A FINITE ELEMENT SIMULATION OF THE BEHAVIOR OF UNSATURATED SOIL

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ABSTRACT

The mechanical behavior of partially saturated soils is very different from that of fully saturated soils. It has long been established that for such soils, changes in suction do not have the same effect as changes in the applied stresses, and consequently the effective stress principle is not applicable. Conventional constitutive models, which are based on this principle, are therefore of limited use when analyzing geotechnical problems that involve the presence of partially saturated soil zones.

In this thesis, a trial embankment on partially saturated Iraqi soil was analyzed by the finite element method. A procedure was proposed to define the H-Modulus function by applying fitting methods. It depends on identifying the basic properties of the soil such as Attereberg limits and particle size distribution in order to predict the soil water characteristic curve by applying fitting methods with the aid of the program (SoilVision). Then this relation is converted to relation correlating the void ratio and matric suction. The slope of the later relation can be used to define the H-modulus function.

The finite element programs SIGMA/W and SEEP/W were used in analysis, four and eight nodded isoparametric quadrilateral elements are used for modeling both the soil skeleton and pore water pressure. A parametric study was carried out and different parameters were changed to find their effects on behavior of partially saturated soil. These parameters include the degree of saturation of the soil (S), depth of water table, hydraulic conductivity (k) and the unsaturated soil modulus (H).

The study reveals that the degree of saturation has a major effect on the swelling process. The effect of unsaturated soil on swelling characteristics appears at early stages of loading.

It is concluded that the effect of unsaturation becomes greater at the middle of the clay layer and near the center line of the embankment where more load concentrates than at its toe.

Also, it can be concluded that the excess pore water pressure of fully saturated soil is greater than that of partially saturated soil and dissipation starts at fast rate and becomes slow with time.

The failure potential of unsaturated soil is less than that for fully saturated soil since the deviatoric stress (σ_1- σ_3) at all stages of consolidation is smaller. The maximum failure potential takes place when the water table is at a depth of (2 m). As the degree of saturation decreases or depth of water table increases, the maximum deviatoric stress decreases.

In addition, the effect of hydraulic conductivity on the behavior of unsaturated soil is apparent when the time proceeds and when the degree of saturation increases. The condition of unsaturation has no effect on the case of low hydraulic conductivity (10^{-5} m/day), but when the hydraulic conductivity is greater than (10^{-5} m/day), the effect of partial saturation will appear.