含水率を変化させた粒子層への高速度衝突クレーター形成実験
High-velocity impact cratering experiments on granular layer with various water contents

*田澤 拓[1]、荒川 政彦[1]、松榮 一真[1]
*Taku Tazawa[1], Masahiko Arakawa[1], Kazuma Matsue[1]

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

Recent study on numerical simulations of large scale impact cratering showed that complex crater such as a central-peak type crater was formed within the region where the materials composing the surface crust lost their shear strength by high shock pressure, and that this fluidized region should have a rheological property like Bingham fluid: it has a finite yield strength and behaves as Newtonian fluid beyond the yield strength. Although there are a lot of studies on the large scale complex craters by numerical simulations by using iSLAE, there is little studies to compare these simulations with laboratory experiments. Thus, the numerical results should be confirmed by the laboratory experiments to assure their numerical models. One of the most important points of the numerical model is rheological properties of the fluidized region and how it behaves during the crater formation process. Then, we try to study the crater formation process of fluidized material with various rheological properties such as yield strength and viscosity.
In this study, we used granular materials including various water contents in order to control the rheological properties of target. Glass beads with the size of 100 μm and quartz sand with the size of 100 μm were used for the target with the water contents from 0 to 24.5 wt.%, and we found that the pore space in the granular layer was completely filled with water at the content larger than 19.3 wt.%. The yield strength, Y, of the wet glass beads layer was measured by means of indentation tests and the obtained Y rapidly increased from 1kPa to 50kPa when the water content changed from 0 to 3wt.%, then it gradually increased from 50kPa to 100kPa until 17.5wt.%. Beyond the content of 17.5wt.%, the Y suddenly dropped below 5kPa until 19.5wt.%. Moreover, the relationship between the Y and the indentation speed for the wet glass beads layer with the content of 20wt.% was studied, and it was clarified that the Y of this saturated layer was proportional to the square root of indentation speed. We used this wet glass beads with various rheology for the high-velocity cratering experiments. The impact experiments were made by using a vertical type gas gun set at Kobe University, and the target box was set below a wind shield in a sample large chamber. The glass bead projectile with the size of 3mm was launched at the velocity of 170m/s, and the cratering process was observed by a high-speed digital video camera with the frame rate of 2×10^3 FPS.
The crater shape was found to change with the water content: a bowl type for 0 to 3wt.%, a pit type with fractured rim for 3wt.% to 17.5wt.%, and a pit type with deformed rim for > 17.5wt.%. The high speed camera image was used to characterize the ejecta corresponding to the crater morphology. The bowl type crater was associated with a continuous ejecta curtain, and the pit type crater with a fractured rim was associated with many fragments composed of clumps. The pit type crater with a deformed rim formed small amount of ejecta and was associated with low velocity ejecta curtain undetached from the surface. The crater diameter was found to monotonically decrease with the water contents up to 18.3wt.% irrespective of the crater morphology, but the crater depth decreased until 15wt.% and then it rapidly increased from 15wt.% to 18.3wt.% corresponding to the pit type crater with a deformed rim. Thus, the depth to the diameter ratio could be classified into 3 region depending on the crater morphology: it simply increased from 0.1 to 0.5 for a bowl type, and it was a constant of 0.5 for a pit type with a fractured

rim, and then it rapidly increased again for a pit type with a deformed rim. The crater depth could be controlled by the yield strength of the wet sand, but the crater diameter could not be controlled by the yield strength at the water content larger than 17.3wt.%. In this region, the wet sand showed non-newtonian behavior, thus this rheological property might cause the decrease of the crater diameter in this region.

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