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A GEOMETRIC APPROACH FOR GENERALIZATION OF CONSTITUTIVE MODELS FOR GEOMATERIALS FROM 2D TO 3D

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ABSTRACT

Constitutive models for geomaterials are typically developed in the form of two dimensional stress and strain states, that is, axi-symmetrical stress and strain conditions. Two dimensional models are relatively simple, and experimental data available for formulating and validating models are readily available from conventional triaxial tests. At the current level of development, laboratory testing of a material in a more general stress and strain space is severely limited. The quality of the tests is not as reliable as that of the two dimensional tests, and these data are more often than not appropriate for qualitative measure of the pattern of soil behaviour in the general stress space (Wroth, 1984; Arthur,1988). However, in geotechnical engineering practice soil states such as those in slope stability, tunnelling and excavation are usually in general three dimensional states, frequently involving shear stresses. It has been widely reported that both the stiffness and the peak strength of geomaterials are influenced by the intermediate stress. Indeed, the application of a two dimensional model for numerical analysis of geotechnical problems may lead to significant divergence from the “true” performance or even wrong answers (Potts and Zdravkovic, 1999).

To provide reliable simulations of geotechnical boundary value problems, a two dimensional model necessarily needs to progresses into a general three dimensional model. In this paper, a study of the generalization of an existing constitutive model for geomaterial is made. Existing methods for model generalization are investigated and their advantages and deficiencies are discussed. A new general method for extending an existing constitutive model is proposed. The idea for the proposed method is to define a general shear stress ratio based on the closeness of the stress state to its corresponding critical state of deformation, because the critical state surface of geomaterials in the principal stress space can be relatively reliably measured. Consequently, two dimensional constitutive relations and models can be extended straightforward by substituting the two dimensional mean effective stress and shear stress ratio in the original equations by the general mean effective stress and the proposed general shear stress ratio.

Based on the proposed method, an existing two dimensional model can be generalized

simply with the selection of an appropriate critical state surface. To demonstrate the working of the proposed method, the Modified Cam Clay model is extended with Matsuoka-Nakai criterion as the critical state surface. Simulations of soil behaviour for loading in the principal stress space are presented. Some comparisons are also made between the performance of the proposed method and that of some existing methods.

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