An Experimental Study on Flow Resistance of Debris Flow on Smoothly Fixed Bed

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1. Introduction

The main object of this research of debris flow is to develop an experiment which will enable one to predict the flow resistance as a function of the characteristic of debris flow. This paper describes the comparison between flow resistance of debris flow over the smoothly fixed and movable bed.

2. Experimental Method

The flume used in this study is 12 m long, 12.5 cm wide, 20 cm deep and the slope were set at 4°~18° . Figure 1 shows the experimental flume and the experimental conditions are presented in Table 1, in which d is diameter of grain; σ is density of grain; ρ is density of water; q_{wo} is water discharge and θ_0 is bed slope. The open flume section is made of acrylic board. The smooth bed used is plywood or aluminium which is placed at the downstream of the flume with 5 m length. The grains were placed upstream, 7 m in length and 11 cm in thickness and almost saturated with water. Then a certain discharge of water was supplied from the upstream end. This experimental work used two VTR cameras which are set side about 1 m of the downstream of the flume. The depth of debris flow in the flume was taken with VTR 1 and the duration of catch of the debris flow in a bucket at the downstream end was taken with VTR 2. The flux average concentration was determined as the volume of the grain divided by the volume of both the grains and water. The discharge was determined as volume of both the grains and water divided by the duration of catch.

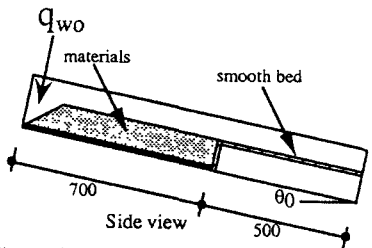

Fig. 1. Sketch of experimental flume
unit: cm

Table 1. Experimental condition

d (mm)	σ/ρ	qwo cm²/s	θ0
0.07	2.63	100	14°
0.09	2.60	100-460	4° - 18°
0.17	2.65	100	6° - 18°
0.29	2.62	100	14°
0.55	2.65	100	14°
0.80	2.64	100	8° - 14°
1.24	2.65	100	14°
1.90	2.61	100	14°
4.40	2.59	100	14° 18°

3. Experimental Results

The results of this study are summarized in Fig.2- 8. The ratio between the mean velocity, $\bar{u}$ and the shear velocity, u_* can be expressed by $\bar{u}/u_*=h/d\,F(\sigma/\rho,\theta_0)$, $\bar{u}=q_t/h$, in which h is flow depth; q_t is discharge per unit width. Figures 2(a) and (b) show that the plot of $\bar{u}/u_*$ versus h/d with all conditions and bedslopeof14°The lower value of h/d corresponds to coarser materials, whole the larger value of h/d to finer materials.

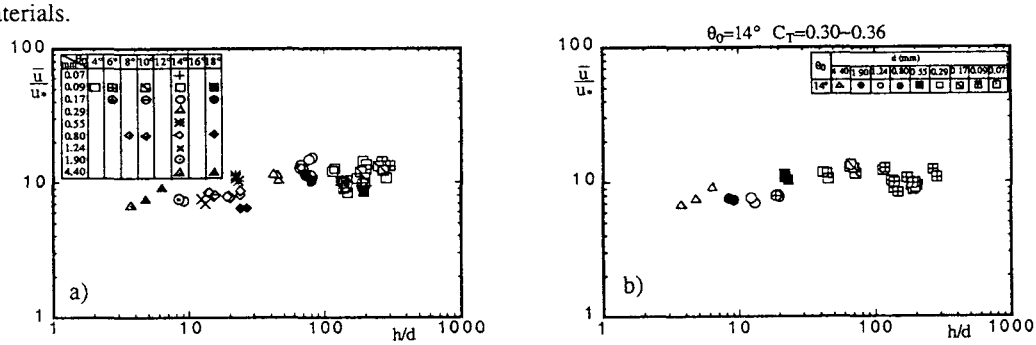

Fig. 2. Plot of $\bar{u}/u_*$ versus h/d for the fixed bed

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Therefore, it can be concluded in the Figure 2 (a) that the finer and coarser materials have a little different flow resistance and Figure 2(b) shows that the flow resistance of two kinds of materials increase with increase of h/d. Experimental results of flow resistance on movable bed [1] is shown in Figure 3. It is found that $\bar{u}/u_*$ increases with increasing h/d on the movable bed. It can be seen from the form of plotting that at the value of h/d smaller than 100 the flow resistance is different on the fixed and movable bed, and at the value of h/d greater than 100 the flow resistance are almost same. Figures 4, 5 and 6 are plots of $\bar{u}/u_*$ versus C_T for the fixed and movable bed condition. The value of $\bar{u}/u_*$ slightly decrease with increase of C_T on fixed bed with finer and coarser materials. On the other hand, the value of $\bar{u}/u_*$ sharply decrease with increase of C_T on the movable bed with coarser materials. It may be noticed from these figures, flow resistance of debris flow on fixed and movable bed with coarser have a lot of difference. The velocity of each grain was measured by using a high speed 16 mm film camera, so that velocity profiles of debris flow can be drawn as a plot of u/us and y/h for the movable and fixed bed, as seen in Figures 7 and 8. The both shapes are different. Therefore, it is found that different flow resistance between on the fixed and movable bed is the result of the difference of velocity profiles.

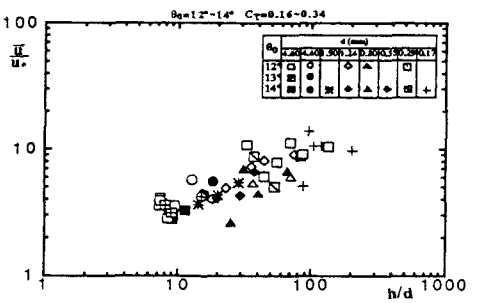

Fig. 3. Plot of $\bar{u}/u_*$ versus h/d for the movable bed

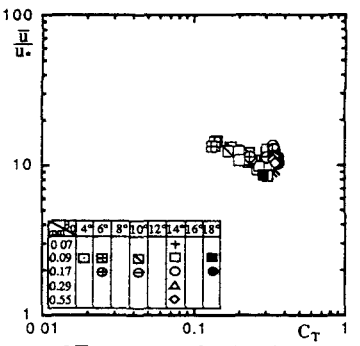

Fig.4. Plot of $\bar{u}/u_*$ versus C_T for the fixed bed with the finer materials

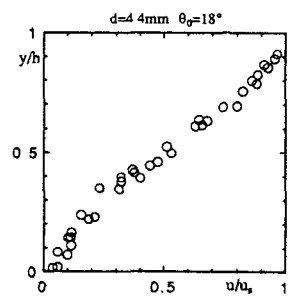

Fig.7. Velocity distribution of debris flow on the movable bed

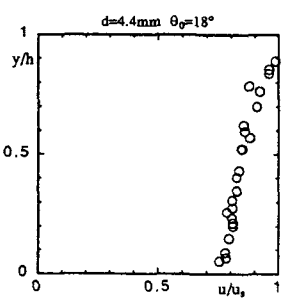

Fig.8. Velocty distribution of debris flow on the fixed bed

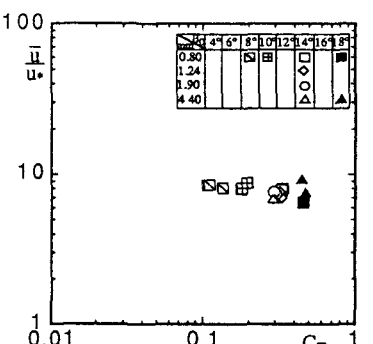

Fig.5. Plot of $\bar{u}/u_*$ versus C_T for the fixed bed with the coarser materials

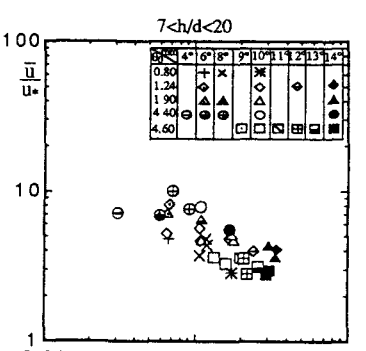

Fig. 6. Plot of $\bar{u}/u_*$ versus C_T for the movable bed with the coarser materials

4. Conclusions

The principle conclusion from these experiments are as follows:

1. The flow resistance of debris flow depends on volume concentration of sediment.
2. Diameter of material has a little influence upon flow resistance of debris flow on the smoothly fixed bed.
3. The value of $\bar{u}/u_*$ on fixed bed condition is smaller with coarser materials than with finer materials.
4. The difference in the velocity profiles of debris flow over the fixed bed and movable bed can explain the difference of flow resistance for the two conditions.

Reference

1) Hirano, Hashimoto, Tasaki, Mine, Takao, Yahiro, Proc. of 44th JSCE Annual Conference, 1989.