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Consolidation Process of Geotextile Tube Filled with Fine-grained Materials

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ABSTRACT

Geotextile tubes have been used for over 30 years in many applications of civil and environmental projects in filtration and drainage. The geotextile tube is a compound technology made up of the filtration and drainage property of geotextiles. They are hydraulically filled with dredged materials and have been applied in coastal protection, scour protection, slurry dewatering, and isolation of contaminated material. Recently, geotextile tube technology has gone from an alternative construction technique to a suitable, desired solution. This paper presents the various issues related to the consolidation process of a geotextile tube filled with fine-grained dredged materials. A new method of approach for a tube-shape prediction due to the consolidation process is highlighted, along with a major variation of fill-material properties. Also provided is the empirical relationship of settling velocity and self-weight consolidation coefficients being used in the approximation of tube shape. The presented results are obtained from the large-scale field model test and SSCC (settling and self-weight consolidation column) tests. The field model and laboratory column tests are performed on fine-grained material dredged by a dredging ship and hydraulically pumped into the geotextile tube. From the large-scale field model test, the settlement behavior after construction is likely to be a zone settling (flocculation, settling, self-weight consolidation). The results of the settling and self-weight consolidation method (SSCM) are similar and in good agreement with the field model test.

INTRODUCTION

Geotextile tubes have been used in the past for many projects. While they are mainly used for flood and water control, they are also used against beach erosion, for shore protection and the containment of contaminated material. Because geotextile sheets are permeable yet soil-tight, excess water is drained from the geotextile tube. Geotextiles have been used for the past 30 years for various types of containers, such as small hand-filled sandbags, 3-dimensional fabric forms for concrete paste, large soil- and aggregate-filled geotextile gabion, prefabricated hydraulically-filled containers, and other innovative systems involving containment of soils.

Koerner and Welsh (1980) and Pilarczyk (1990) provide an overview of the many, primarily erosion-control applications using the various types of geotextile containers. Though construction of erosion-control structures using dredged materials in geotextile containers is quite straightforward, underwater installation is often required, and that is thoroughly discussed by Groot et al. (1994).

Fowler et al. (1997), Pilarczyk (1996) and Mori et al. (2002) have reported on environmental dredging and backfill technology using geotextile tubes.

The most attractive features of geotextile tube technology are that it can use the in-situ filling materials by hydraulic pumping, it can be established economically, and the construction process is faster than that of other technologies. The properties of the filling materials are very important in the design and analysis of geotextile tube behavior. Although the coarse-grained material, such as sand and silty sand, is good material for tube construction, the fine-grained materials are frequently used under field conditions. At present, most of the geotechnical issues are focused on the ways to accurately predict final tube height during and after tube construction, especially the fine-grained, material-filled tube. There are several prediction methods for the filling process (Liu, 1981; Silvester, 1986; Kazimirowics, 1994; Leshchinsky et al., 1996; Plaut and Suherman, 1998; Cantre, 2002); these approaches are based on several assumptions of the relation of developed tension in geotextiles and hydrostatic pumping pressure. However, the prediction method of the consolidation process is more complicated and needs many assumptions.

The objective of this paper is to examine several issues associated with the prediction of the tube shape and mechanical properties of the filling material inside the tube during and after the consolidation process. This paper presents a brief review of the volume reduction method and of some of the experimental data that verify its feasibility for a fine-grained, material-filled tube. Following is a review of studies for new methods of approach for the prediction of tube shape, especially those dealing with prediction based upon the concept of settling and self-weight consolidation. The new method is verified by comparing the field model test and laboratory settling and self-weight consolidation column (SSCC) tests. The final main portion of this paper covers the variation of mechanical properties of internal filled-material during the consolidation process.

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KEY WORDS: Geotextile tube, shape variation, field model test, fine-grained material, consolidation process, settling velocity, self-weight consolidation.