Discrete element method analysis of a state-parameter based constitutive model

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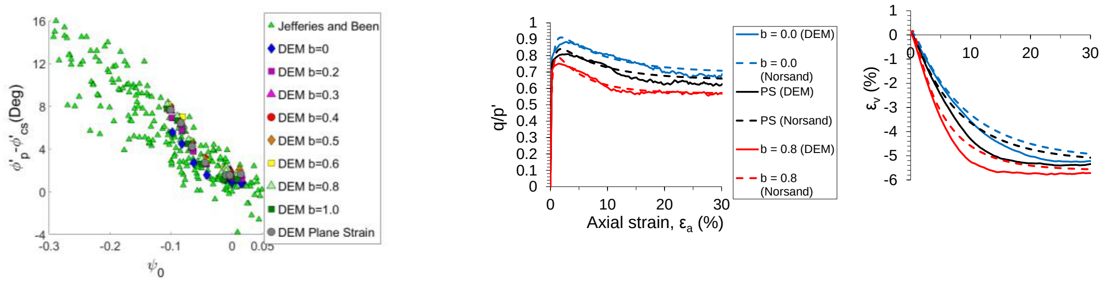
ABSTRACT

It is well established that the shear deformation response of granular materials depends on both the packing density and the stress level. One way to quantify the combined effect of these two parameters is the state parameter, ψ, that was proposed by [1]. The state parameter has formed the basis for a number of constitutive models to predict sand behaviour in continuum analysis. This contribution demonstrates that DEM simulations can quantitatively capture many of the correlations between the state parameter and features of soil strength and dilation that are experimentally documented in [2]. For example Figure 1(a) illustrates that DEM simulations of triaxial and true triaxial tests, using spherical particles, can capture the correlation between $\phi'_p - \phi'_{cs}$ and the initial state parameter (ψ_0), where ϕ'_p and ϕ'_{cs} are the peak and critical state angles of shearing resistance (friction angles), respectively.

As demonstrated in [3] particular advantage of DEM over physical experiments is that DEM simulations can achieve sufficiently large strains to attain critical state behaviour under general stress conditions. Experiments to achieve this combination of stress and deformations are very difficult. Consequently DEM can fill a gap in understanding of the performance of constitutive models by supplementing experimental triaxial and plane strain test data with true triaxial test data. The data shown in Figure 1(b) compare the performance of the Norsand continuum model and DEM simulations of plane strain and true triaxial tests. The b parameter is the intermediate principal stress ratio given by $b = (\sigma'_2 - \sigma'_3)/(\sigma'_1 - \sigma'_3)$, where σ'_1, σ'_2, and σ'_3 are the major, intermediate and minor principal stresses, respectively, p' denotes the mean effective stress, $q = \sigma'_1 - \sigma'_3$, and ε_a and ε_a are the axial and volumetric strains, respectively.



(a) Variation in $\phi'_p - \phi'_{cs}$ and ψ_0

(b) Comparison of DEM simulations with calibrated Norsand model behaviour

Figure 1: DEM analysis of state parameter based constitutive model

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