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Suction and shear strength relationships of granular materials

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ABSTRACT

Unsaturated soils are the predominant soil type in moisture deficient areas of the world. These soils have the characteristic ‘suction’, which is the potential for a soil to absorb water. With more than one-third of the world located in moisture deficient zones, understanding the characteristics of these soils is important in enhancing engineering design and analysis.

Much of the research focus on unsaturated soils is centered on the formulation of the effective stress equation involving suction and its relevance to strength and volume change. Suction therefore is a key parameter linked to the behavior of these soils. It is made up of two components namely matrix and osmotic (solute) suction of which both are believed to influence soil properties. However, the exact role of each or both components in influencing the effective stress, strength and volume change behavior of unsaturated soils has not been fully verified. The hypothesis postulated is that osmotic or solute suction contributes to the shear strength of soils.

The focus of this research is experimentally to isolate the effect of osmotic suction and further evaluate its contribution as well as those of other capillary forces to the shear strength of granular soils.

The experimental method consisted in altering the suction characteristics of the pore matrix in granular soils by mixing it with various solutions. This was achieved by using distilled water, ionic solutions of NaCl and non-ionic solutions of detergent, and measuring the effects of these solutions on shear strength. In addition, surface tension measurements were made in a set of capillary tubes with these solutions and psychrometer tests were made on granular soils mixed with these solutions. Three sets of triaxial shear strength parameters and corresponding suction ranges were obtained from the verifications:

- Shear strength parameters and matrix suctions measured by the axis translation technique in the undrained triaxial test.

- Shear strength parameters measured in the drained triaxial test.
- Shear strength parameters measured in the undrained state on specimens exposed to different atmospheres in equilibrium with saturated salts solutions and others exposed to atmospheres in equilibrium with distilled water, ionic solutions of NaCl and non-ionic solution of detergent.

Results of the experiments revealed that though solute suction may indirectly influence the shear strength of granular soils, it does not contribute to it in a direct way. The Bishop equation appropriately describes the strength and deformable characteristics of unsaturated soils.