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Numerical simulation of Pile Penetration into Granular Materials Using the Discrete Element Method

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The pile-ground interaction is one of the engineering interests that involves the ground movement. Driving precast pile and steel pipe pile drives the soil material away without boring any holes when they are installed in the ground. The ground movement in pile installations induces the increase of ground density and stress. The advantages and disadvantages of the ground change in pile penetration are discussed quantitatively but qualitatively so far. When the numerical methods are applied to pile penetration into granular materials such as soil, it is quite difficult for the methods based on the continua theory because the discretized elements go under intensive large deformation that induces the mesh-tangling. Therefore, Discrete Element Method (DEM) is one of the engineers options used for pile penetration simulation. In this study, in order to understand the ground behavior in pile penetration, DEM is applied , and the numerical simulations are compared with experimental results of vertical penetration of piles into aluminum bar laminated ground. In the experiment, a model ground was constructed using aluminum bars, simulating the granular materials, and a steel solid pile was set above the model ground. The pile was installed into the model ground with constant velocity. The experiment was conducted to obtain the load-displacement relationship. The experimental results were analyzed by Particle Image Velocimetry (PIV) to obtain the ground displacement , and the maximum shear strain were calculated. In the numerical analysis, the experimental results were simulated, and the particle displacements and maximum shear strains were obtained and compared with the experimental results. The results of the numerical analysis using the discrete element method shows that the penetration resistances, displacements, and deformation regions give close agreement to the experimental results. Physical quantities that could not be obtained experimentally, such as angular velocity of the particles and mean stress, were also calculated in the simulation. The distribution region of the maximum shear strain in experiments coincided with the angular velocity distribution region of the particles. Therefore, the rotational motion of the particles is related to the formation of the shear zone.

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