Experimental study of compaction behavior of regolith analogs due to vibration: Dependence on particle size and shape

*大村 知美[1]、中村 昭子[1]
*Tomomi Omura[1], Akiko Nakamura[1]

1. 神戸大学大学院理学研究科
1. Graduate School of Science,Kobe University

The surface of asteroids are covered by regolith. The characteristics of regolith surface, i.e. geological feature such as impact crater and groove and physical properties such as filling factor and strength reflect the evolutional pass of the body. These characteristics have been changed by vibration due to impacts. For instance, the low number of small craters on Eros and obscure craters on Itokawa have been explained by relaxation of craters by impact-induced vibration (Richardson et al., 2004; Miyamoto et al. 2007). Such fluidization due to vibration also changes the filling factor of regolith layer. The compaction or dilation behavior of granular layer is characterized by a dimensionless acceleration Γ, which is the maximum vibration intensity relative to gravity (e.g. Philippe and Bideau 2003). The vibrational acceleration required to achieve a certain Γ is very small on asteroids because of their small gravity, therefore small impacts may be sufficient to change the filling factor of regolith. However, the Γ dependence of compaction behavior was obtained by experiments using millimeter-sized particles under Earth’s gravity. In these cases, interparticle force between the particles is negligible, but the force becomes significant under the microgravity of asteroids. Moreover, a result of numerical simulation shows that the constituent particles of a rubble-pile body 1950DA, which has short rotation period needs a cohesive strength of 75-85 Pa to avoid failure (Hirabayashi and Scheeres, 2015).

In this study, we conducted tapping compaction experiments with particles smaller than 1 mm to mimic regolith particles under microgravity. We used quasi-monodisperse spherical glass beads and irregular particles as sample powder. The particles were sieved into cylindrical die with an inner diameter of 50 mm and a depth of 30 mm and tapped by free fall of the die. The vibrational acceleration applied to the sample was controlled by the falling height and measured by an accelerometer attached to the die. The maximum acceleration of the tapping was either 112±9 m/s^2 (Γ=11±1), 272±22 m/s^2 (Γ=28±2), or 685±60 m/s^2 (Γ=70±6). We obtained filling factor of the sample before and after N ($3 \leqq N \leqq 2\times10^4$) times tapping. Most of experiments were conducted at room temperature in air, but some were conducted at room temperature under ambient pressure of ~500 Pa.

Here we describe about results of spherical particles. The cohesive strength of sample particles measured in this study was 111±29 Pa, 38±20 Pa, and 62±52 Pa for 19 μm (GB19), 55 μm (GB55) and 93 μm (GB93) particles, respectively. Initial filling factor of samples were 0.47 for GB19 and 0.57 for GB55 and GB93. The filling factor of samples increased with N and finally achieved the steady state. The steady state filling factor of GB19 was much smaller than other particles due to larger cohesion of this particles. The cohesion of other particles did not affect the steady state filling factor under our experimental conditions. However, the characteristic value of Γ which determined the steady state filling factor and the characteristic compaction time increased as the particle diameter decreased to an order of magnitude greater than the case of 1 mm particles. The ambient pressure did not change the results of experiments, therefore these differences were not due to atmospheric drag.
We also investigated compaction behavior of irregular particles. In these cases, small particles, which had small initial filling factor achieved larger steady state filling factor. We will further investigate and discuss

about effects of the shape of the particles on compaction behavior.

キーワード：レゴリス、振動、固着性、充填率、圧密
Keywords: regolith, vibration, cohesion, filling factor, compaction