ABSTRACT

Berney IV, Ernest Samuel. Ph.D., Purdue University, May, 2004. A Partially Saturated Constitutive Theory for Compacted Fills. Major Professors: John Haddock and Thomas D. White.

Partially saturated soil is the most common material encountered in the field of geotechnical engineering. Yet, mechanics of partially saturated soil lags far behind that of saturated soil. A partially saturated soil is a complex multi-phase system consisting of air, water and solid material whose response is a function of the stress state, moisture condition and other internal variables present within the soil. From a thermodynamic viewpoint, a partially saturated soil can be best described by the free energy associated with each component of the soil and water mixture.

It is noted that many thermodynamic formulations have been proposed for soil plasticity. In the current research, a theory to capture the mechanical response of partially saturated materials was constructed from a saturated soil model by adding a term for the free energy of the capillary phase that includes coupling between the solid and water phases. In defining the free energy a distinction is made between water in the capillary phase and mobile water that flows as an independent phase. This inherent relationship between the variables appearing in the free energy expression and their conjugate stress terms obviates the traditional problem of defining the effective stress. The principles of the theory are illustrated by extending an existing plasticity model for

saturated soils, which is based on an internal variable formulation, by adding terms that account for free energy of the capillary phase. The model exhibits the tendency of partially saturated soil to either swell or collapse depending on the compaction state. Simulations of consolidated-undrained triaxial tests demonstrate the proper relationship between strength and the state as described by water content, void ratio, and total confining stress.