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MICROMECHANICAL ASPECTS OF NATURAL FORMATION PROCESS OF GEOLOGICAL GRAINS

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Summary. Geomaterials are natural materials formed by long-time geological process. Their physical and mechanical properties differ in different places, not only horizontally but also vertically, and change in time as well. Therefore, one of the big challenges in geomechanics is to develop a simulation tool for quantitatively evaluating such properties in the context of geological layer formation process. On solid planetary surfaces, geomaterials are composed of a lot of solid geological particles of various sizes and shapes. Those particles have been formed and evolved either by crushing or agglomeration process under a certain natural environment. The objective of this study is to clarify a universal features on such grain-scale processes.

We performed two types of loading experiments; one-dimensional compression (ODC) tests and rotary shear (RS) tests [1]. We used an angular mountain silica sand (Gifu sand) and a round river silica sand (Kashima sand). The major findings in ODC tests are summarized as follows: (1) The grain size distribution starts to change remarkably when the compressive stress reaches so-called 'yield stress', which is expressed by a kink point in the classical e-log p (void ratio – pressure) plot. This yield stress differs in different sand (3~ 20 MPa), which implies the different single grain crushing stress. (2) The obtained e - p relation fits better on a bi-linear model in a log e – log p plot than in the classical e-log p plot especially under high-pressure (100 to 500 MPa) region. (3) The grain size distribution converges into a fractal (power-law) distribution with the fractal dimension (power) of about 2.5, which is close to that in Apollonian sphere packing, 2.47 [2]. On the other hand, RS tests revealed that the grain crushing occurs with much smaller stress level (~ 1 MPa) than in the ODC tests. Moreover, the steady state is reached after a very large shear strain of about 500 and its grain size distribution is almost identical to that obtained in ODC tests. These can be understood by stochastic rearrangement process and heterogeneous stress distribution of granular materials in crushing process.

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