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A Bounding Surface Viscoplastic Model for Rate-Dependent Behavior of Soils Including Primary and Tertiary Creep



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Abstract

The prediction of rate-dependent behavior of geomaterials, such as creep, stress relaxation, and strain rate dependency, is of great interest in geotechnical engineering. Creep and strain rate dependency is of particular concern in the analyses of the long-term settlement of infrastructures founded on soft soils, the stability of natural and excavated soil slopes, deformation and failure analysis of earth structures subject to cyclic and dynamic loading, construction of tunnels in squeezing ground, analysis of pavement structures, design of geological nuclear waste disposal facilities, and dynamic penetration and anchor installation problems to name a few.

In this work, a rigorous viscoplastic constitutive model is presented for the rate-dependent behaviour of soils with particular reference to capturing drained and undrained behavior during primary and tertiary creep. The model is formulated in the context of the consistency viscoplastic framework and the bounding surface plasticity theory. It captures the accumulation of viscoplastic strains upon loading and unloading as well as creep rupture in normally and overconsolidated soils. Hardening and softening characteristics of the material are accounted for through the influence of viscoplastic volumetric strain as well as strain rate on the evolution of the bounding surface. Unlike the overstress models, the viscoplastic model meets the consistency condition and allows a smooth transition from rate-independent plasticity to rate-dependent viscoplasticity. A non-associated flow rule is defined to generalize the application of the model to a wide range of soils. The model requires minimal material parameters determined using standard laboratory testing equipment. The model is validated through the comparison of the simulation results with experimental data from the literature highlighting the capabilities of the model.

Bio data

PSM Professor and Scientia Professor Khalili has about 30 years of experience in geotechnical engineering both as a consultant and as an academic/researcher. Prior to joining The University of New South Wales in 1993, he was responsible for managing the geotechnical group in the Chicago Office of the consulting firm Dames & Moore. He is currently the President of the Australian Association for Computational Mechanics (AACM), Fellow of Institution of Engineers Australia, Fellow of Australian Geomechanics Society, and Fellow of Academy of Technological Sciences and Engineering (ATSE). His research interests lie primarily in the areas of mechanics of unsaturated soils, soil plasticity, and mechanics of multi phase multi porous media. He is the recipient of many prestigious international awards including: Chandra Desai Medal from International Association for Computer Methods and Advances in Geomechanics (IACMAG) in 2014, and Valliappan Medal from International Association for Computational Mechanics (IACM) in 2016.

