A Theory of Critical State for Granular Materials Based on Interparticle Sliding and Rolling

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Abstract

The concept of critical state has been the backbone of most constitutive models proposed for clays, and some proposed for granular materials. While there is a clear meaning of the critical state concept at a macroscopic observational level, a clear explanation of why there exists a critical state is still lacking. In this paper, representing an assembly of granular materials by an approximate microstructural model and by considering interparticle sliding and rolling that contributes to the plastic deformation, a flow rule is developed. With the aid this flow rule, and some fundamental rules supported by experimental data, the existence of the critical state is demonstrated. The analysis is then continued for developing a constitutive model in the triaxial space. The theory also considers the evolution of material anisotropy based on the distribution of contact normals. The theory is shown to simulate the behavior of granular materials not only under monotonic loading, but also under cyclic loading involving stress reversals. For example, theory can simulate the liquefaction behavior typically observed for sands under cyclic loading, especially the large pore water pressure build up during stress reversals. The numerical results are compared with experimental data and discussed. The model parameters are identified and procedure for determining them is described. Some earlier related works may be found in Anandarajah (2004a, 2004b).

References

Anandarajah, A. (2004a). Sliding and Rolling Constitutive Theory for Granular Materials. *J. Engineering Mechanics, ASCE*, 130(6):665-681.

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