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Uniaxial compressive behavior of scrapped tire and sand-filled wire netted geocell with a geotextile envelope

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ABSTRACT

Cellular structures are widely used in civil engineering. Their design is based on the understanding of the mechanical behavior of geocells. This paper investigates the response of a single geocell to a uniaxial compression test. The geocells were cubic, either 500 mm or 300 mm on a side. The fill materials were sand and scrapped tire and sand mixtures in different mass ratios. The envelope of the geocell was made up of a hexagonal wire netting cage and a containment geotextile. The response of the geocell is discussed based on the axial load and displacement measurements as well as the change in geocell volume.

The axial load was found to be globally governed by the interaction between the fill material and the envelope, which depends on the shape of the wire mesh and the volumetric behavior of the fill material.

1. Introduction

The principle of associating a soil with a man-made envelope to create a reinforced structure was first applied in the 2nd century B.C. for military applications and mainly for rapid repair of fortifications. Based on this principle, gabion cages made of metallic wire netting were developed at the end of the 19th century. In the late 1970s, the US Army Corps of Engineers re-investigated the original principle with the aim of stabilizing beach sand for roadways (Webster, 1979), the first steps towards the development of geocells. Nowadays, geocells are defined as three-dimensional and permeable structures made of alternately linked strips of geotextiles or any planar polymeric products such as HDPE sheets. To a large extent, gabions can be likened to geocells and both are used to build cellular structures.

Cellular structures fulfill various functions in civil engineering applications. For reinforcement purposes, cellular structures are used to build flexible gravity walls, retaining structures, and rockfall protection embankments (Nicot et al., 2007; Chen and Chiu, 2008). Geocells are more specifically used for the reinforcement of base courses over weak subgrades (Yuu et al., 2008). Cellular structures can also serve as building blast protection structures (Scherbatiuk et al., 2008). In hydraulics, cellular structures are used to build weirs (Peyras et al., 1992) to protect banks against erosion and scour and also as components of rapid-deployment flood protection structures (Turk, 2001).

The design of cellular structures must account for the prevailing mechanisms, which are related to the fill material–cell envelope interaction and to the interaction between individual cells (Wesseloo et al., 2009). The interaction between adjoining and interconnected single geocells has been thoroughly investigated with respect to base reinforcement of roads on soft subgrades and embankments (Yuu et al., 2008; Pokharel et al., 2010; Zhang et al., 2010). On the other hand, the number of published studies investigating the interaction between the envelope and the fill material is rather limited. In addition, given the variety of (a) the possible fill material, (b) the envelope's mechanical characteristics, and (c) the geocell's cross-sectional shapes, this interaction is expected to vary greatly from one type of geocell to another.

The interaction between an envelope and a soil was first investigated by Henkel and Gilbert (1952). The aim was to correct triaxial test results depending on the characteristics of the membrane used to contain the tested clayey specimen. These authors proposed a model based on elastic membrane theory to account for the effect of the envelope on the fill material. This effect was considered to be equivalent to an additional confining pressure, $\Delta\sigma_3$, such that:

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