CONSTITUTIVE MODEL UPDATE USING OBSERVED FIELD BEHAVIOR

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The successful use of finite element analysis in geotechnical engineering is highly dependent on the constitutive model chosen to represent soil behavior. Typical complex soil behavior that the constitutive law has to model includes small strain non-linearity, and stress-strain strength anisotropy. A common approach to numerical simulation in geomechanics consists of the following steps: (a) characterize soil behavior from a limited number of laboratory and field tests, (b) calibrate or develop a constitutive model to capture measured soil response at the element level, (c) use the constitutive model in a numerical simulation of a geotechnical boundary value problem of interest such as that of an embankment or a braced excavation. In many cases this approach to the solution of boundary value problems is not successful in capturing measured field behavior due various factors including the lack of sufficient knowledge of soil behavior under complex shearing modes experienced in the field. This represents an inherent limitation to our ability to simulate soil response in the field.

In this paper a new method for simulation of geotechnical problems is presented that uses field measurements to update and enhance the material constitutive model. This direct field calibration method uses the autoprogressive algorithm in conjunction with a neural network (NN) material model to extract material behavior from field observations [1]. NN constitutive laws define the material behavior through learning from available material stress-strain data. Therefore, the NN constitutive response is reliable for states similar or within the range of available training data. A NN material model does not possess the generalization characteristics of a conventional constitutive model that uses a set of hypothesis to define the stress-strain relationship throughout the stress-strain space. However an important advantage of a NN material model is its flexible learning capability. The NN model is not limited by pre-defined stress-strain relationships. This approach allows the numerical model to truly learn as new data are obtained. A rich data set of material stress-strain response has to be available in order for the model to generalize material response. The field measurements in conjunction with dual force and displacement controlled finite element analyses are used to extract a rich stress-strain data set needed for training NN based material model of the soil. The soil constitutive model simulation capability is enhanced using additional field measurements. The algorithm is applied to the problem of estimating ground deformations due to construction of a braced excavation. The NN based soil constitutive model learns the soil behavior using measured lateral deformations and settlements around a deep excavation. The proposed methodology represents a major departure from conventional approaches for development and calibration of numerical models. The methodology provides a rational and systematic procedure for incorporating field observations into numerical models.

References

[1]. Hashash, Y.M.A., et al., *Systematic update of a deep excavation model using field performance data.* Computers and Geotechnics, 2002. Submitted for review.