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Electrically conductive geosynthetics for consolidation and reinforced soil

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Abstract

The concept of electrically conductive geosynthetics (EKG) materials has recently been introduced. These materials extend the traditional functions of geosynthetic materials by incorporating electro-kinetic phenomena. Electro-kinetic geosynthetics offer technical benefits over conventional electrodes in that they can be formed as strips, sheets, blankets or three-dimensional structures. They are light and easy to install and can be structured so as not to be susceptible to electro-chemical corrosion, whilst continuing to provide conventional functions of filtration, drainage, separation, reinforcement or to act as impervious membranes. This paper describes initial laboratory tests on different types of EKG materials which can be used as combined electrodes/drains in electro-osmotic consolidation and as conductive geosynthetic reinforcement used to improve and reinforced weak cohesive soil. Results of the consolidation tests showed that the EKG electrodes were as efficient as a copper electrode and that the filtration and drainage characteristics did not deteriorate under electro-osmotic conditions. Results of the reinforced soil tests showed that EKG reinforcement can be used to increase the undrained shear strength of cohesive fill and that reinforcement/soil bond increases in proportion to the increase in shear strength.

Keywords: Electrically conductive geosynthetics; Reinforced soil; Consolidation; Electro-osmosis

1. Introduction

During the last 20 years the growth in the use of polymeric-based geosynthetic materials in civil and environmental engineering has been exponential. The

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Nomenclature

γ_w	unit weight of water
A	cross-sectional area
i_e	$\Delta V/\Delta L$ voltage gradient
i_h	hydraulic gradient
J	current density
k_e	electro-osmotic conductivity
k_h	hydraulic conductivity
L	length
ρ	soil resistivity
V	voltage
q_e	electro-osmotic flow
q_h	hydraulic flow
u	difference in pore water pressure between anode and cathode
U_e	negative pore water pressure developed by electro-osmosis
V_m	maximum applied voltage

established roles of these materials is to provide filtration, drainage, separation, reinforcement and act as impermeable members. A recent trend is to optimise the use of geosynthetic materials by creating combinations of geotextiles, geogrids, geomembranes and/or other materials to form geocomposites. Some of the geocomposites currently in use include: geotextile–geonet materials for combined filtration and drainage, geotextile–geogrid material for combined drainage and reinforcement, and geotextile–geomembrane composites which provide impermeable membranes with their own protective barriers to limit puncture damage.

It has been found that new uses and applications of geosynthetics can be created by incorporating electro-kinetic phenomena with the existing traditional functions of geosynthetic materials. This entails the creation of a new range of geosynthetic materials (or geocomposites) that are electrically conductive. An electrically conductive geosynthetic is referred to as an electro-kinetic geosynthetic (EKG). Potential applications of EKG materials demonstrated in laboratory trials include: the in situ decontamination of contaminated soils by electro-chemical means; the electro-kinetic transport of nutrients into a soil to encourage bioremediation; the treatment of industrial waste; the improvement of the performance of lime piles; and improvements in reinforced soil technology and accelerated consolidation of soil using the principle of electro-osmosis. The last two have been demonstrated in full scale trials.

This paper describes the laboratory assessment of the performance of prototype EKG materials which can be used in civil engineering applications such as consolidation and soil reinforcement. Based upon these trials the first commercially available EKG electrode was developed.