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Grain shape dependence of the convective structure in a vertically vibrate granular bed

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Miyamoto et al. reported that the migrations and sorting of regolith could result from gravel fluidization induced by vibration caused by an impact on surface of asteroid Itokawa [1]. In order to understand the detailed mechanism of such phenomena, fundamental physics of vibrated granular matter must be revealed. When granular materials such as regolith are shaken, we can see various phenomena, e.g. convection, segregation, and so on. In this study, we study the granular convection by the experiment. Although many literatures have reported on both experimental and numerical studies of granular convection [2-5], most of them have used spherical grains as constituents. In general, geophysically relevant sand grains are not spherical. Thus, we use rough shaped sand (JIS standard sand) as well as spherical glass beads, to examine the influence of grains shape to the granular convection. In the experiment, we investigate the global structure of granular convection and measure the convective velocity.

The experimental setup consists of a cylinder made by plexiglass of 75 mm inner diameter and 150 mm height, which is mounted on an electromechanical vibration exciter (EMIC 513-B/A). The vibrator frequency f is varied from 10 to 300 Hz and the dimensionless accelerations from 2 to 6. The grains used are glass beads (0.8 mm in diameter) and JIS (Japan Industry Standard) standard sand (from 0.71 mm and 1.4 mm in diameter). The granular layer height is fixed to 50 mm. We use a high-speed camera (Photoron SA-5) with a macro lens to record the motion of grains at 1000 fps. PIV (Particle image velocimetry) method is used to obtain the convective velocities on the side wall of the container.

We find that global structure of convection shows a transition from single cycle roll state to doughnut like roll state when f increases. In the former, grains rise up on the one side wall and fall down on the other side wall. In the latter, grains rise up at the center of container and fall down on all over the wall. We also find that the measured convective velocity decreases rapidly in deep region of the bed. While this tendency is more or less similar to previous studies [2,3], the form of decreasing function is clearly different between glass beads and rough shaped sand. Moreover, the convective velocity field seems to have spatial and temporal inhomogeneities.

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