Accounting for Temperature Dependence in Numerical Analysis of Elasto-Plastic Deformation of Saturated and Unsaturated Soils

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As utilization of renewable geothermal heat energy is increasing recently, it is important to have a tool that can assess the influence of disturbing the subsurface thermal regime on the mechanical behavior of the ground. Many previous studies on saturated soils had shown that while there is reduction in consolidation yield stress and shear strengths with increasing temperature, the strengths at the critical state were almost independent of temperature. Our previous study based on the triaxial compression tests for unsaturated soils (DL clay) showed the similar temperature effect as saturated soils. In this study, we have developed a tool that can numerically simulate elasto-plastic behavior of saturated and unsaturated soils under different temperatures based on the finite element method. The effect of temperature on the mechanical behavior of the soil was modeled by formulating an intercept of a normal consolidation line (NCL) as a function of temperature. We additionally adopted a concept of the shear band to modify plastic volumetric strains of dense specimens. The developed model was evaluated by analyzing our experimental data. The analysis domain was 2.5 cm ×5 cm, assuming the axial symmetry of the specimen. Shearing process was simulated by applying a constant strain rate at the top of the soil specimen. Simulated results showed that, for loose specimens, while the initial increase in the shear strength became smaller with increasing temperature, the strengths at the critical state were almost independent of temperature. Temperature effects on the volume change were relatively small. As for dense specimens, the simulated results showed that the peak strength and the volume expansion became smaller with increasing temperature. The strength at the critical state was again independent of temperature as similar as the loose specimens. The simulated results were in good agreement with experimental data.

