Calibration of Contact Model Parameters and Analysis of Microscopic Behaviors of Cuxhaven Sand Using The Discrete Element Method

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Abstract : The Discrete Element Method is a promising approach to modeling microscopic behaviors of granular materials. The quality of the simulations however depends on the model parameters utilized. The present study focuses on calibration and validation of the discrete element parameters for Cuxhaven sand based on the experimental data from triaxial and oedometer tests. A sensitivity analysis was conducted during the sample preparation stage and the shear stage of the triaxial tests. The influence of parameters like rolling resistance, inter-particle friction coefficient, confining pressure and effective modulus were investigated on the void ratio of the sample generated. During the shear stage, the effect of parameters like inter-particle friction coefficient, effective modulus, rolling resistance friction coefficient and normal-to-shear stiffness ratio are examined. The calibration of the parameters is carried out such that the simulations reproduce the macro mechanical characteristics like dilation angle, peak stress, and stiffness. The above-mentioned calibrated parameters are then validated by simulating an oedometer test on the sand. The oedometer test results are in good agreement with experiments, which proves the suitability of the calibrated parameters. In the next step, the calibrated and validated model parameters are applied to forecast the micromechanical behavior including the evolution of contact force chains, buckling of columns of particles, observation of non-coaxiality, and sample inhomogeneity during a simple shear test. The evolution of contact force chains vividly shows the distribution, and alignment of strong contact forces. The changes in coordination number are in good agreement with the volumetric strain exhibited during the simple shear test. The vertical inhomogeneity of void ratios is documented throughout the shearing phase, which shows looser structures in the top and bottom layers. Buckling of columns is not observed due to the small rolling resistance coefficient adopted for simulations. The non-coaxiality of principal stress and strain rate is also well captured. Thus the micromechanical behaviors are well described using the calibrated and validated material parameters.

Keywords : discrete element model, parameter calibration, triaxial test, oedometer test, simple shear test
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