Presented to the 13th Canadian Congress of Applied Mechanics, June 2-6, Winnipeg, Manitoba. (1991)

COMPARISONS OF ELASTIC AND PLASTIC APPROACHES TO THE PREDICTION OF DEPTH OF CRACKING

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Large portion of the earth surface is covered by desiccated soils with cracks developed to some depths. The presence of cracks in soils has a significant effect on the shear strength and volume change behavior of the soil. Therefore, the depth of cracking is required in analyzing numerous geotechnical problems (Pufahl, Fredlund and Rahardjo, 1983), such as bearing capacity, lateral earth pressures, slope stability and heave predictions. This paper presents the elastic and plastic approaches to the prediction of depth of cracking. The constitutive equations used in both approaches are outlined and their predicted depths of cracking are compared.

Desiccated and cracked soils are considered as an unsaturated soil with its pore-water pressures being negative. The stress state variables that control the mechanical behavior of an unsaturated soil are net normal stress, ($\sigma - u_a$), and matric suction, ($u_a - u_w$) (where: σ = total normal stress, u_a = pore-air pressure and u_w = pore-water pressure). Therefore, constitutive equations for unsaturated soils are expressed in terms of the stress state variables.

The elastic approach considers cracking in soils as a volume change problem. The soil is assumed to behave as an isotropic, linear elastic material. The constitutive relations for the soil structure are of a semi-empirical extension of the elasticity formulation commonly used for saturated soils. The depth of cracking is determined by setting the net lateral stress to zero while the lateral strain is assumed to be equal to the tensile strain of the soil. The theoretical crack depth is found to be a function of the matric suction profile above the groundwater table and the ratio of the elastic moduli, E/H (where: E = elastic modulus with respect to ($\sigma - u_a$) and H = elastic modulus with respect to ($u_a - u_w$)). The modulus ratio, E/H, can be related to the volume change indices commonly measured in the conventional soil mechanics tests. It appears that the depth of cracking is quite sensitive to the value of the E/H ratio (Lau, 1987).

The plastic approach considers cracking in soils as a shear strength problem. A soil is in a state of plastic equilibrium when every part of the mass is assumed to be on the verge of failure (Terzaghi and Peck, 1967). The equation for the failure envelope of an unsaturated soil is an extended form of the Mohr-Coulomb failure criterion. The extended form of the failure criterion incorporates the tensile strength of the soil (Fang and Chen, 1971 and 1972) and the matric suction variable (Fredlund, Morgenstern and Widger, 1978). The depth of cracking is determined at a depth where the lateral stress is equal to the allowable tensile strength of the soil as obtained from the extended failure criterion. The crack depth predicted by the plastic equilibrium analysis is found to be a function of the matric suction profile above the groundwater table and the shear strength properties of the soil (i.e., cohesion and angle of friction). In particular, the predicted crack depth is quite sensitive to the friction angle with respect to the matric suction (i.e., ϕ^b angle).

Comparisons between the elastic and plastic approaches indicate that the crack depth predicted by the plastic analysis is almost twice as deep as that predicted by the elastic analysis. The elastic analysis appears to be more appropriate for the prediction of crack depth since the formation of desiccation cracks is primarily caused by the reduction in soil volume.

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