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Effect of the slope of flume bed to the debris potential flow

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Abstract. This article aims to determine the effect of the basic flume slope to the potential flow of debris flow. This article discusses the combination of open check dam type (beam type) placed at the top and the closed check dam type placed at the bottom with variation of the distance between the checks of dam in a flume with the size used in the experiment that is 30 cm x 32.8 cm x 1200 cm with a slope of 10°. The composition of the sediment used is type D50. The results of this study using three types of base flume slope are the greater the slope of the base flume will result in a greater debris flow on the condition without wood and on conditions with wood. The larger the slope, the greater the sediment and wood that passes from the check dam series. The smaller the base slope of the flume, the larger the timber being retained on the open check dam.

1. Introduction

Natural disasters due to sediment flow often occur in volcanic areas as well as in non-volcanic areas. Disaster flow disasters have great destructive power and are one of the most dangerous natural disasters. Natural disasters can occur as a result of environmental changes naturally. But this disaster can also result from human mistakes and omissions

Research on the behavior of debris flow and check dam as one of the methods to overcome debris flow has been done by the previous researcher. The purpose of this research is to know the influence of base flume slope on debris flow potential.

A check dam is one of the most important buildings of sediment control. Therefore, an understanding of check dam behavior as a sediment control building is essential. In addition to controlling sediment in rivers, a Check dam can serve to reduce debris flow and to stabilize the river bed by sediment material in debris flow [1-4].

The closed check dam can function effectively to control the flow of debris if the storage area is not filled with sediment [5,6].

However, this type of check dam is often less effective to withstand sediment due to limited permeability and narrow storage space. Maintaining an effective storage capacity will require dredging and excavation of riverbeds in the sediment chamber so as to decrease the technical and economic feasibility [7].

Open check dams can serve to hold the debris flow through the catch at the opening due to the large and interlocking material during the flood or debris flow. But the sediment will overflow when the flow has begun to shrink. Open check dam can be distinguished in several types, such as beam type, slit type and grid type [8-10].



The study consisted of laboratory testing and numerical simulation of a combination of 2 closed sabo and 5 to investigate the effect of sabo dams capacity in capturing the material. The results showed that the distance between the two sabo dams affected the capacity of the container [11].

The research examined the combined behavior of 2 check dams through the event of wood debris flow in 2 rivers in Japan namely S. Tsurugi and S. Hachimdani [12]. Tsurugi River has 2 check dams covered type and S. Hachimdani has 2 open check dam types. After the debris flow occurs on S. Hachimdani, wood material accumulates at the opening of the check dam so that its accumulation blocks the sediment in the downstream direction. Whereas in S. Tsurugi, the wood material does not accumulate at the check of the closed dam type but in the middle of the bend of the river.

2. Research methodology

The flume size used in the experiment is 30 cm x 32.8 cm x 1200 cm with a slope of 10°. The movable bed contains 5 meter of sediment while the fixed bed 4 m long. Sediment particles and wooden cut models are placed at the movable bed while the check dam model is placed on a fixed bed. The wood used in this study has a specific gravity of 0.5-1.05 g/cm³ made in the form of cylinders with varying diameters 2 mm, 3 mm, 4.1 mm and 5.2 mm and length respectively 5.25 cm, 7 cm, and 10 cm. The initial conditions of the woodcuts are presented in figure 1.



Figure 1. The initial condition of woodcut on a movable bed.

The size and scenario of the number of pieces of wood used in this study are presented in table 1 and table 2.

Table 1. Size of wood pieces.

Material	Specific Gravity (g/cm³)	Diameter (mm)	length (cm)
Wood A	1.04	2	7, 10
Wood B	0.86	3	7, 10
Wood C	0.68	4.1	7, 10
Wood D	0.5	5.2	5.25, 7, 10

Table 2. The scenario of the number of pieces of wood on the laboratory test.

Scenario	Diameter (mm)	Length (cm)	Number of pieces	Total number
Scenario I	2, 3, 4, 5.2	10	45	180
Scenario II	2, 3, 4, 5.2	7	45	180
Scenario III	2, 3, 4, 5.2	10, 5.25	30	150
Scenario IV	2, 3, 4, 5.2	7, 5.25	30	150
Scenario V	2, 3, 4, 5.2	10, 7, 5.25	20	180

For sediment composition and particle size, the distribution of sediment material refers to the standard as presented in table 3 and figure 2.

Table 3. Sediment material composition.

Type D ₅₀ (mm)	G1	G2	S1	S2	S3	S4	S5	S6
	15	10	4.26	2.56	1.85	0.94	0.67	0.29
Ratio	1	2	1.5	1	1	1	1	0.5

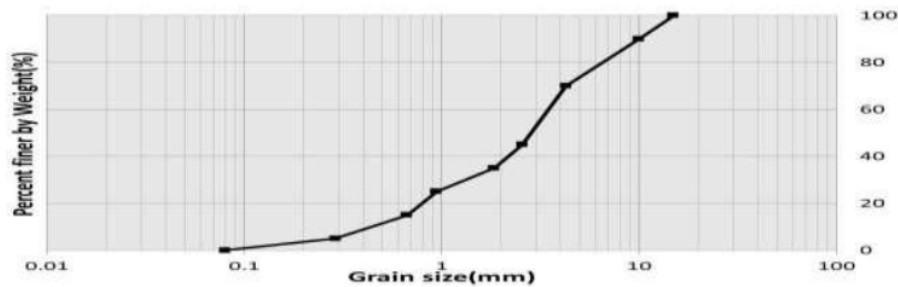


Figure 2. Particle size distribution of sediment materials.

Check dam used in this research is the type of series that is a combination of check dam type closed and check dam open type (beam type). Check the closed type with a height of 100 mm and a thickness of 10 mm as shown in figure 3 a is placed on the bottom of the flume while the beam type uses a 23 mm diameter steel pipe and the width of the opening is 35 mm as shown in figure 3 b placed at the top adjusted to the minimum distance per check check. The distance between the check dam in the study was 85 cm, 115 cm, and 145 cm based on the calculation of the effective distance between the check dam by using a slope of 10°.

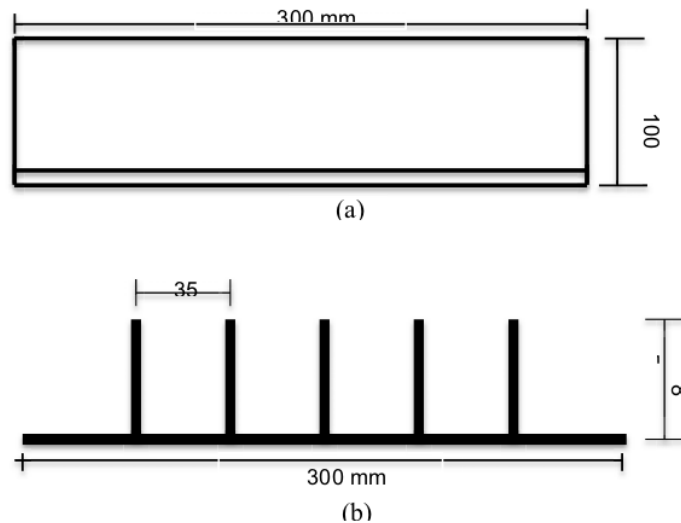


Figure 3. Check dam lab model in the laboratory.

3. Results and discussion

Before debris flow measurements and sediment concentrations on check dams need to be tested early without check dam. Testing the magnitude of the debris flow, sediment concentration, and water flow without check as shown in figure 4, figure 5 and figure 6 shows that maximum debris flow discharge and maximum sediment discharge occur in the second while the flow discharge without sediment gradually grew until normal discharge.

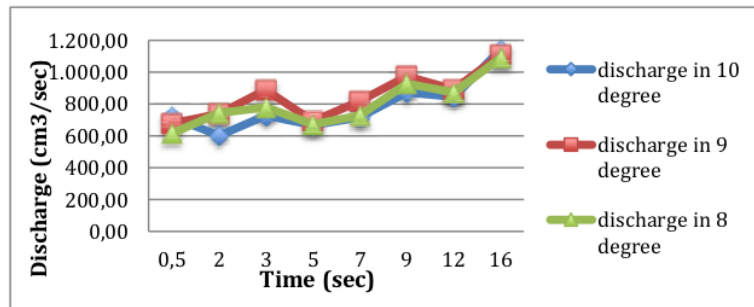


Figure 4. Water flow discharge.

In the experiment only water use, the initial discharge entering the flume of 1204.55 cm³/sec and discharge out flume of 1296.55 cm³/sec. So that there is an increased discharge of 7.64%. Maximum Debris flow discharge and maximum sediment discharges occur at the second of all the flume slopes with wood or without wood as shown in figure 5 and figure 6.

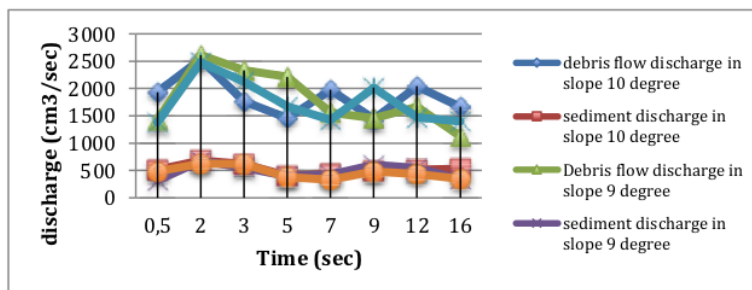


Figure 5. Debris flow discharge and sediment discharge without wood.

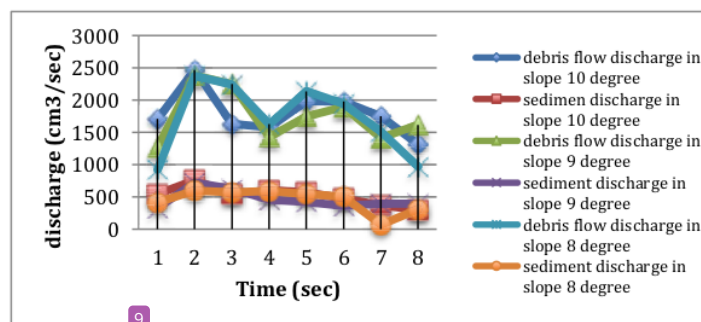


Figure 6. Debris flow discharge and sediment discharge with wood.

At the time of testing without a check dam, wood that escapes from flume is greater than 90% for all slopes. Figure 7 shows that on a slope of 80 and the movement of wood exceeds 50% in the first second.

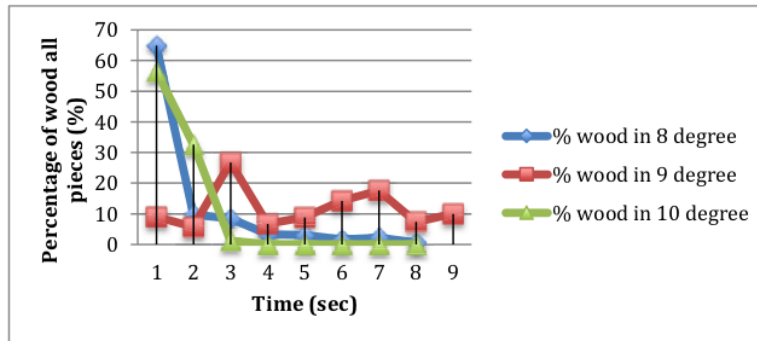


Figure 7. Percentage of wood all pieces.

In the woodless trial, the larger the base flume slope produces a larger debris flow. In experiments with wood, the larger the slope of the flume base produces an increasing debris flow. The relationship between the base slope of flume and debris flow discharge is presented in table 4.

Table 4. The relationship between the base slope of flume and debris flow discharge.

Slope (°)	Without wood (Cm ³ /sec)	With wood (Cm ³ /sec)
8°	812.743	744.338
9°	989.127	978.442
10°	1211.077	999.008

The concentration of sediment retained at the open check dam in a wooden experiment showed that sediment was much less than in wood experiments. The concentration of sediment that passes the check dam gets bigger if the flume base slope gets bigger. The concentration of sediment that is retained and passes at the check of the dam is presented in table 5.

Table 5. The sediment concentration retained and passes at check dam.

Slope (°)		Sediment concentration passes at the check dam		Sediment concentration retained at the check dam (cm ³ /sec)
		Open check dam (cm ³ /sec)	Closed check dam (cm ³ /sec)	
8°	Without wood	563.72	16.29	0.97
	With wood	433.71	46.99	1.44
9°	Without wood	247.00	557.31	3.57
	With wood	610.94	184.35	4.11
10°	Without wood	445.42	575.47	6.74
	With wood	821.27	242.68	5.74

The piece of wood that is trapped and passed on the check dam series is determined by the type of the bed flume. The larger the base slope of the channel, the smaller the number trapped in the open

check dam. As for the wood that passes from the check dam, the greater the slope of the base of the channel the greater the wood that passes. The volume of wood material that is retained and passed at the check dam is presented in table 6.

Table 6. The volume of wood material that is retained and passed at the check dam.

Slope (⁰)	Wood material passes at the check dam		Wood material retained at the check dam (%)
	Closed check dam (%)	Open check dam (%)	
8 ⁰	4.58	74.37	10.49
9 ⁰	2.84	73.05	11.28
10 ⁰	5.02	71.63	11.95

4. Conclusions

The results of this study by using three basic types of flume slope are:

- The greater the slope of the flume base will result in greater debris flow in the without wood condition and in the wood condition
- The larger the slope, the greater the sediment and wood that passes from the check dam series
- The smaller the base slope of the flume, the larger the timber held in the open check dam

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