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Enhancements to the Coupled Hydro-Mechanical Hypoplastic Model for Unsaturated Soils

Authors : Shanujah Mathuranayagam, William Fuentes, Samanthika Liyanapathirana

Abstract : This paper introduces an enhanced version of the coupled hydro-mechanical hypoplastic model. The model is able to simulate volumetric collapse upon wetting and incorporates suction effects on stiffness and strength. Its mechanical constitutive equation links Bishop's effective stress with strain and suction, featuring a normal consolidation line (NCL) with a compression index (λ) presenting a non-linear dependency with the degree of saturation. The Bulk modulus has been modified to ensure that under rapid volumetric collapse, the stress state remains at the NCL. The coupled model comprises eighteen parameters, with nine for the hydraulic component and nine for the mechanical component. Hydraulic parameters are calibrated with the use of water retention curves (IWRC) across varied soil densities, while mechanical parameters undergo calibration using isotropic and triaxial tests on both unsaturated and saturated samples. The model's performance is analyzed through the back-calculation of two experimental studies: (i) wetting under different vertical stresses for Lower Cromer Till and (ii) isotropic loading and triaxial loading for undisturbed loess. The results confirm that the proposed model is able to predict the hydro-mechanical behavior of unsaturated soils.

Keywords : hypoplastic model, volumetric collapse, normal consolidation line, compression index (λ), degree of saturation, soil suction

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