A CYCLIC FUZZY-SET PLASTICITY CONSTITUTIVE MODEL FOR GRANULAR SOILS

Yu Bao and Stein Sture

Civil, Environmental & Architectural Engineering Department
UCB 428
University of Colorado at Boulder
Boulder, Colorado 80309, USA
Yu.Bao@Colorado.edu

Soils can undergo very large shear deformations, and thus can be regarded as plastic in the conventional sense. It is well known that the mechanical behavior of granular soils is sensitive to effective confinement pressure and void ratio. Strong ground motion induces a tendency for volume change and the soil-skeleton dilatancy is of great importance to cause a progressive pore water pressure build-up as well as cyclic pore pressure variations depending on the drainage condition and soil permeability. These characteristics should be considered to make accurate prediction of sand behavior under cyclic loading. Rational analysis of the development of earthquake – induced pore pressures requires a fundamental description of the soil's constitutive relations. Therefore, the ability of the constitutive model to predict permanent volume changes during cyclic loading becomes a major factor in seismic analysis. Many constitutive models have been developed to incorporate pressure dependency and shear induced dilatancy. However, most of the models have complicated formulations.

Fuzzy-set plasticity theory was first proposed by Klisinski et al. (1987) [1]. In this paper, we develop an enhanced kinematic and cyclic plasticity model based on the concept of Fuzzy-set plasticity to simulate realistic sand behavior during loading, unloading and reloading cycles. The enhanced model is not only be able to capture the general nonlinear behavior of soil, but also the essential soil characteristics, such as confinement dependency, contraction and dilation, critical state soil mechanical features, pore pressure build-up and so forth. Moreover, the formulation of the proposed model is relatively simple and it can readily be implemented into a finite element code. This paper begins with the general description of the fuzzy-set model, and then it concentrates on model capabilities under cyclic loading conditions and gives three examples showing the model responses.

References

[1] Klisinski, M., Alawi, M.M, Sture, S., Ko, H.-Y., and Muir Wood, D. (1987). "Elasto-plastic model for sand based on fuzzy sets." *International Workshop on Constitutive Equations for Granular Non-Cohesive Soils*, Case Western Reserve University.

Key words: fuzzy-set, cyclic, plasiticity