Large-scale DEM simulation of plate drag in dry granular materials

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Plate drag in granular materials is a simple system but important from an engineering perspective because it provides an understanding of the drag force exerted on machineries used in agriculture, construction and mining that interact with soil. However, it is difficult to observe experimentally a failure behavior in the materials during the drag. On the other hand, the analysis using numerical simulations is useful to understand the phenomena. In this study, we simulated plate drag in dry granular materials using a large-scale DEM (Discrete element method) simulation and analyzed the relationship between the drag force acting on the plate and the evolution of a shear band (failure surface) that is formed in the materials. As the first step in the study, the effect of initial packing volume fraction of the materials on the drag force was examined for the drag of a vertical plate. The results showed that at lower initial fraction, the force reached an approximately constant value as the plate advanced, while at higher initial fraction, the force oscillated with a large amplitude. In addition, the force averaged over a steady state increased approximately linearly with the volume fraction. The observed force behavior was consistent with that obtained experimentally in previous studies. The analysis of local volume fraction in the materials during the drag showed that at the higher initial fraction, a clear shear band, reaching from the plate tip to the free surface, was observed but not at the lower initial fraction. The force oscillation at the higher initial fraction were attributed to the periodic evolution of the shear bands. In the presentation, we will also report the effects of rake angle of the plate on the drag force and the evolution of the shear band.

Keywords: granular materials, plate drag, discrete element method, packing volume fraction, drag force

