geotextiles in contact with geosynthetic barriers.
3. ASTM D5514-06 (2011): large-scale hydrostatic puncture testing of geosynthetics.

The LFE-2 and DIN EN 13719 (2002) (Annex B) are virtually identical test methods and use a 300 mm diameter column of materials loaded vertically to mimic actual in situ conditions (Fig. 1). Note while a minimum gravel thickness of 150 mm is specified no maximum height of the cylinder and gravel is specified. The geomembrane, geotextile and metal sheet are placed loose in the column.

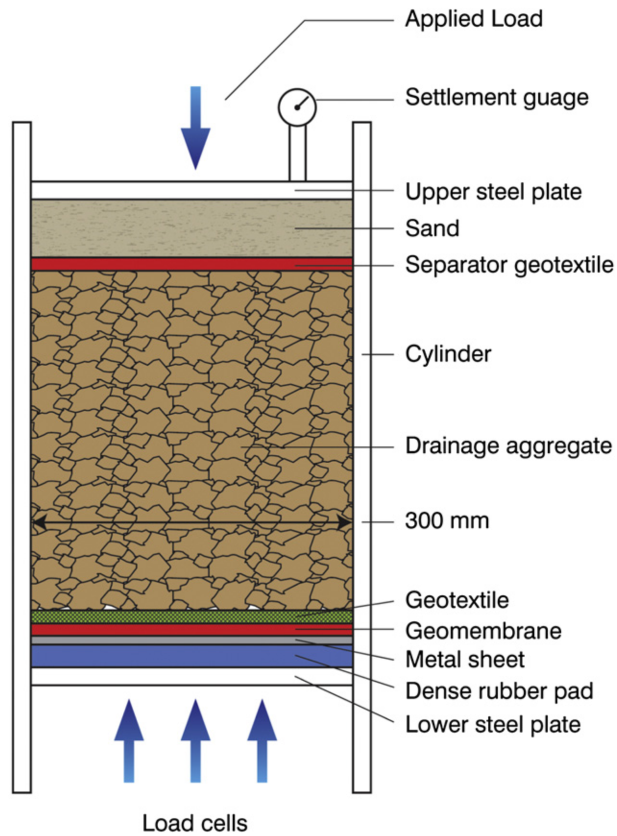

Fig. 1. LFE-2 and DIN EN 13719 (2002) test setup.

Once the testing is completed the apparatus is dismantled and the metal sheet is removed and analysed. The method of analysis requires the operator to identify the worst five indentations and measure them along two perpendicular axes. The measurement requires a vertical displacement reading, accurate to 0.01 mm, every 3 mm along both axes. The local and incremental strain is then calculated.

The ASTM D5514-06 (2011) test method inverts the profile and applies the load via water or air pressure onto a 450 mm diameter sample (Fig. 2). The geomembrane is clamped in position while the protection geotextile, drainage aggregate and metal sheet are placed loose.

The analysis method for the ASTM D5514-06 (2011), procedure B, requires the user to place a layout grid (constructed by overlying 3 mm aluminium bars) over the specimen and mark 20 different areas. The depth from the top of the grid to the contact with the specimen is recorded before and after and a strain calculated from these two values. For procedure C, a complex formula is applied to calculate the strain across the total indentation width.

The metal sheet used in the above method is a 0.5 mm sheet of organ pipe (40% lead, 60% tin) while the UK method has been modified due to lack of organ pipe manufacturing and availability and uses a 1.3 mm grade 3 lead.

2.1. Critique of current methods

After reviewing the currently available test methods it became clear that there were important limitations and advantages within the various methods. These are discussed below:

Advantages of LFE-2 and DIN EN 13719 (2002)

- Test setup allows the influence of the subgrade to be assessed.

Download English Version:

https://daneshyari.com/en/article/274209

Download Persian Version:

https://daneshyari.com/article/274209

Daneshyari.com