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Flume experiments on woody debris accumulation at the bridge pier during flood

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Abstract. Woody debris accumulation at some bridges during the flood. It is found that the source of the woody debris are transported log from the mountain river during the heavy rain. The purpose of the present study is to analyze the woody debris accumulation phenomena in the flume experiments. The experiments shows that the percentage of trapped wood pieces increased with the number of the released wood pieces. The water depth profile also shows that the backwater rise are increased with the number of trapped wood pieces. Moreover, it is shows that the flood discharge have more significant backwater rise compare to the the lower discharge.

1. Introduction

During heavy rain, landslides and debris flows produced woody debris and sediment in the upstream part of the river channel. During the transportation process, the transported woody debris was trapped by the pier of some bridges, which creates blockage to trap the woody debris one another. As the result, it caused backwater rise at the upstream part of the bridges, and caused overflow to the both sides of the banks.

Some field studies has been conducted for woody debris cases. For example, Schmocker & Weitbrecht [1] investigated the flood event in Switzerland in 2005. The previous study of Rusyda et al. (2014) also investigated the flood event in Tsuwano Town, Shimane Prefecture, Japan in 2003 [2]. Some flume experiments studies also has been conducted. Braudrick & Grant (2001) discussed about the movement of the wood pieces [3]. Schmocker et al. (2013) discussed about the movement of the log with different type; single log and log with root, and its probability to be blocked by the bridge [4]. Schalko et al. (2018) also conducted the experiment with various flow condition, bed material, and initial conditions [5]. However more studies about the wood accumulation are needed. Present study is the additional study for several previous works [2].

The purpose of the present study to do further investigation on the relationship between the accumulations of the wood pieces at the bridge pier with the flood discharge based on the flume experiments.

2. Method of laboratory flume experiments

2.1. Experimental condition

2.1.1. Laboratory flume. We used flume during the experiments. The volume of the flume was 11 m length and 30.5 cm width. The installed moveable bed was 6 m length and the fixed bed was 4 m. The model bridge was set at 5 m from the basket of wood pieces.

2.1.2. Wood Pieces. In these experiments, we used three kinds of variation of the wood pieces; they were wood pieces with length 7 cm and diameter 4, 5, 6 mm.

Each of the wood pieces model parameters are shown in the table 1. The dimension of the present study are the variation of the previous works of Rusyda et al. (2014) [6]. The dimension of the wood pieces model in the previous works are 7 cm length with 2 mm diameter, moreover the dimension of the wood pieces model for the present study are variate 4, 5, and 6 mm diameter wood pieces model.

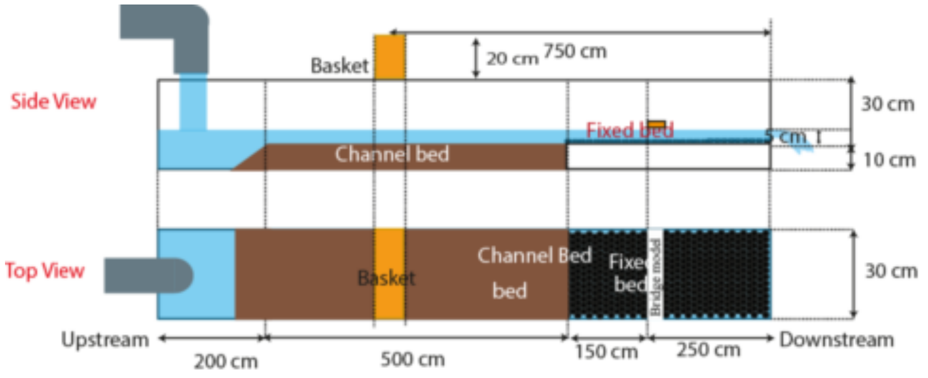

Figure 1. Laboratory flume.

Table 1. Wood Pieces and Bridge model.

Model Wood Length (cm)	Uniform Wood Pieces L_D=7 cm
Number of released wood pieces	50, 100, 150, 200,250
Diameter	D = 4, 5, 6 mm
Model Bridge	Model Bridge with 1 pier
Bridge Scale	1/120
Flume Slope	0

2.1.3. Model bridge. In the flume, model bridge was set at the station 5 m from the basket of wood pieces. The dimension of the model bridge was 30 cm length, 5.2 cm width, and 1 cm thickness (Figure 2), was similar with the scale of 1/120 to the bridge in the field (Table 1). The dimension of the model bridge are the variation of the previous works of Rusyda et al. (2014) [6]. In the present study, the pier of the model bridge are attached.

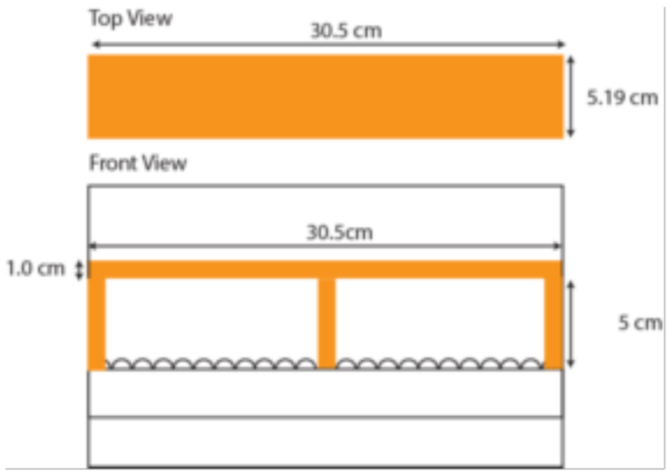

Figure 2. Model Bridge measurement.

2.2. Experimental procedure

Before the experiments, preliminary water discharge were measured. The water level on several points also measured during the water flow. After that, the water discharge were stopped, and move to another step. On the next step, the wood pieces were prepared by soaked in the basket for around 10 minutes in order to recreate the condition of deposited woody debris along the river channel. The unit weight of the wood pieces were changed due to the waterlogged condition. After that, the wood pieces are set up on the installed basket at the position 5 m from the model bridge.

After the preparation of the wood pieces were finished, the water discharge are released from the upstream of the flume channel. After the discharge are stable, some of the wood pieces will be released at the 5 m from the model bridge. As the results, some of the wood pieces are trapped in the model bridge, and it will formed wood accumulation at the upstream part of the model bridge. Besides that, some of the wood pieces were not trapped in the bridge and transported to the downstream. The wood pieces which transported to the downstream were catch and counted in order to calculate the number of wood pieces which trapped by the upstream of the model bridge.

Right after the wood pieces trapped by the model bridge, flow discharged were measured. The flow discharges were measured by using basket and weight scale.

3. Results and discussions

3.1. Wood accumulation at a model bridge

Wood accumulation occurred at the upstream part of the model bridge (Figure 3 and 4). The first contact of the wood pieces with the model bridge and the flume bed formed the wood accumulation at the model bridge. Figure 5 shows the relationship between the released wood pieces with the percentage of the trapped wood pieces. It shows that the bigger total number of the released wood pieces are more easily to be trapped at the upstream of the model bridge

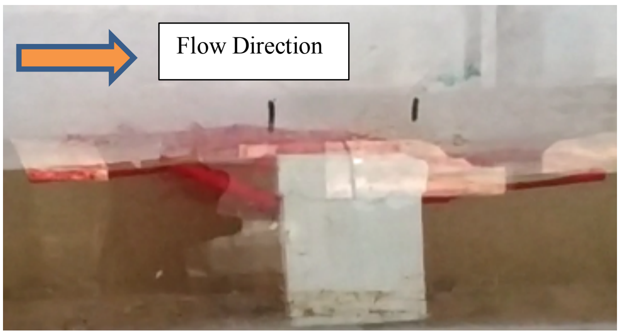

Figure 3. Side view of wood accumulation and backwater rise at the model bridge

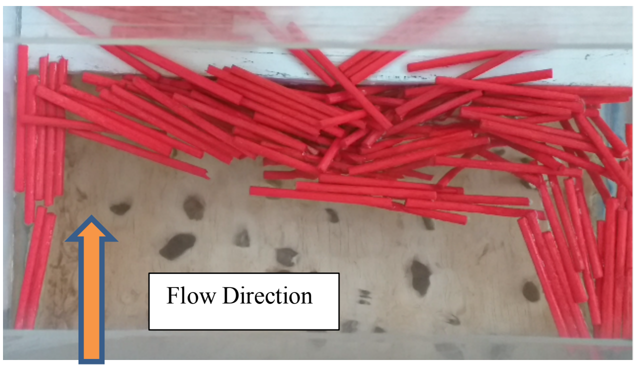

Figure 4. Top view of wood accumulation at the model bridge

3.2. Backwater rise

Figure 6 shows the measurement of water depth for both cases, with and without wood accumulation at the model bridge. In addition, the water depth profile on lower discharge shows that for the lesser differences between the water depth for both cases on lower discharge compare to the differences of both cases on flood discharge.

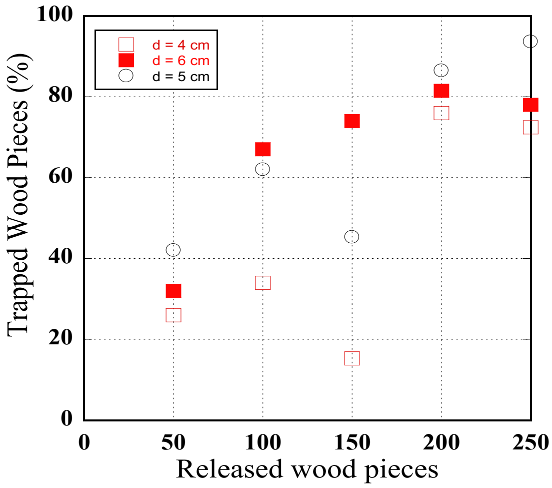

Figure 5. Relationship between released wood pieces with percentage of trapped wood pieces.

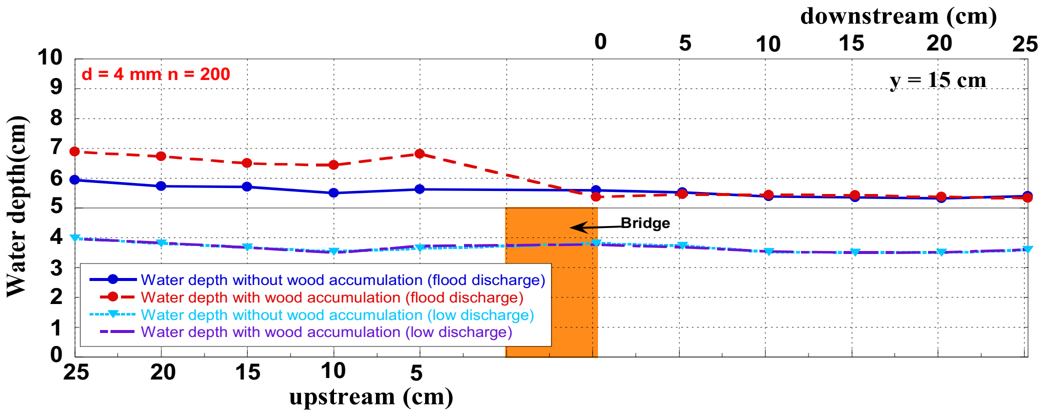

Figure 6. Water depth profiles on the flume for two water level conditions.

Figure 7 shows the relationship of the backwater rise with the volume of trapped wood pieces. It shows that the backwater rise increase with the total volume of trapped wood pieces in the model bridge. Backwater rise are calculated by the equation by Rusyda et al [6] :

$$\Delta h_{ud}^{j} = h_{u}^{j} - h_{d}^{j} \quad (1)$$

Where : h_u^j = 5 cm upstream from the model bridge during wood accumulation
h_d^j = 5 cm downstream from the model bridge during wood accumulation

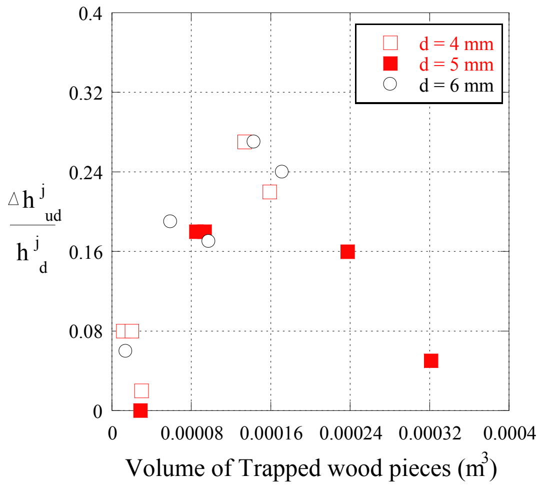

Figure 7. Relationship between the backwater rise and the volume of wood pieces trapped by model bridges.

4. Conclusions

The result obtained in this study are as follows:

1. Bigger total number of the released wood pieces are more easily to be trapped at the upstream of the model bridge.
2. Present study shows that the comparison of water depth profile for two different discharge which conclude that the backwater rise for the flood discharge are bigger than the backwater rise for the backwater rise on lower discharge.
3. Backwater rise increased with the total volume of trapped wood pieces

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