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Technical note

Pullout tests conducted on clay reinforced with geogrid encapsulated in thin layers of sand

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ABSTRACT

The interaction between reinforcement and backfill materials is a significant factor for analysis and design of reinforced earth structures which is simplified as pullout or direct shear resistance. This paper presents the results of pullout tests aimed at studying the interaction of clays reinforced with geogrids embedded in thin layers of sand. Pullout tests were conducted after modification of the large direct shear apparatus. Samples were prepared at optimum moisture content and maximum dry densities obtained from standard Proctor compaction tests. Tests were conducted on clay–geogrid, sand–geogrid and clay–sand–geogrid samples. A unidirectional geogrid with sand layer thicknesses of 6, 10 and 14 mm were used. Results revealed that encapsulating geogrids in thin layers of sand under pullout conditions enhances pullout resistance of reinforced clay. For the clay–sand–geogrid samples an optimum sand layer thickness of 10 mm was determined, resulting in maximum pullout resistance which increased with increasing confining pressure. The optimum sand layer thickness was the same for all the normal pressures investigated. For sandy soils the passive earth pressure offered the most pullout resistance, whereas for clayey soils, it was replaced by frictional resistance. It is anticipated that provision of thin sand layers will provide horizontal drainage preventing pore pressure built up in clay backfills on saturation.

1. Introduction

Throughout the world there is an increasing demand for geotechnical structures which are more economical and environmentally acceptable. To reduce the negative environmental effects caused by aggregate extraction and to save costs, there is a tendency to use local cohesive soils as construction materials. If the properties of these materials do not fulfill the geotechnical requirements, their engineering behavior can be modified using chemical additives (i.e. lime or cement) or they can be reinforced by inclusions. Geosynthetics have been used in geotechnical engineering for the past three decades because of speed of construction, flexibility, durability, use of local soils rather than imported material, and cost effectiveness. Their use is well established for the purpose of material separation and filters (Faure et al., 2006; Liu and Chu, 2006; Wu et al., 2006) and as reinforcement for improving the stability of embankments and walls (Bathurst et al., 2005; Skinner and Rowe, 2005; Varsuo et al., 2005; Hufenus et al., 2006; Nouri et al., 2006; Chen et al., 2007; Bergado and Teerawattanasuk, 2008; Li and Rowe, 2008; Sieira et al., 2009; Palmeira, 2009).

Cohesive soils being one of the most abundant and cheapest construction materials, their use can be extended by improving its engineering performance by incorporation of reinforcing elements. The main function of these elements is to redistribute stresses within the soil mass in order to enhance the internal stability of reinforced soil structures. The inclusions undergo tensile strains as they transfer loads from unstable portions of the soil mass into stable zones. Thus, a safe and economic design of soil reinforcement requires a good understanding of interaction mechanisms that develop between the soil and the reinforcement (Giroud, 1986; Bergado et al., 1991; Touahamia et al., 2002). The interactions can be simplified as soil sliding in direct shear over the reinforcement and pullout of reinforcement from the soil (Jewell et al., 1984). The pullout mechanism has been investigated by full-scale and laboratory model tests and numerical analysis (Goodhue et al., 2001; Sugimoto and Alagiyawanna, 2003; Desai and El-Hoseiny, 2005; Moraci and Gioffre', 2006). These studies mostly investigated geosynthetic/granular soil interactions. Few researches have been done to evaluate the interactions between cohesive soils and the geosynthetics (Bergado et al., 1991; Keller, 1995; Almohd et al., 2006; Abdi et al., 2009).

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