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可視化した応力鎖の解析による粉体層における締固め現象の理解
Understanding characteristics of the granular compaction by analyzing visualized stress chain

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Granular material is defined by an ensemble of many solid grains. Although the grains composing granular material are solid, granular material sometimes behaves like fluid [1]. The rheological property of granular matter is very complex in general. Granular matter deeply relates to various phenomena occurring on the earth and planetary environments. For example, an avalanche or a liquefaction of ground caused by vibration such as earthquake relates to the complex nature of granular behavior. In this study, we focus on the granular compaction induced by vibration. Granular compaction is a peculiar phenomenon observed in various granular related behaviors, it is usually defined by the increase of the packing fraction of a granular bed.

To reveal the granular behavior, researchers have carried out various experiments. As a result, deeper understandings for the granular behaviors have been obtained. However, these understandings have not yet been perfect. In general, image analyses and data acquisition by sensors are used to investigate the granular behavior. For example, we can measure the packing fraction or the particle velocity in granular material from the former method [2]. In addition, the data such as pressure or acoustic wave on granular material can be obtained from the latter method [3]. However, we cannot completely understand the characteristics of individual particles from these macroscopic quantities. By using photoelastic discs, recent studies succeed in measuring the force applied to particle at each contact point and the stress distribution in a bulk granular material, so-called stress chain in the case of two dimension [4].

In this study, we carry out the experiment of tapping-induced granular compaction using photoelastic discs for granular material to understand granular compaction. In the experiment, we add vertical tapping to photoelastic discs piled layer in two-dimension (2D) experimental vessel. For this experiment, we use 2D experimental vessel made of acrylic plates and fill it with bidisperse photoelastic discs. To lead to the granular compaction, we tap the experimental vessel by using an electromagnetic vibrator. We systematically vary the tapping condition, the duration of tapping impulse and applied maximum acceleration. As a result, the degree of granular compaction varies depending on tapping condition. By taking and analyzing pictures of this 2D experimental vessel in the bright and dark fields at initial and tapped states, we obtain following results.

(1) Although both the packing fraction and total internal forces in the granular pile increase by the tapping, the latter saturates more quickly than the former.
(2) The applied forces on each particle become large, but the total length of the stress chain is almost constant during the granular compaction caused by tapping.
(3) The degree of granular compaction strongly depends on the applied maximum acceleration rather than the number of tapping or the duration of the tapping pulse.

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