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Numerical Studies on the Behaviour of Marine Clay Walls Using GHD

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ABSTRACT

Numerical analyses have been carried out to study the performance of GHD reinforced embankment/wall with low grade saturated soil as fill material. Influences of various parameters in embankment deformation and tensile force development in GHD have been presented. These parameters include drainage condition, spacing, length and modulus of GHD, and embankment geometry.

KEY WORDS: GHD, reinforced embankment/wall, drainage condition, finite element analysis, marine clay, saturated soil

1. INTRODUCTION

In the past, marine clays have not been employed as a fill material in constructing offshore earth structures such as quay walls/embankments due to their unacceptably low drainage performance. However, such high water content and low grade marine clays are, often times, abundantly and readily available near construction sites. If such low grade soils can be utilised in constructing offshore soil structures, not only saving in cost of construction would be tremendous but also the related environmental concerns caused by their disposal problem would be resolved.

Traditional reinforcing materials such as geogrids and steel reinforcements, which have only reinforcing effect, are not sufficient in themselves to drain water out of such low grade fills because of their inherent inability to drain out water. Among various techniques commonly employed to enhance the properties of low grade cohesive marine clays, use of geosynthetics is remarkable. In association with geosynthetic having high degree of drainage capacity and tensile strength, high water content cohesive soils and marine clays can be employed successfully in constructing offshore soil structures.

Geosynthetic Horizontal Drain (GHD) has high level of water drainage capacity, in addition to its tensile strength. Therefore, when the fill material with low permeability is to be used in constructing reinforced soil structures such as embankments/walls, GHD can be very appropriate reinforcing/draining geomaterial. GHD is composite sheet made of synthetic materials. Typical GHD consists of core of undulated shape warped on both sides by a thin filter cover. Filter functions as a filter of soil particles, while letting the free passage of water. The core works as a drainage path. Typical GHD sheet has apparent thickness of about 1 cm and a width of 30 – 60 cm. Due to its ability to function as drainage as well as reinforcement material, GHD is getting wide acceptance in many reinforced embankments/walls works in which fill soils have relatively low permeability. Various properties of GHDs and their uses can be found elsewhere (Kamon et. al. 1994, Kamon et. al. 1995, Pradhan et. al. 1996a,b,c).

In this research, numerical studies on behaviour of saturated marine clay walls/embankments reinforced with GHD are conducted. Finite element analyses on such walls are carried out to examine the effects of various parameters in wall performance. These parameters include drainage capability of GHDs, length of GHD, modulus of GHD, vertical spacing of GHD, and wall geometry. Properties of clay used correspond to that of reconstituted Tokyo Bay Marine Clay. It should be kept in mind that wall and embankment have been used interchangeably in this paper.

2. MODELLING DETAILS

Finite element program, DACSAR, developed by Iizuka and Ohta (1987), that incorporates critical state soil model proposed by Sekiguchi and Ohta (1977), has been employed for the investigation. Elasto-plastic soil model is used to represent clay elements while GHD is modelled by bar elements.

Typical finite element mesh used is shown in Fig. 1. The analysis assumes that plane strain condition exists in wall. Half part of symmetric wall is considered in analysis. It is 3 m high and 9.9 m long at base. Displacement boundaries specified in analysis are also shown in Fig. 1. At rear end, wall is allowed to settle only vertically, which is achieved by providing roller type supports at side boundaries. Wall is assumed to have a base on solid foundation. As shown in Fig. 1, nodes of base elements can move only horizontally.

All the wall elements are constructed in one step at the rate of 0.5 m/day. At the end of wall construction, total surcharge load equivalent to 2 m height of the wall is given at the loading rate of 0.5 m/day in two equal steps. Analyses have been performed by varying drainage capability of GHD, length, modulus and vertical spacing of GHD, and wall geometry. Walls with vertical and inclined front faces are analysed. In case of inclined facing, front face slope is kept 1 horizontal for 2 vertical.