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SHEAR BEHAVIOUR OF PARTIALLY SATURATED SOILS

by

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CERTIFICATE

This is to certify that the thesis entitled, "SHEAR BEHAVIOUR OF PARTIALLY SATURATED SOILS" being submitted by Mr. B.S. SATIJA to the Indian Institute of Technology, Delhi, for the award of the degree of DOCTOR OF PHILOSOPHY is a record of the bonafide research work carried out by him. Mr. B.S. Satija has worked under my guidance for the submission of this thesis which to my knowledge has reached the requisite standard.

The thesis or any part thereof, has not been submitted to any other university or Institution for the award of any degree or diploma.

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ABSTRACT

Effective stress concept has perhaps been primarily responsible for the scientific development of soil mechanics. This concept enunciated by Terzaghi has been the subject of extensive study in fully and more recently in partially saturated soils. It was readily apparent that the classical effective stress equation would not be satisfactory for describing the behaviour of partially saturated soils, this equation was therefore modified and new equations suggested by many researchers which in 1960 finally took the following form:

$$\bar{\sigma} = (\sigma - u_a) + \alpha(u_a - u_w)$$

where u_a is the pore air pressure, u_w is the pore water pressure, and α is a parameter dependent on degree of saturation with a value of 1.0 for 100% saturation and 0 for dry soil.

Even this effective stress could not be shown to control the engineering behaviour of partially saturated soils on account of the difficulty in evaluating the parameter α . Fredlund (1973) on the basis of continuum mechanics identified three stress state variables $(\sigma - u_a)$, $(u_a - u_w)$ & $(\sigma - u_w)$ as being relevant for partially saturated soils and suggested that the engineering behaviour must be studied in terms of these variables.

This thesis presents results of an experimental investigation designed to study the shear behaviour of a partially saturated soil in terms of these stress state variables. Statically compacted soil samples, using two energies at the same moisture content were prepared at a water content somewhat dry of the optimum. Two types of tests were carried out on these samples: i) constant water content tests and ii) Drained tests. Influence of four test variables has been studied viz. (i) stress state variable $(\sigma_3 - u_a)$, (ii) stress state variable $(u_a - u_w)$, (iii) Pre-shear density, & (iv) Drainage condition during shear.

A statistically relevant relation has been identified between shear strength of a partially saturated soil and a pair of stress state variable each acting independently. The strength equation which takes the form of $\left(\frac{\sigma_1 - \sigma_3}{2}\right)_f = a + (\sigma_3 - u_a)_f \tan \alpha + (u_a - u_w)_f \tan \beta$ has been found to be valid not only for the experimental investigation reported herein but has also been found to be valid for data published in literature. Not only the shear strength but the shear behaviour of a partially saturated soil as a whole has been shown to be a function of a pair of stress state variables.

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