Implementation of an Isotropic Elastic-Viscoplastic Model for Soft Soils Using COMSOL Multiphysics

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Abstract

Long-term settlement in clay constitutes an engineering challenge in road design and construction in areas with deep deposits of soft clay. Soil improvement and construction of building foundations or embankments can be quite complicated and expensive in such areas. Construction costs need to be balanced against high maintenance costs. In order to do this optimally, there is a need to predict long-term settlement with a high degree of accuracy. To be able to predict long-term settlements of building foundations or embankments constructed on soft soils it is needed to include the effect of creep. In this paper an elastic-viscoplastic (creep) model is implemented in COMSOL Multiphysics 4.2a and 4.3 and is validated against commonly performed laboratory tests such as Constant Rate of Strain tests (CRS) and Consolidated Undrained triaxial tests (CU). It is also benchmarked against another commercial finite element software package with a very similar material model. The implementation in COMSOL is conducted by using a fully coupled analysis between the Solid Mechanics interface and Darcy´s Law interface. In version 4.2a a distributed ODE node is used to simulate the creep contribution. It could be seen that the implemented model in COMSOL can capture the laboratory tests in a satisfactory way for CRS tests with a volumetric strain less than 10-15% and for the active CU tests. But for the passive CU tests the result is, as expected, not so well. This due to the isotropic formulation. The benchmark between the implemented creep model in COMSOL and the other commercial finite element software, Plaxis BV, with a material model called Soft Soil Creep (SSC), see Brinkgreve et al. (2011), gives very similar results (see Figure 1). This is anticipated as the formulation are more or less the same. The conclusion of the implementation is that the material model works as anticipated and could capture the active shear strength i.e. active CU triaxial tests relatively good. For the CRS tests the material model could capture the first 10-15% of the volumetric strain which is in most cases the relevant strain area. Further development of the model could be to incorporate an anisotropic surface of the cap to be able to capture the natural state of soft soils since they are often anisotropic. This would imply that the passive shear strength, i.e. passive CU triaxial test, would be more accurately modeled. This would probably increase the performance of the creep model significantly.

Reference

1. Brinkgreve, R. B. J., Swolfs, W. M. & Engin, E. 2011. PLAXIS Manual 2D 2010. Netherlands.