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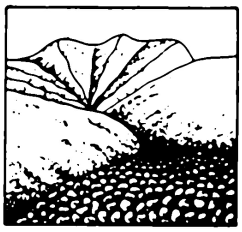
Пятигорск, Россия, 22-29 сентября 2008 г.



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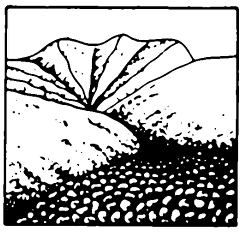

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При создании логотипа конференции использован рисунок из книги С.М. Флейшмана «Селевые потоки» (Москва: Географгиз, 1951, с. 51).
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Experimental study of landslide-induced debris flows and the mobilization process

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Экспериментальное исследование селей оползневого происхождения и процесса мобилизации материала

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В данном исследовании проанализирован процесс формирования селевых потоков оползневого происхождения путем экспериментов и теоретического анализа. Разработана специальная система наблюдения за началом движения оползневого блока. Процесс его мобилизации сосредотачивается в зоне разрушения (то есть открытого разрыва) около нижней части. Более крупная зона разрушения генерирует более быстрый процесс отрыва. Процесс начала движения занимает около 0,5–1,0 секунды после сдвига. Температура отдельных частиц заметно поднимается в зоне разжижения, которая имеет толщину примерно в 4 частицы.

The process of landslide-induced debris flows is examined by experimental work and theoretical analysis. A special synchronised observation system for the mobilisation block has been developed in this study. The mobilisation process is controlled by the failure zone (i.e. the open slit) near the bottom. A larger failure zone will generate a faster failure process. The mobilisation process initiates around 0.5–1.0 s after the movement. The granular temperature is mainly intensified in the fluidised zone, which is about 4 particles in thickness.

1 Introduction

Landslide-induced debris flows are very destructive, and their runout distance is crucial for downstream communities. Hutchinson (1986) proposed a slide model with the consideration of excess pore pressure for the landslide blocks. The decay of pore pressure is assumed to follow the diffusion process. Ashida et al. (1983) assumed the landslide block is fully fluidized when the required deformation energy of the block is provided by the basal friction. Iverson et al. (1997) examined the mobilization process of the landslide block, and a constant fluidized layer near the block/ bottom interface is assumed. The vibration and velocity fluctuation inside the thin fluidized layer greatly reduces the frictional force and enhance the mobilization process as well. Takahashi (2000) proposed the erosion rate is proportional to the velocity in the fluidized zone. Volfson et al. (2003) proposed an order parameter, ρ ($0 \le \rho \le 1$) to account for the percentage of solid contact, when the inter-particle tangential forces are less than the frictional forces. The granular material can be regarded as fluid when $\rho = 0$ or as solid when $\rho = 1$, respectively.

During its sliding process, the landslide may gradually transfer to the debris flow under favourable conditions, such as liquefaction due to increasing granular temperature in fluidized layer; the contraction induced excess pore pressure and the collision among grains. The thickness of fluidization and the mobilization process of the granular body are examined by the flume experiments.

2 Experiment

The parameters of landslide-induced debris flows are examined by experimental work and theoretical analysis. In order to eliminate the wall friction effect and to keep the CCD carrier in phase with the landslide block, a special weight is added on top of the block based on the Jassen model. Under such an condition, the pressure at the flume bottom remains constant independent of block thickness. The extra resistance required to keep CCD carrier synchronized with the block is calculated and implemented with a spring and counterweight system shown in Fig.1. A acrylic flume of 5m long, 10 cm wide and 20 cm high is installed with the inclined angles between 12°~28°. The sliding block is presented by an acrylic box (15 cm long, 8.8 cm wide and 20 cm high) infilled with uniform plastic beads (diameter = 0.59 cm, restitution coefficient e= 0.9, angle of repose = 20.5°). A slit of 0.8 cm and 1.4 cm is open at the tail wall to mimic the failure of the block, which controls the process of the block fluidization. In order to capture the fluidization process of the block, a high-speed CCD (Pulnix TMC6740GE, sampling rates up to 540fps) is mounted on a cart carrier (see Fig. 1), which movement is synchronized with the sliding block. A special design of spring – weight system is developed in this study to ensure the synchronization procedures. The captured images from the high-speed CCD are then analyzed by employing the Voronoi method. The velocity field, fluidized zone and granular temperature thus can be obtained accordingly.

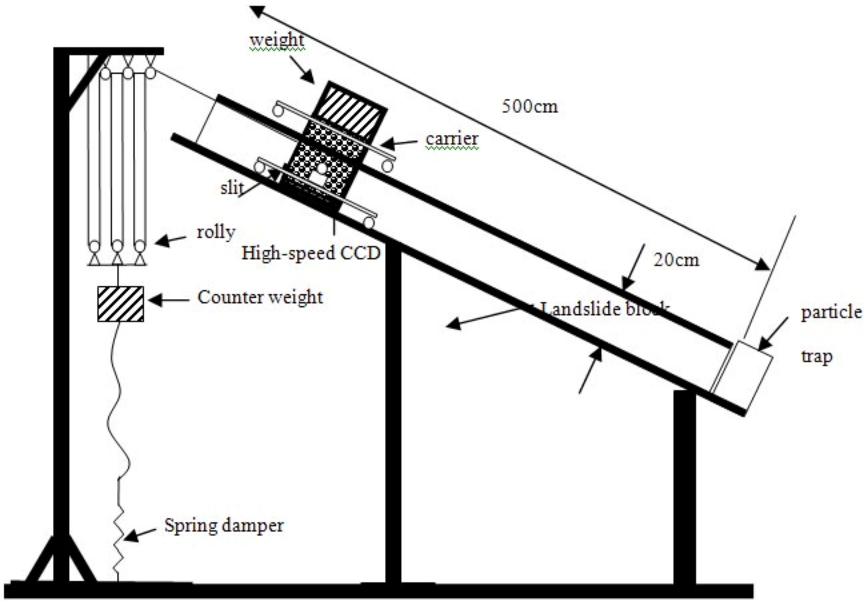

Fig. 1. Experimental setup for landslide mobilization process.

3 Results and discussion

The experimentally added resistant force agrees well with the theoretical calculation. The particle velocity histograms at different layers of the landslide block is shown in Figs. 2 and 3 for the narrow slit (opening of single layer) and normal slit (opening of two layers), respectively.

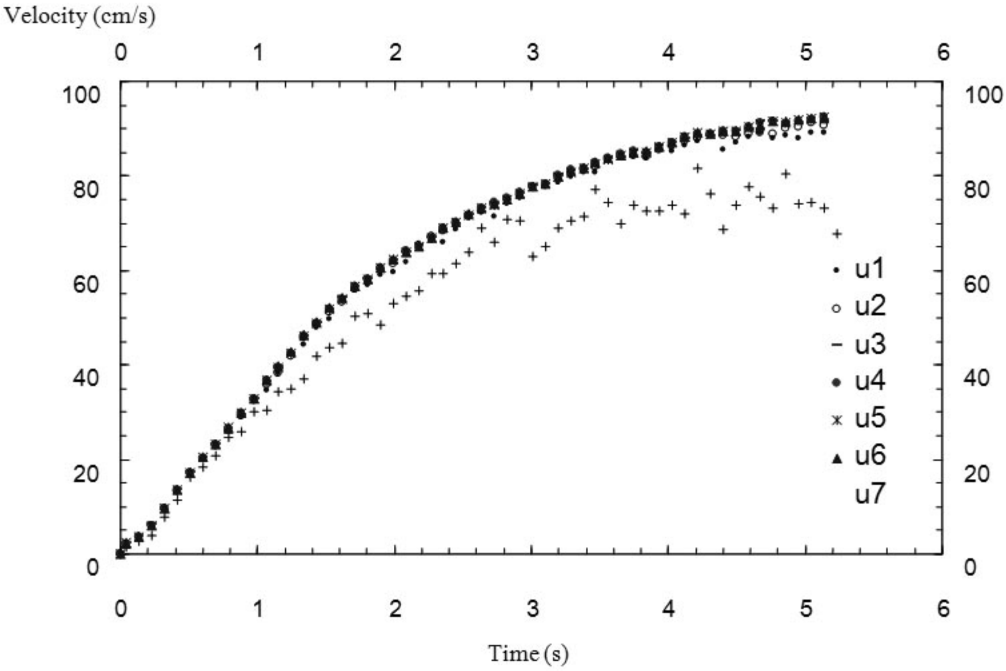

Fig. 2. Particle velocity histograms for the bottom 7 layers inside the landslide block (narrow slit).

The mobilization process initiates around 0.5–1 second after the movement as shown in Figs. 2 and 3. The thickness of fluidized zone is only about one layer from the bottom for the narrow slit, while it is about 4 layers for the normal slit. The coefficient of friction between the lower fluidized layer and the upper solid mass depends on collision condition at the interface.

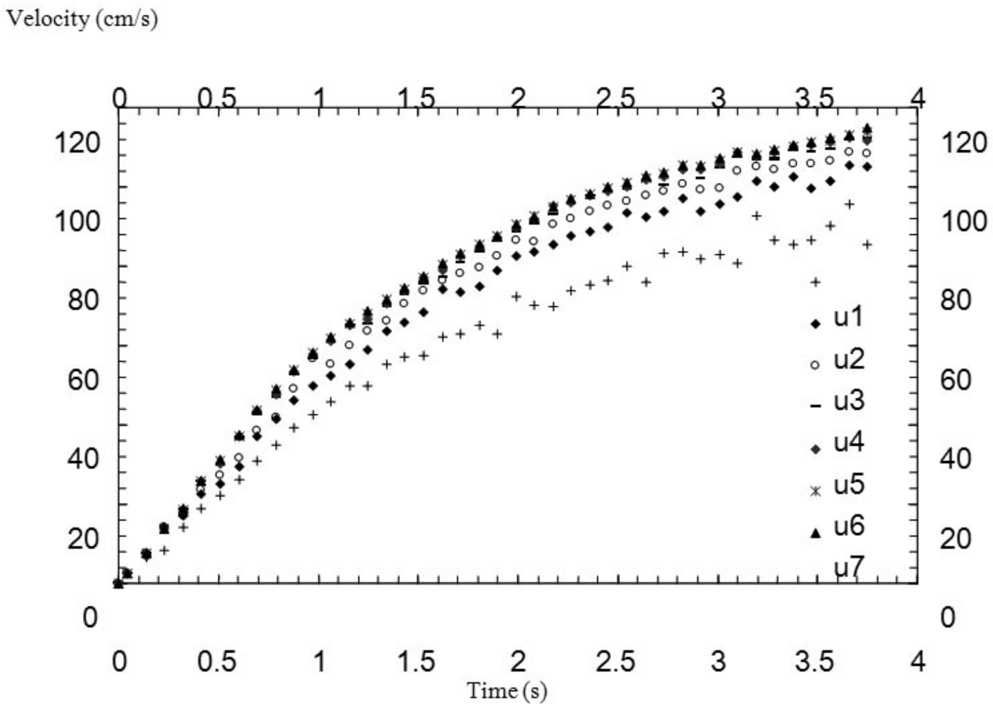

Fig. 3. Particle velocity histograms for the bottom 7 layers inside the landslide block (normal slit).

In this study, a theoretical model is also proposed to examine the run-out distance and the corresponding fluidized thickness of the sliding mass. The granular temperature is mainly intensified in the fluidized zone, which is about the thickness of 4 particles.

4 Conclusion

The process of landslide-induced debris flows are examined by flume experiment in this study. A special synchronized observation system for the mobilization block is developed to obtain the particle images. Larger failure zone near the bottom will generate faster failure process. The mobilization process initiates around 0.5–1.0 second after the movement. The granular temperature is mainly intensified in the fluidized zone with the thickness of up to 4 particles.

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