Geotextiles and Geomembranes 29 (2011) 249–256

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

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

Analysis of geosynthetic tubes filled with several liquids with different densities

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ARTICLE INFO

Article history:
Received 19 March 2010
Received in revised form
29 October 2010
Accepted 11 November 2010
Available online 18 December 2010

Keywords:
Geosynthetic tube
Rigid horizontal foundation
Liquids with different densities
Numerical modeling

ABSTRACT

A two dimensional model of a geosynthetic tube sitting on a rigid horizontal foundation and filled with several separated liquids with different densities is proposed. The material from which the tube is made is a special synthetic fabric which is inextensible, perfectly flexible, and leakproof. Such a model is useful for modeling a consolidations process in the tube filled with a slurry. The equilibrium equations of the model are formulated. Unknown values like the pressure on the top and bottom of the tube, the tension in the geosynthetic fabric, the length of the contact zone between the tube and the rigid foundation are searched with respect to the given perimeter, the volumes and densities of liquids. Such a problem is solved by the Newton's method. The initial approximation is obtained by solving a simplified problem with one liquid with the average density. The problem is implemented in a MATLAB code for geosynthetic tubes filled with two, three, and four liquids with different densities. The tubes filled with two different liquids are studied in more detail. The graphs of the relations are compared with the graphs for the tube filled with the single liquid whose density is the average of the densities of the liquids. The comparison enables to discuss the influence of the consolidation process on the height, the contact zone, the pressures and the tension of the tube. The results of the proposed model for a tube filled with a single liquid are compared with another model.

1. Introduction

Geosynthetic tubes have found applications in many branches of engineering. The reader can find a description of these applications, for instance, in the monograph (Pilarczyk, 2007).

Geosynthetic tubes have been studied in many papers, but only the problems related to the tubes filled with a single liquid have been analyzed.

The models of geosynthetic tubes on a rigid horizontal foundation are presented, for instance, in (Kazimierowicz, 1994; Leshchinsky et al., 1996; Namias, 1985; Plaut et al., 1998). The mathematical models of geosynthetic tubes filled with both liquid and air are investigated in (Antman and Schagerl, 2005). The equilibrium of air filled geosynthetic tubes that rest on rigid foundations with arbitrary shapes are studied in (Ghavanloo and Daneshmand, 2009). The authors in (Leshchinsky et al., 1996) mentions Program GeoCoPS developed by Leshchinsky, D. and Leshchinsky, O. for US Corps of Engineers in the 90's which includes a solution for two slurries. In their paper, some experimental results connected with a consolidation process are presented for the tubes made of a permeable geosynthetic fabric. Some generalized results for a deformable horizontal foundation are presented in (Plaut and Suherman, 1998). Three dimensional problems are studied in (Seay and Plaut, 1998).

Application of stacked geosynthetic tubes attracts more and more attention. Such problems are solved in (Plaut and Klusman, 1999), where the behavior of stacked tubes is analyzed both on a rigid foundation as well as on a deformable one. Mathematical problems connected with existence, stability, and uniqueness are analyzed in (Antman and Schagerl, 2005; Malik, 2009). The existing numerical methods are reviewed and compared in (Cantre, 2002).

The most common method for flood protection is a sandbag embankment studied in (Recio and Oumerac, 2008). Geosynthetic tubes are used as an alternative to old methods for flood protection. The tubes are usually simpler to install and remove than sandbags. The applications of geosynthetic tubes as flood fighting devices are studied in (Huong et al., 2002) and (Kim et al., 2004). Geosynthetic tubes are used for variety of purposes, for instance, as break waters in beach (Alvarez et al., 2007). Very similar problems are studied and analyzed in different areas of engineering. Floating tubes filled with a liquid are studied in (Zhao and Aarsnes, 1998) and (Zhao, 1995). The shape of a towed boom of logs leads to the same equations which describes the equilibrium of geosynthetic tubes (Newman, 1975).

In this paper we will deal with an equilibrium problem of a geosynthetic cylindrical tube sitting on a rigid horizontal foundation. The tube is filled with several separate layers of liquids with different densities. The layers remain separated. Such problems are

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doi:10.1016/j.geotexmem.2010.11.004