

Modeling rate sensitivity in soils with multiple viscous mechanisms

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Abstract:

Constitutive models constructed within the combined framework of kinematic hardening and bounding surface plasticity have proved to be successful in describing the rate-independent deformation of soils under non-monotonic histories of stress or strain. Most soils show some rate-dependence of their deformation characteristics, and it is important for the constitutive models to be able to reproduce rate- or time-dependent patterns of response. This talk explores a constitutive modeling approach that combines multiple viscous mechanisms contributing to the overall rate-sensitive deformation of a soil. A simple viscoplastic extension of an inviscid kinematic hardening model incorporates two viscoplastic mechanisms applying an overstress formulation to a ‘consolidation surface’ and a ‘recent stress history surface’ (Fig. 1). Depending on the current stress state and the relative ‘strength’ of the two mechanisms, the viscoplastic mechanisms may collaborate or compete with each other. This modelling approach is shown to be able to reproduce many observed patterns of rate-dependent response of soils. Complete details can be found in a manuscript under review,¹ from which this abstract is replicated. The manuscript is available upon request.

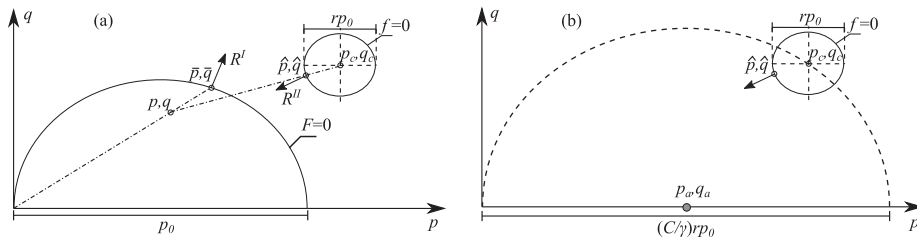


Figure 1: Schematics showing (a) the definition of the consolidation surface $F = 0$, the recent stress history (RSH) surface $f = 0$, image stresses (\bar{p} , \bar{q} , \hat{p} , and \hat{q}), and viscoplastic flow directions (R^I and R^{II}); (b) the limit surface on the kinematic hardening stress state (p_c, q_c) . Variables q and p denote deviatoric stress and mean normal stress, respectively, and r is assumed to be a material constant. The size ratio between the RSH surface and the limit surface is given by C/γ , while the stress state (p_a, q_a) gives the centre of the limit surface.

¹Shi, Z., Muir Wood, D., Huang, M., & Hambleton, J. P. (2020). *Tay creep: a multi-mechanism model for rate-dependent deformation of soils*. Manuscript submitted for publication.