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The Effect of Using Hyper-Elastic Theories to Improve the Prediction of SANICLAY Constitutive Model

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Abstract

Most of constitutive models which today are used to predict soft clays behavior are not capable to accurately predict the mechanical behavior of highly over-consolidated clays. A reason behind this deficiency may be attributed to the use of hypo-elastic theories in order to simplify the elastic response of clays. In practice, this phenomenon may lead to unsafe design of infrastructures. In this paper, predictions obtained by a recently proposed clay model are compared with the experimental data and its limitations are discussed. Then it is shown that modifying this constitutive model according to the various hyper-elasticity theories improves the predictive capacity of the model.

Keywords: Constitutive Model, Soft Clays, Over-consolidation, Elastic Behavior, SANICLAY.

1. INTRODUCTION

The increasing interest in using soft clay constitutive models has led to development of reliable constitutive models in order to simulate the mechanical behavior of these soils [1]. Modified Cam-Clay model (MCC) has a capacity to simulate soft soils behavior compared to the current models. Proposed based on the plasticity theory, MCC has been extensively used in designing of geotechnical structures on soft soils. However, the model overestimates the shear stress of over-consolidated clays in small strains, which can lead to unsafe design of infrastructures. Recently used as an appropriate alternative to MCC model, SANICLAY [1, 2] presents more realistic predictions than MCC. Nevertheless, this model still over predicts shear stress of highly over-consolidated samples.

Figure 1 compares the experimental data and the simulations of the MCC and the SANICALY models, in terms of effective stress paths for undrained triaxial compression and extension tests on hydrostatically consolidated samples of Lower Cromer Till (LCT) under OCR = 1, 1.5, 2, 4, 10 and 20. It can be seen from Figure 1 that the predictions obtained from the SANICLAY in comparison with MCC are favorable. However, the simulated stress paths in both models are over predicted. Also, for over-consolidated samples, the simulated undrained stress paths retain a constant value of mean effective stress initially, which corresponds to a purely elastic stress-strain response. In this paper after introducing SANICLAY model and various elasticity theories, this model is modified based on hyper-elasticity theories in such a way that can predict soft clays behavior more accurately, especially for highly over-consolidated samples.

2. GENERAL FORMULATION OF ELASTO-PLASTIC CONSTITUTIVE MODEL

Each strain increment component is decomposed into elastic and plastic parts:

$$\dot{\varepsilon}_v=\dot{\varepsilon}_v^e+\dot{\varepsilon}_v^p \quad ; \quad \dot{\varepsilon}_q=\dot{\varepsilon}_q^e+\dot{\varepsilon}_q^p \qquad (1)$$

where, "ε_v" and "ε_q" are respectively the volumetric and shear strains measured in triaxial space. Superscripts "e" and "p" indicate the elastic and plastic parts of strain rate.

When the stress condition is within the yield surface, soil behavior is purely elastic and elastic strains are determined based on elasticity theories. In the next section, elasticity theories used in this study are presented and discussed.