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# Effect of subgrade soil stiffness on the design of geosynthetic tube

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Water or soil filled geotextile or geosynthetic tubes have been used for coastal or river protection projects in recent years. How to design and analyze geosynthetic tube is still an important research topic. Although a number of solutions for geosynthetic tube have been proposed in the past, most of these solutions assume that the geosynthetic tube is resting on a rigid foundation. In this paper, a two-dimensional analysis of geosynthetic tube resting on deformable foundation soil is presented. The deformable foundation is assumed to be an elastic Winkler type represented by the modulus of subgrade reaction, $K_f$. The study shows that the smaller the modulus, the smaller the height of the geosynthetic tube above the ground surface and the higher the tensile force in the geotextile or geosynthetic given the other conditions the same. When the foundation soil has a modulus higher than 1000 kPa/m which is representative of soft clay, the foundation soil can be assumed to be rigid in the analysis. The results obtained from the method proposed in this paper are compared with those from the solutions of Leshchinsky et al. and Plaut and Suherman for verification. The differences between the solutions are also discussed.



## 1. Introduction

There has been an increasing use of geosynthetic tubes in river or coastal protection projects in recent years (Leshchinsky et al., 1996; Pilarczyk, 2003; Kim et al., 2004; Oh and Shin, 2006; Shin and Oh, 2007; Yan and Chu, 2010) or waste sludge dewatering projects (Mori et al., 2002; Koerner and Koerner, 2006; Muthukumaran and Ilamparuthi, 2006). Geosynthetic tubes have also been used for other constructions such as for small dams or spillways, flood control, water diversion, groundwater recharging, and dewatering of high water content, contaminated waste or lagoon solid (Perry, 1993; Tam, 1997; Alvarez et al., 2007; Sehgal, 1996; Plaut and Suherman, 1998). Normally geosynthetic tubes are formed by sewing or gluing geotextile or geosynthetic sheets together and then filled with water, clay slurry, or sand. The geosynthetic tubes are sometimes stacked together to form a dike or other types of geotechnical structures (Yan and Chu, 2010).

In this paper, geosynthetic tube refers to a cross-section geometry that is more or less circular like a sausage. It is assumed in the following discussion that the geosynthetic tube is either watertight and inflated with water or air, or permeable but the fills in the geosynthetic tubes has dissipated fully so the volume or geometry of the geosynthetic tube does not change anymore. Therefore, the solutions developed in this paper are only applicable to watertight geosynthetic tubes or those filled with sand where consolidation is fast and does not affect much the final geometry of the geosynthetic tubes.

Analytical solutions for water filled impervious geosynthetic tubes resting on rigid foundation have been derived by Liu and Silvester (1977), Silvester (1986), Leshchinsky et al. (1996), Kazimirowicz (1994), Plaut and Suherman (1998), Antman and Schagerl (2005), Malík (2007) and Ghavanloo and Daneshmand (2009). Most of these solutions are based on the assumptions that the tube is long enough to be simplified into a plane strain problem and the tubes are resting on a rigid base. The only exception is the solution given by Plaut and Suherman (1998) in which the geosynthetic tube is assumed to be resting on tensionless Winker foundation. It uses non-dimensional parameters in which $H$ and $H_f$ are normalized by the length of cross-section, $L$; the pumping pressure, $p$, by $\gamma L$; the tensile force, $T$, by $\gamma L^2$; and the modulus of subgrade reaction, $K_f$, by $\gamma$. The tube was modeled as an inextensible membrane and filled with an incompressible fluid. The geometry of geosynthetic tube was resolved by partial differential equations with non-dimensional parameters. In Plaut and Suherman's solution, the perimeter of the cross-section of the tube and the pumping pressure

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