An Investigation of Reinforced Steep Slopes Constructed from Excavated Soil Waste and Incorporating a Novel Multi-functional Geosynthetic

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ABSTRACT: This study investigated the pullout performance of a novel multi-functional drainage-reinforcement geosynthetic and a conventional geogrid in a marginal fill. Testing investigated the influence of confining stress, pullout rate and moisture content of the soil on pullout resistance in a novel pullout rig, which facilitated pore pressure dissipation. Higher confining stresses and increased moisture content in the marginal fill resulted in reduced pullout resistance for the conventional geosynthetic. Faster pullout rates generated greater pullout resistances in both the conventional geogrid and the novel drainage-reinforcement geosynthetic. The reinforcement-drainage geocomposite was seen to produce higher pullout resistances than the conventional geosynthetic for all drainage conditions examined; zero, partial and full dissipation of excess pore pressures in the marginal fill. This increase was greatest at higher confining stresses and was attributed to rapid dissipation of excess pore water pressures by the drainage element of the geocomposite.

INTRODUCTION

Large volumes of fine grained soils are disposed of each year as there are little engineering uses for them on site. The estimated volume of construction and demolition waste (CDW) for the twenty five members of the European Union (EU) for 2002 was 1,126kg/capita resulting in a total of 5.1m tons[1]. Significant proportion of CDW is soil waste, comprising 38% (2001 value) of Irelands total CDW[2].

The development of a new geosynthetic with the combined functions of reinforcement and drainage has opened up the opportunity of using poorer draining soils in the construction of reinforced structures.

The internal drainage dissipates excess pore pressures that can develop during the construction of the structure. This in turn increases the strength of the reinforced fill and improves the bond between the reinforcement and soil, providing adequate short term stability for the structure and decreasing horizontal and vertical settlement[3].

Naughton & Kempton[4] reported on a failed slope in Taiwan which was reconstructed and reinforced with the new geocomposite. The slope had initially failed due to the poor soils used and a build-up of pore water in the soil following heavy rainfall in the typhoon season. The material used in the re-construction was the original soil from the failed slope with was reinforced by the geocomposite at 1m vertical spacings. The geosynthetic was very successful at dissipating excess pore water pressures during the construction allowing the structure to be completed in just three weeks. This, coupled with the reuse of the backfill material, resulted in significant cost savings for the project.

Figure 1: (a) Failed slope (b) reconstructed slope using reinforcement-drainage geocomposite and backfilled with original soil

The behaviour of reinforced steep soil slopes is largely governed by interaction mechanisms that develop between the reinforcement inclusions and the backfill soil. Pullout is a very important mode of soil-reinforcement interaction and occurs when the reinforcement pulls out of the soil after the maximum bond stresses between the fill and the reinforcement has been mobilised. Therefore the pullout performance of the geocomposite in marginal fills is of great importance.

AIMS

Principle Objectives

- To construct a versatile pullout apparatus suitable for investigating pullout in cohesive fills
- To investigate the pullout behaviour of conventional and geocomposite geosynthetics.
- To quantify the dissipation of pore pressure potential in a geocomposite geosynthetic.
- To develop a numerical model of the pullout and dissipation mechanism associated with a geocomposite geosynthetic.

METHODOLOGY

An innovative experimental model (Fig.2) was developed to examine the pullout behaviour of a conventional geosynthetic reinforcement strip (Fig. 3a) and a multi-functional geocomposite (Fig. 3b) under different loading conditions and at varying soil moisture contents

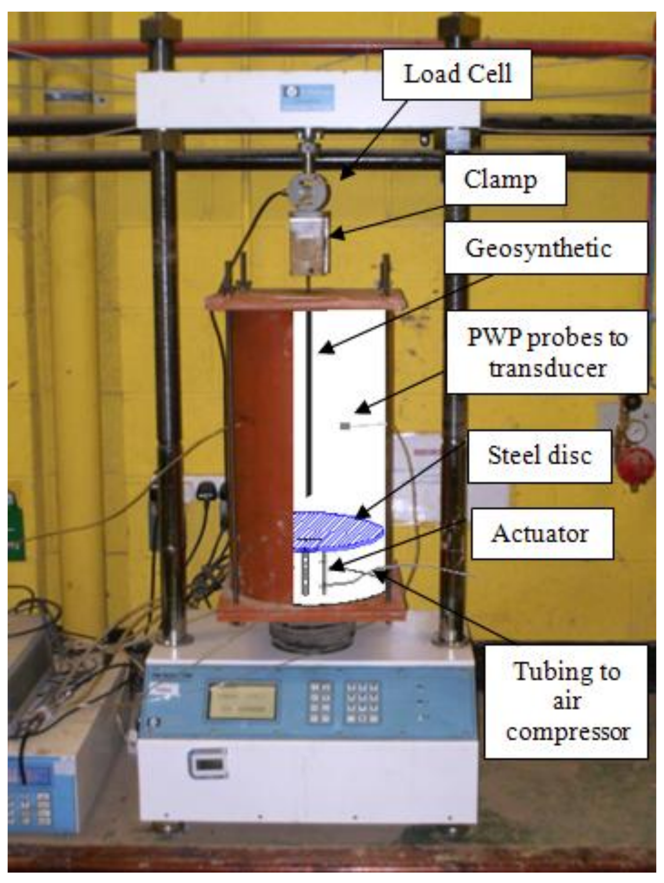

Figure 2: Experimental pullout apparatus

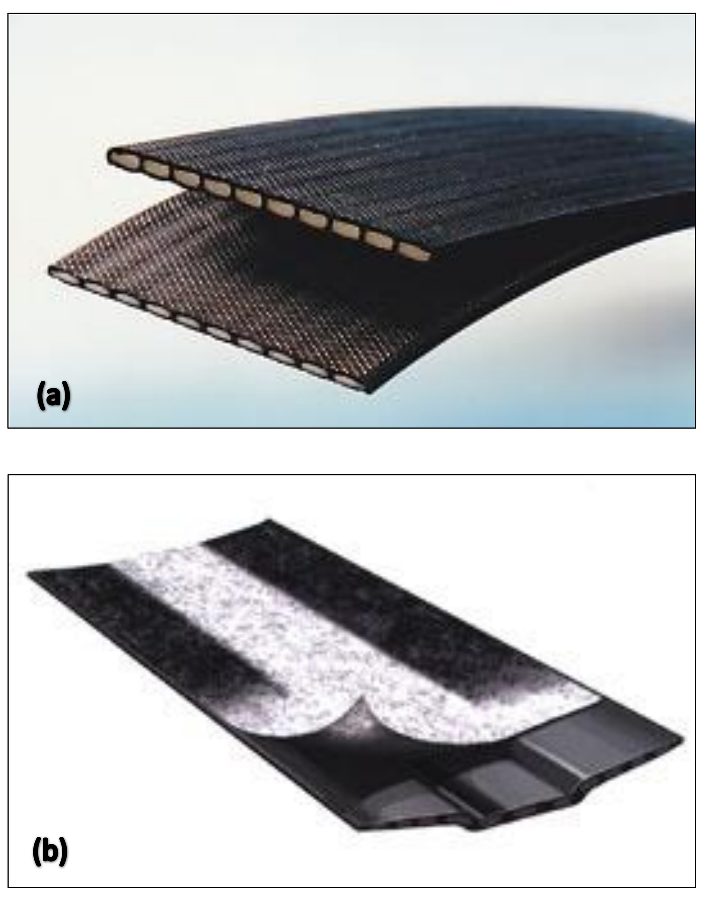

Figure 3: (a) Conventional reinforcement geosynthetic (b) novel reinforcement-drainage geocomposite

RESULTS

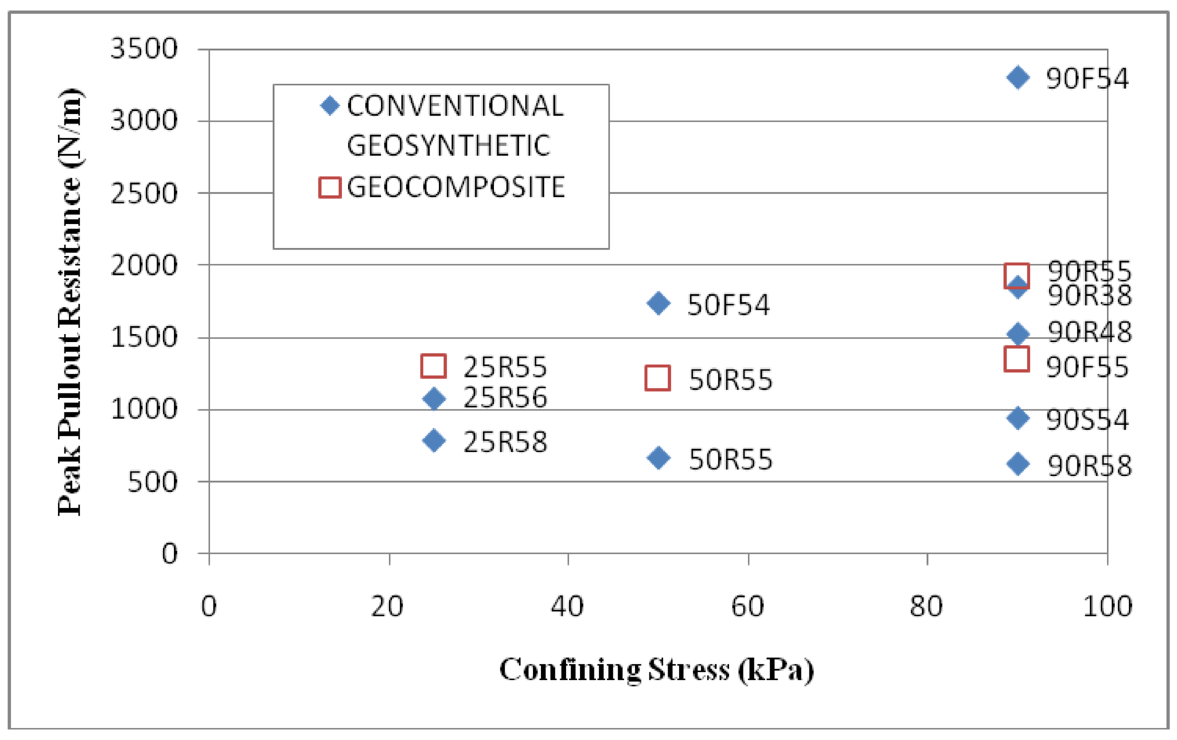

Figure 4: Maximum pullout resistance at confining stresses examined

- Higher moisture contents result in reduced pullout resistances
- Faster rates of pullout shown to increase pullout resistance
- Reinforcement-drainage geocomposite yielded greater pullout resistances.

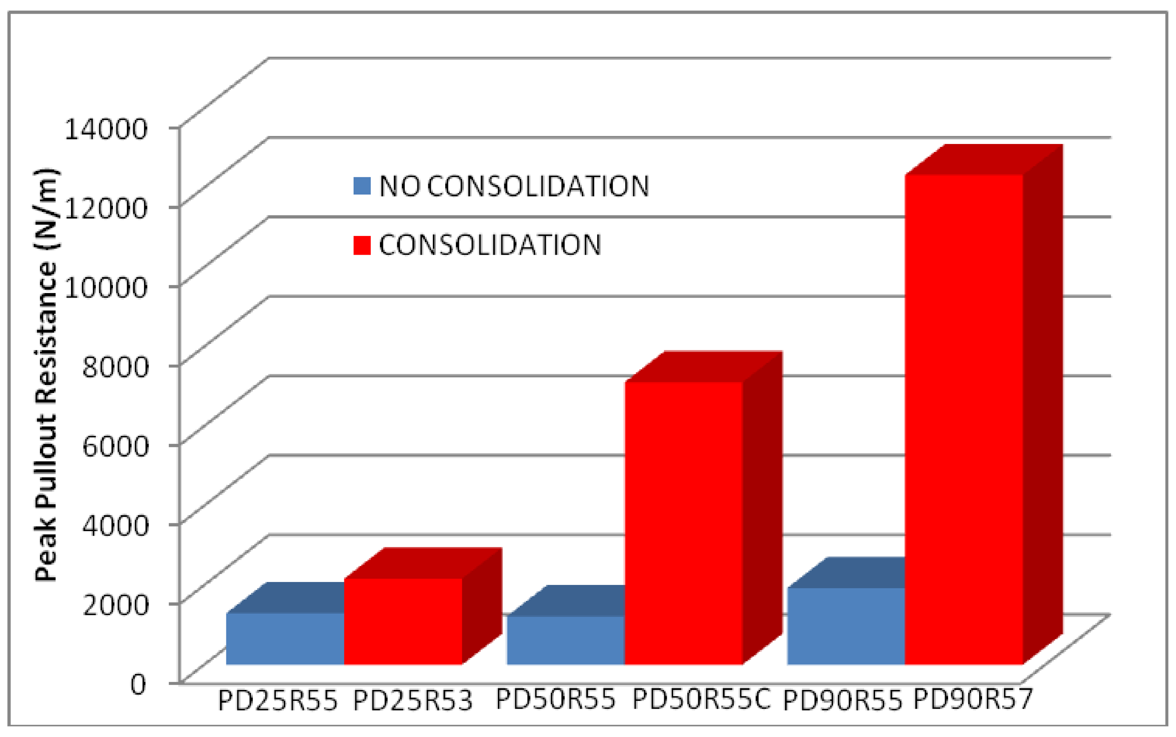

Figure 5: Increase in peak pullout resistance following consolidation of soil mass

- Consolidation of sample resulted in significantly increased pullout resistance
- Increase greater at higher confining stresses.

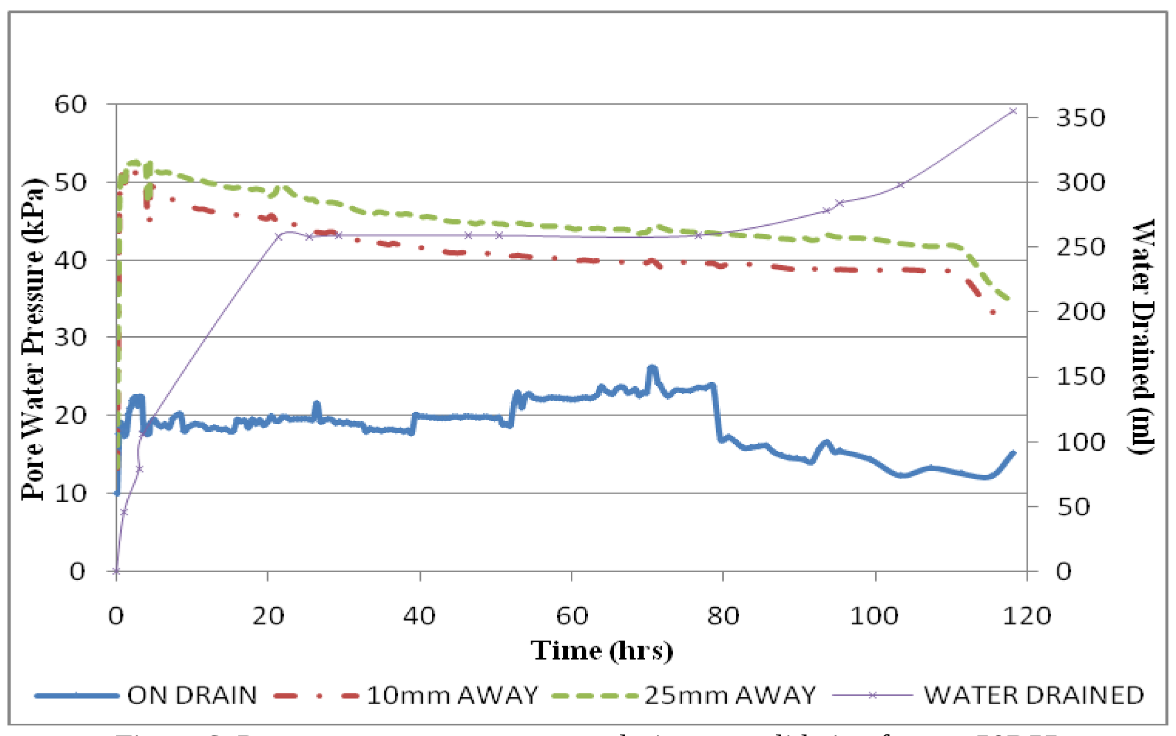

Figure 6: Pore water pressure response during consolidation for test 50R55

- Dissipation of excess pore water pressures, greatest dissipation at drain.
- Little evidence of clogging of drainage element.

CONCLUSIONS

- It was found that for a conventional geosynthetic increased moisture content and confining stress resulted in a decreased pullout resistance while higher pullout rates increased the pullout resistance.
- It was found that peak pullout resistances for the reinforcement-drainage geocomposite were increased for all confining stresses compared to the conventional geosynthetic, with greater increases at higher stresses.
- Further improvement in pullout resistance was achieved when consolidation was permitted of the sample.
- Pore water pressures at the drainage channel of the geocomposite was seen to only reach a fraction of the applied pressure.

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