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Hysteretic response of the CBR of an unsaturated deformable subgrade along drying and wetting paths

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Abstract

The California bearing ration (CBR) test is the basis for determining the strength of a subgrade layer. Nonetheless, the influence of unsaturated condition and in particular the different hydraulic responses during drying and wetting cycles have been rarely considered in the determination of the CBR of a pavement material. The goal of this paper is to examine the strength of a subgrade soil layer compacted at three different initial dry densities along drying and wetting paths. To achieve this, a series of California bearing ratio (CBR) test were performed on a sand-kaolin mixture. Wetting CBR tests were measured on the soil samples mechanically wetted to target void ratio and saturation condition, while drying CBR values were determined on the compacted saturated soil samples that were air dried to desired degrees of saturation. The experimental results showed a hysteretic pattern for the variation of CBR in examined pavement material.

Keywords: Unsaturated soils, CBR, Initial compaction, Degree of saturation, Hysteresis.

1. INTRODUCTION

Many of the road subgrade geomaterials are built on unsaturated compacted soils; therefore a comprehensive study on the performance of pavement layers should be made according to the more advanced behavior behavioral aspects of unsaturated soils such as the distinction in the variation of degree of saturation versus matrix suction along drying and wetting paths (i.e. hydraulic hysteresis).

One of the most common and frequently used engineering parameters in the design of road pavement materials is California bearing ratio (CBR). The extensive amount of past research on the CBR of saturated soils led to the generation of standards such as ASTM D1883-07 and or AASHTO 193-99 for determination of CBR in saturated soils. In unsaturated soils, many of the experimental observations such as the early contributions of Davis (1946) or Black (1962) or recent studies of Sanchez (2002) or Talokdar (2014) were mainly confined to examine the influence of soil moisture content on CBR. Additionally, efforts were carried out to investigate the variation of California bearing ratio with respect to the matrix suction or the degree of saturation of the soil. Among the notable contributions are the works of Prair (1987), Sivakumar and Tan (2002), Vogrig (2003), Ampado (2007), Purwana et al. (2012) and Wu et al. (2014) which all appeared to show an increase of CBR within increment of soil suction or within decrement of degree of saturation.
Although the previous studies has generated a basic knowledge on the behavior of CBR in unsaturated soils, there is still a need for further experimental study to clarify the dependencies of CBR to other complex aspects in unsaturated soils. As an example, most of the road pavement materials are subjected to different drying and wetting hydraulic loadings, and the bearing ratio and any deformation of subgrade layers are highly affected to the changes of degree of saturation or matrix suction of the soil. Another point to be mentioned is the significant influence of hydraulic hysteresis on mechanical behavior of unsaturated soils, which already reported by Mirzaii & Yasrobi (2012), but has not received a level of attention in previous experimental studies on CBR.
In this article, an elaborate laboratory test program is carried out to determine the influence of the initial compaction density, and hydraulic hysteresis on the California bearing ratio of a sand-kaolin mixture along