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堆積土體坡面之崩落過程分析

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摘　　要　堆積土體坡面之落石崩落現象與顆粒物理特性息息相關。本文分別以三種粒徑之球體進行坡面破壞實驗，配合流動粒子影像法分析堆積顆粒之斜坡崩落特性，探討該非穩態運動下之定量與定性關係。破壞面與莫爾-庫倫摩擦定律中之主動壓力破壞角相近。本文進一步提出塊體滑動與表面滾動兩歷程的崩落模式，以描述不同粒徑、坡度下之坡面流動發展歷程，預測值與實驗資料相近。不同時期之崩落流速剖面具相似剖面，其無因次速度 $V/\sqrt{gd}$ 變化與粒徑(d)及渠底坡度(θ)相關。根據質量與動量守恆所推求出之深度-平均速度($\overline{U}$)與平均流深($\overline{H}$)皆顯示其變化與流動時間呈反比關係，且兩參數間彼此具有指數相依性。坡趾處的流量歷程則可量化爲：(1)塊體滑動區、(2)漸變段與(3)表面流型態三個階段。

關鍵詞：顆粒流、崩落、破壞滑動面、深度平均速度。

On the collapsing process of granular slopes

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ABSTRACT　The processes of rock avalanching and slope sliding are significantly related to the physical properties of granular material. In this study, the relaxation process of dry, dense granular slopes is experimentally investigated by employing a transparent plexiglass chute with flow imaging analysis methods. Three types of uniform spherical beads were used at different toe slopes and channel widths to explore these flow characteristics. The angles of slip surface are close to the failure angles associated with the state of active earth pressure by the Mohr-Coulomb friction law. For a given particle size (d) and an inclination angle (θ), the flowing progress can be quantified by a logarithm relationship and decreasing only with a dimensionless time parameter t^*. Velocity profiles measured at the side-wall depict linear distribution on the top and an exponential tail near the static region at the bottom. According to the conservation of mass and momentum, the measured depth-averaged velocity and flowing thickness collapse well with exponential curves.
Key Words:　granular flows, avalanches, slip surface, depth-average velocity.

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