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Review Article

Tensile Testing of Soils: History, Equipment and Methodologies

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Abstract

Tensile strength of soil is indeed one of the important parameters to many civil engineering applications. It is related to wide range of cracks especially in places such as slops, embankment dams, retaining walls or landfills. Despite of the fact that tensile strength is usually presumed to be zero or negligible, its effect on the erosion and cracks development in soil is significant. Thus, to study the tensile strength and behavior of soil several techniques and devices were introduced. These testing methods are classified into direct and indirect ways depending on the loading conditions. The direct techniques including c-shaped mold and 8-shaped mold are in general complicated tests and require high accuracy as they are based on applying a uniaxial tension load directly to the specimen. On the other hand, the indirect tensile tests such as the Brazilian, flexure beam, double punch and hollow cylinder tests provide easy ways to assess the tensile strength of soil under controlled conditions. Although there are many studies in this topic the current state of the art lack of a detailed article that reviews these methodologies. Therefore, this paper is intended to summarize and compare available tests for investigating the tensile behavior of soils.

Keywords: Tensile Strength of Soils; Direct/ Indirect Tensile Test; Brittle Materials; Brazilian Tensile Test; Double Punch Test.

1. Introduction

Soil tensile behavior plays a significant role in various engineering applications [1]. Furthermore, understanding the formation and development of soil cracks is indeed a key factor affecting its performance in fields such as geological, geotechnical and environmental engineering [2-4]. In general, tensile cracks of soil are related to its mechanical and hydraulic properties [5]. These cracks occur when the induced tensile stress or strain exceed the soil capacity [6]. In fact, soil is weak in tension [7], therefore, engineers often assume the tensile strength of soil to be zero because it is relatively small in comparison to the its compressive strength [1, 8-11]. As a result, many strength improvement methods have been discussed in the literature. These efforts encouraged scholars in this filed to introduce and develop several testing techniques to study soil's tensile behavior [8]. However, due to some factors such as the brittleness of the material, finding the tensile strength of soil is considered to be very difficult and needs proper and careful setup in order to reach the best stress state [12]. Regardless of that, available testing methodologies are defined into either direct or indirect technique based on the way of applying the load and computing the tensile strength of soil. In the direct tests, the sample is placed in a cube, cylinder or prism mold then a uniaxial tensile force is imposed to the two ends of the sample [13]. On the other hand, the indirect tests involve the correlativity of different parameters and soil characteristics to measure the tensile strength of soils in simple and easy way compared to the direct one since it

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