Constitutive Modeling of Soil Particle Breakage during Cyclic Shearing of Soil-Structure Interfaces

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The cyclic behavior of soil-structure interface can be very important in dynamic soil-structure interaction problems. Under cyclic loading, the nonlinear behavior of soil-structure interface is very complicated, including cyclic hysteresis, cyclic hardening, normal contraction, and even particle breakage [1]. The breakage of soil particles during cyclic shearing of soil-structure interface can affect the dynamic behavior of soil-structure system considerably, and the proper description of such property as well as the other nonlinear behaviors of soil-structure interfaces is very important in the numerical simulation of dynamic soil-structure interaction problems.

The concept of critical state soil mechanics (CSSM) was already used to simulate the monotonic nonlinear behavior of soil-structure interface [2]. In the proposed model, the concept is extended and modified to describe the cyclic behavior, especially the soil particle breakage during cyclic shear shearing. The experimental observation in [1] that relates the soil particle breakage with energy consumption during cyclic shearing is used. The critical state line of the soil-structure interface is assumed to translate with the consumption of shearing energy during cyclic shearing after certain threshold value. The model is formulated in the framework of generalized plasticity theory [3] and is able to describe the complicated cyclic behavior of soil-structure interface, including nonlinearity, cyclic hardening, cyclic hysteresis, and normal dilation and contraction with modest number of model parameters. Most of the model parameters have straightforward physical meanings and may be calibrated using monotonic or cyclic interface testings.

The proposed model was calibrated and verified using different cyclic interface testing results. The dependency of interface behavior on stress path can be successfully described by the proposed model.

References

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