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Investigation of the strength of carbon-sand mixture

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Abstract

The greatest stress that a composite soil can sustain is a critical value when dealing with slope stability, bearing capacity and lateral earth pressure. Cohesion and internal friction of soil composite particles will create tension and retain any stresses which are applied to the composite material. The soil composite will remain secure unless the applied external stress reaches its shear capacity. This research examined composite materials consisting of sand and various percentages of carbon. The sand used in this experiment was yellow sand which is available in Western Australia. For the purpose of testing strength, three different percentages of carbon (5, 10 and 15) were added and mixed homogenously with the sand. The strength of the composite material was tested using a small direct shear machine, in order to determine the effect of the presence of carbon on the soil strength. The experiment results provided evidences that the presence of carbon influenced the shear performance of the sand, with the shear strength of the sand-carbon composite being significantly lower than that of pure sand. The more carbon that was added to the mixture, the lower the shear strength. Carbon also takes up initial moisture content in the sand during the mixing process. The results of this research are potentially very useful in the geotechnical field, particularly with regard to construction sites containing carbon.

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Keywords: Stability; sand; carbon; strength test

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1. Introduction

Structures can collapse for many reasons. One of them is settlement, which may be due to the extraction of water [1], and another is a loss of strength. Stabilization of soil has therefore always been an issue for the researcher. If soil fails, the consequences may be significant, such as major damage to civil engineering projects. Soil shear strength parameters are required to analyze soil bearing capacity, slope stability and retaining walls [2]. The capability of the soil to support any structure relies mainly on the soil's shear strength. The shear strength of soil can be represented by its cohesion (C) and internal friction angle (θ) [3].

In Western Australia, sand or coarse-grained soil is the type of soil often used as a basic foundation in civil engineering work. The disadvantage of sandy soil is that there is no holding capacity between the particles and it can therefore be classified as a non-cohesive (cohesionless) soil [4]. Non-cohesive soils display intergranular looseness, which is indicated by the separation of the soil particles in dry conditions and the fact that the particles only adhere to each other when wet, as a result of surface tension forces [5].

The shear strength performance of sand is also influenced by the purity and particle uniformity of the sand [3, 6]. Some other components may be found in sand, such as carbon, which may affect the purity of the sand. The percentage of carbon in the sand varies from one area to another, and it may have some influence on the shear performance [7]. Therefore, this project examine of carbon content in the sand upon the shear strength performance of the sand and look for any potential uses of carbon as a soil stabilization material.

2. Materials

The composite that was studied included the following components:

2.1. Sand

Yellow sand or Baldivis sand was selected for this experiment due to its availibility in Perth, Australia. Baldivis sand can be classified as a poorly-graded sand and has a specific gravity of 2.65.

2.2. Carbon

This experiment used granular activated carbon (GAC) obtained from a local supplier. The adsorption suface area of the GAC was about 650 to 1000 m^2/gram. This type of carbon was produced from a carbon source (wood, lignite, nutshells or coal) in the absence of air. This type of carbon is generally used in water treatment processes or the filtration of any other liquid to remove contaminants [8].

2.3. Experiment procedure

At least four sets of direct shear tests were conducted for four different types of sample, consisting of pure sand and sand containing 5%, 10% and 15% carbon. The sand was prepared by sieving to achieve particle uniformity and drying to remove the initial moisture content. For the preparation of the sand-carbon mixture, the percentage of carbon was calculated based on the dry weight of the sand. The direct shear test itself was run according to the procedure given by AS 1289.6.1.1-1998 [9]. Each sample was poured and compacted into the shear box prior to direct shear testing. Once the sample was ready, water was added to the shear box and the first 50 kPa of normal stress was introduced to the sample. The sample was then allowed to become fully consolidated before the shear stress was applied. Since the direct shear testing was performed using the automated direct shear machine, the results were logged and saved automatically by the software installed in the computer. After completion of the tests, the results were transferred to a spreadsheet in order to perform the calculation. The same procedure was carried out a normal stress of 150 kPa and 250 kPa and continued for each sample. The failure stresses were treated as being of high importance in order to discover the friction angle and cohesion.