ELASTOPLASTIC MODELLING OF THE MONOTONIC AND DYNAMIC BEHAVIOR OF SOILS

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EXTENDED ABSTRACT

This dissertation describes the formulation of an elastoplastic constitutive model of the monotonic and cyclic rate-independent behavior of non-cohesive soils.

The first step towards this goal was an extensive literature survey aiming at: a) codifying the experimentally measured monotonic and cyclic behavior of non-cohesive soils and formulating the general frame of effective stress - strain behavior that should be simulated, b) critically reviewing recent developments in analytical modelling and selecting the constitutive model which would act as point of departure for the analytical formulation.

Having as point of departure the model of Manzari and Dafalias (1997), the proposed formulation is a two-surface (Yield and Bounding surfaces) elastoplastic model with the following main characteristics:

a) Effective stress - strain behavior is designated according to:
   - the running value of the State Parameter ψ, defined with respect to a unique Critical or Steady State Line which is known a priori, and
   - the history of loading, defined in terms of the accumulated plastic volumetric deformation (long-term memory), and the "distance" from the point of the last load reversal (short-term memory).

b) Behavior at small and intermediate cyclic shear strains γ_c is simulated via a modified expression of the perfectly-hysteretic model of Ramberg and Osgood (1943). Specifically, the aforementioned perfectly-hysteretic model is used for explicitly defining the elastic deviatoric component of deformation, as well as indirectly estimating the elastic volumetric component via a constant Poisson ratio.

c) The magnitude of plastic deformations is partly scaled by the simulated effect of soil fabric evolution during mechanical loading. This is achieved via a homonymous scalar function, the value of which depends on the history of loading.

Evaluation of model predictions was achieved via comparison with experimental data from forty (40) monotonic and forty-one (41) cyclic laboratory tests performed on a fine-grained uniform sand, named Nevada. Wherever laboratory data were either lacking or of poor quality, empirical correlations from the literature were additionally used for comparison purposes. This procedure assessed the reliability of analytical predictions in a systematic manner. Moreover, it showed that the proposed model reliably predicts the behavior of non-cohesive soils with parameters practically independent of: a) drainage conditions (fully drained or undrained), b) loading path (triaxial loading or direct simple shear), c) initial effective stresses and void ratio, and d) cyclic shear strain amplitude. Out of fifteen (15) model parameters that practically require calibration, only two (2) have different values for monotonic and cyclic loading. This is due to the large difference in the order of magnitude of deformations between monotonic and cyclic loading.

Furthermore, specific directions for future research are provided, aiming at improving the proposed model and at generalizing the existing analytical framework for predicting behavior of uncemented cohesive soils as well. Finally, the need for implementing the proposed model in available boundary problem solving codes is underlined.