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Effect of Geosynthetic Reinforcement Inclusion on the Strength Parameters and Bearing Ratio of a Fine Soil

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Abstract

This paper reports an investigation on the beneficial effects of reinforcing a fine soil with a geosynthetic (reinforcement geocomposite) and their behaviour under loading. The effectiveness of the reinforcement was investigated through triaxial and California Bearing Ratio, CBR, tests. The triaxial tests showed that including the reinforcement provided additional confinement to the reinforced soil samples, causing an increase in the corresponding strength parameters. However, the reinforcement decreased the secant stiffness modulus of the composite material, particularly for low strains. The CBR tests were performed on soaked samples, compacted for different initial water content values. The influence of increasing the number of reinforcement layers was also analysed. The results showed that the reinforced samples had a maximum bearing capacity larger than the unreinforced material. The reinforcing mechanisms observed in the CBR tests were membrane tension support and bearing capacity increase. Increasing the number of reinforcement layers induced an improved response of the soil-geosynthetic composite material, particularly for a water content lower than the optimum. An increase in the initial water content induced reductions of the bearing capacity of the soil, with different values, depending on position of the initial value relative to the optimum water content.

Keywords: Fine soil, geosynthetic, reinforcement, triaxial, CBR, water content

1 Introduction

Traditionally reinforced soil structures are built using good quality granular fill materials. However, these are not always available locally. Nevertheless, in some cases, local (marginal) soils can be used as backfill materials without compromising stability or serviceability. Geosynthetics have been used widely as reinforcements for a wide range of structures (roads, slopes, retaining walls and embankments). Abu-Farsakh et al. (2015) summarise a series of studies on unpaved roads where geosynthetics have been used to extend the service life of pavements, reduce base course thickness for a given service life and delay rutting development. Geosynthetics can also be used to reinforce weak subgrade layers, or they can be placed at the base-subgrade interface or within the base layer.

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There are several studies in the literature where the response of reinforced soil with geosynthetics is analysed using triaxial tests for granular soil (Chen et al., 2014, Nair and Latha, 2014, Nguyen et al., 2013) or fine soils (Noorzad and Mirmoradi, 2010). Although the California Bearing ratio (CBR) test is only valid for uniform materials, performing CBR tests of reinforced soil can demonstrate the qualitative benefit of adding reinforcement under the same test conditions (Kamel et al., 2004). Similar approaches have been used to assess the influence on the bearing ratio of reinforced soil of parameters such as plasticity index and gradation of soils (e.g., Adams et al., 2016). Moayed et al. (2013) studied the bearing ratio of a two-layered soil (granular soil as base layer; cohesive soil as subgrade layer) for three conditions (unreinforced, with geotextile and with geogrid at the interface between the two soils).

The data presented herein is part of a wider research project focused on designing new solutions for building and rehabilitating existing structures using local fine soils reinforced with geosynthetics. The structures are small dykes, used as boundaries of salt pans and the canals in a tidal lagoon. Using the local fine soil has the additional advantage of providing adequate low permeability to the structures, while the reinforcements improve the mechanical response.

2 Test Program

The effectiveness of reinforcing a fine soil with a geosynthetic was studied by performing triaxial and CBR tests. The materials used (geosynthetic and soil) were characterised in laboratory. The results presented in this paper are part of a wider research project in which several geosynthetics (with different structures) and different soils (granular and fine) were used.

2.1 Materials

The geosynthetic studied was a reinforcement geocomposite (GC) consisting of continuous filament non-woven, reinforced by high tenacity polyester yarns material. Table 1 summarises some characteristics of GC, with indication of the corresponding test methods: tensile strength (T_{max}); strain for maximum load (ε_{max}); thickness for different normal pressures, 2kPa (t_{2kPa}), 20kPa (t_{20kPa}) and 200kPa (t_{200kPa}); mass per unit area (μ). Figure 1 summarises the load-strain curves of GC in both machine and cross-machine direction (MD and CMD, respectively).

Direction	T_{max} kN/m	ε_{max} %	t_{2kPa} mm	t_{20kPa} mm	t_{200kPa} mm	μ g/m^2
	EN ISO 10319	EN ISO 10319	EN ISO 9863-1	EN ISO 9863-1	EN ISO 9863-1	EN ISO 9864
MD	54.6	10.6	2.14	1.59	1.07	325
CMD	15.6	79.9				

Table 1: Properties of geosynthetic GC

The soil, collected from a wall of the salt pans in Aveiro lagoon (Portugal), was characterised in laboratory and classified using USCS, Unified soil classification system (ASTM D2487–11), and AASHTO classification system (AASHTO M 145-91-UL) as ML, sandy silt, or A-4, respectively. Table 2 includes: percentage of fine particles (<0.074 mm); 10% (D_{10}), average (D_{50}) and maximum (D_{max}) grain sizes; liquid limit (w_L); plastic limit (w_P); plasticity index (I_P); unit weight (γ); classification of the soil samples; and compaction characteristics of the soil (ASTM D1557-12, modified Proctor tests), maximum dry density (ρ_{dmax}) and optimum water content (w_{opt}). Figure 2 illustrates the particle size distribution of the soil.