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HYDRAULIC MODEL EXPERIMENTAL STUDY ON BARK STRIPPING PROCESS USING DRIFTWOOD MODEL

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ABSTRACT: Due to heavy rain such as typhoons, landslides and slope failures are caused, and driftwood occurs along with debris flows. Since the bark of driftwood peels off during flow, elucidating the bark peeling process will lead to the estimation of the source of driftwood. It is also considered to be useful for river management. There is a study of the past that examined the situation of the detachment using the branch. However, the scale of the driftwood model had a problem. It had a small real model for a scale. In this study, a driftwood model was created using the bark of grown cedar (Cryptomeria japonica) and fixed in a waterway for peeling experiments. As a result, when fresh water and earth and sand were circulated, the bark peeling rate increased in the order of upstream side, side surface, and downstream side due to the collision of earth and sand. Furthermore, the separation rate on the riverbed side was higher than that on the water's surface side. In the case that only freshwater circulated, it was revealed that the fluid power did not influence the bark exfoliation. Observation of the progress of the exfoliation confirmed two cases, exfoliation produced by the friction with sand and lump of the bark exfoliates.

Keywords: driftwood, bark, separation, cedar (Cryptomeria japonica), circular waterway, image analysis

1. INTRODUCTION

The influence of heavy rains such as typhoons, landslides and slope failure were caused [1][2]. In late years heavy rains have increased in Japan, and a lot of such damage has occurred. It increases the outbreak of driftwood. The driftwood increases the damage of the flood. As a result, driftwood occurs with a debris flow. And damage such as bank rip, flooding, and the collapse of the house was caused downstream by driftwood flowing down (Fig. 1). The damage looks like it frequently occurs [3-5]. Damage may occur to a building or a car by driftwood (Figure 2). The driftwood flows down, and the bark exfoliates (Figure 3). It becomes clear from fieldwork about the situation of the driftwood. (Figure 4) [6].

Elucidating a bark exfoliation process may lead to an outbreak source estimate of the driftwood. It is useful for river management. The identification of the outbreak source of the current driftwood is carried out by local observation. There is an observation method of the driftwood using the satellite. However, this method cannot observe it when a tree is piled up by the observation with the satellite. The technique using the exfoliation of the driftwood solves such problems.

Many studies on driftwood were performed. Previous studies were as follows. It was gotten three main conditions for the outbreak of driftwood caused by hydraulic experiment and field survey with a debris flow [7]. In addition, the rotating cylinder elucidated the segregation phenomenon of the driftwood during a debris flow [8].

As stated above, the study of debris flow and driftwood was conducted from various viewpoints. Furthermore, it was considered using a plane circulating water channel about the bark exfoliation process of the driftwood [9-12]. However, to use a branch of the cedar (Cryptomeria japonica) as a driftwood model, there was the problem that the bark was easy to exfoliate than real driftwood thinly.

In this study, a driftwood model using the cedar's bark grew enough. An experiment in the near situation is possible practically by using the peel of a cedar that grew up. The driftwood model was locked to the channel and the bark exfoliation experiment was carried out.

2. RESEARCH SIGNIFICANCE

The driftwood which flowed down affected the house and human life. It is useful for reducing the damage to human life and the house to know the outbreak source of the driftwood. However, it is not revealed where driftwood flows at the time of a flood where.

It is thought that it is connected to an outbreak source estimate of the driftwood by clarifying the bark detachment process of the driftwood. In a past study, to make a driftwood model using the bark using the branch of the cedar.

However, the scale of the experiment had a problem. Therefore the driftwood model greatly changed the scale using the bark of the cedar.

Fig. 1 The driftwood which flowed out

Fig. 2 Damage of a building and the car

Fig. 3 The exfoliation of the driftwood

Fig. 4 Fieldwork of the driftwood

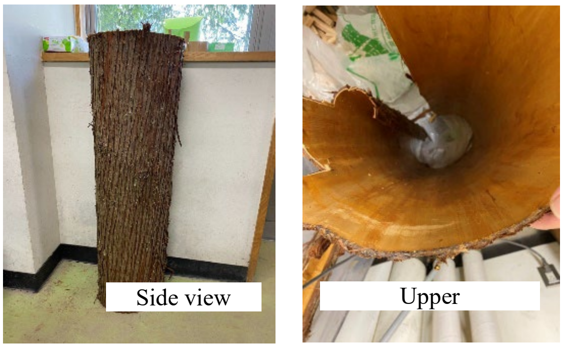
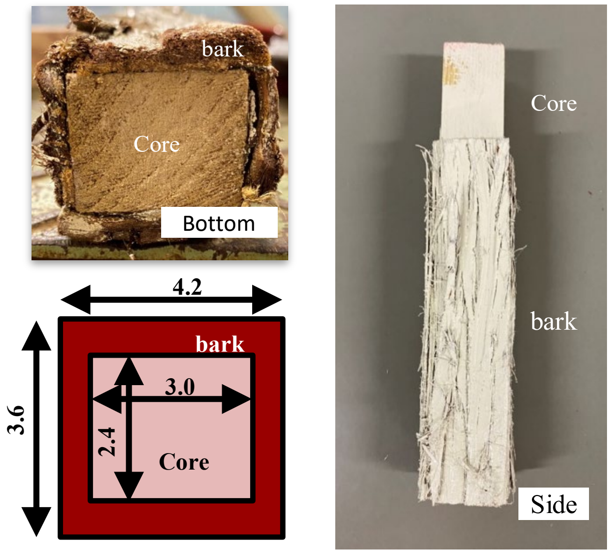


Fig. 5 The bark of the cedar
(Cryptomeria japonica)



unit : cm

Fig. 6 Driftwood model

3. DRIFTWOOD MODEL

3.1 Choice of the Tree Class

It was the flood that occurred in the Omono River of Akita in July 2017, and cedar was deposited on a bridge and farmland as driftwood [13]. A cedar was more likely to flow out in Akita, which had abundant cedar forest [14] and used the bark of the cedar was used for a driftwood model in this study. The bark of the cedar is shown in Fig. 5. The cedar was a product in Akita-City Iwami, three of 40~50 years old. It was 1m in width, 1m in height, and thickness of 6.7mm and the specific weight was 0.348 [15].

3.2 Manufacture of the Driftwood Model

The driftwood model was made using except the node. The driftwood model is shown in Fig. 6. The bark of the driftwood model was cut into a strip of paper form and made a prism. (4.2*3.6cm in width,

Fig. 7 Gravel and sediment at Babamegawa River

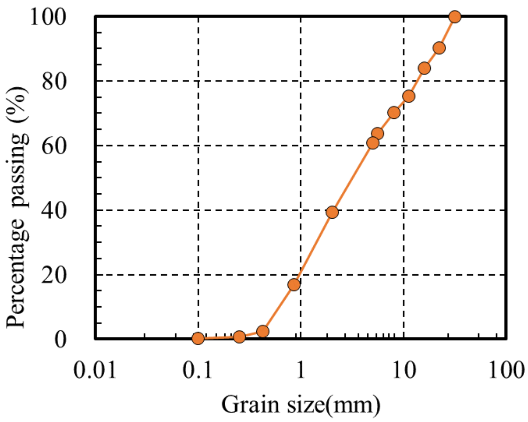


Fig. 8 Grain size accumulation curve

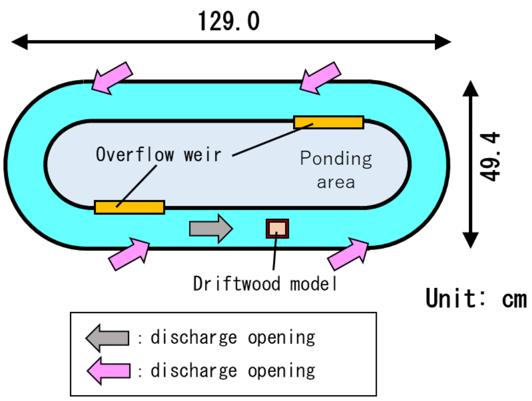


Fig. 9 Plane circulating water channel

17.0cm in height)

As a result of having carried out a preliminary experiment using the driftwood model, it was difficult to confirm the bark detachment by visual observation. Therefore spray of white was applied to the model before an experiment to make an exfoliation point clear. In addition, the model was applied thinly as possible because there might be an influence on exfoliation when the spray was too thick.

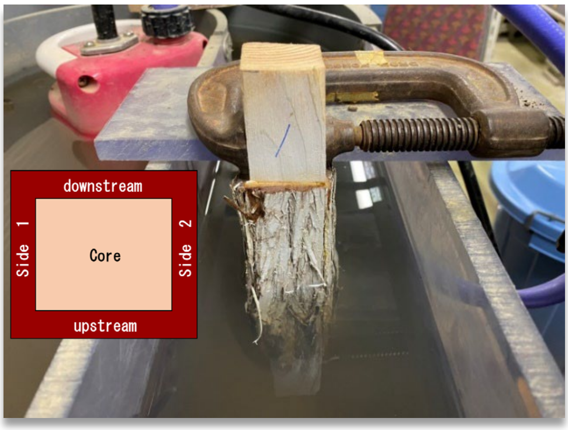


Fig. 10 The fixed situation of the driftwood model

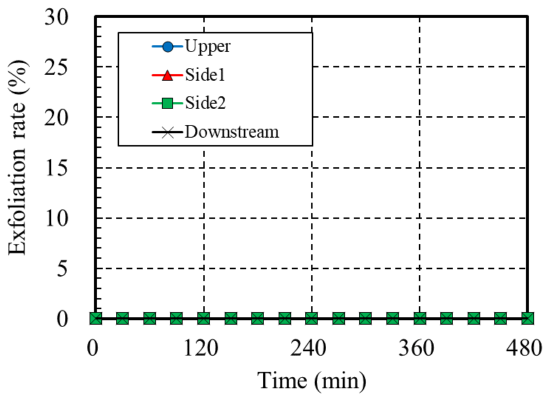


Fig. 11 Relations of experiment time and the exfoliation

4. OUTLINE OF EXPERIMENT

4.1 Condition of Sand

The sand was gathered by the Babamegawa River [16]. The image of the sand is shown in Fig. 7 and the grain size accumulation curve is shown in Fig. 8. The sand was constructed with sand and gravel. Gravel was about 60%. In addition, it was a maximum particle size of 31.5mm, uniformity coefficient was 7.60 [17-18] [19-21].

4.2 Experiment Channel

This study was performed using a plane circulating water channel [5] about the bark exfoliation process of the driftwood.

The current produces by the drainage pump, but the water level of the ponding water area decreases to continue drawing water. Therefore the overflow weir at the curve part exit of the channel was made to the ponding water area. The system was such that the water was circulated through. The pump to circulate water used three.

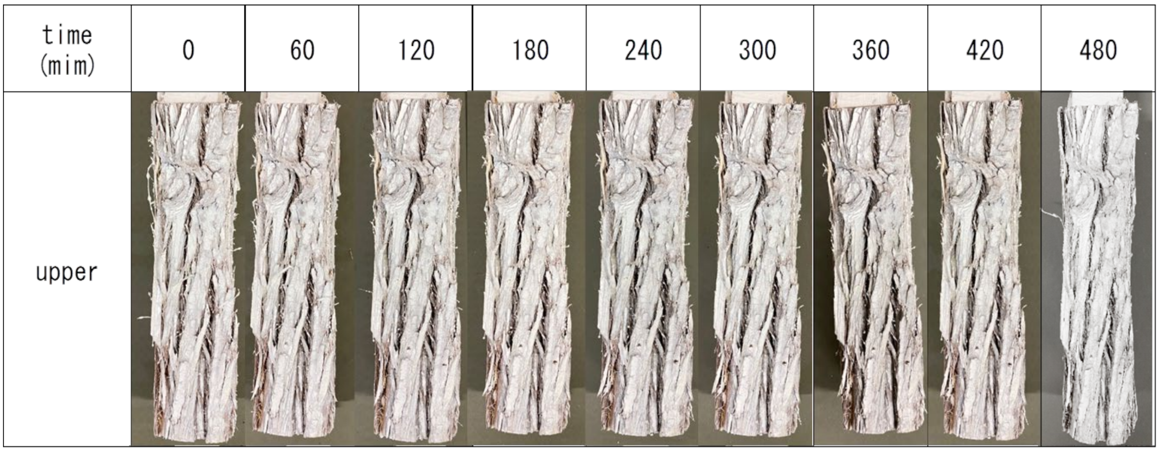


Fig. 12 The exfoliation situation of the driftwood model

4.3 Experiment Channel

The diminishing scale of the driftwood model assumed it was 1/7 from the ratio of the circumference of the bark and the length of the four sides of the driftwood models. And the speed of the plane circulation waterway is 0.91m/s and is equivalent to 2.4m/s in the conversion speed. However, as for the speed of this study, it was the value that was slightly lower than a debris flow. Because the speed of the debris flows in the actual phenomenon was 3~10 m/s [20]. The driftwood model fixed it to the plane circulating water channel (Figure 9). The setting aside of the model assumed a side of upper reaches, the downstream side, and the orthogonality direction side 1 and 2 for a current (Fig.10). The current mixed for water and sand was produced for 480 minutes. Then the image analysis of exfoliating stopped a pump every 30 minutes to be performed. The experiment performed two patterns. It was a case only for fresh water and a case of water and sand.

4.4 Image Analysis

An image of each plane of the driftwood model was taken pictures. Then the area of the exfoliation was calculated by image analysis. The exfoliation rate is calculated from Eq (1). The driftwood model was evaluated from the exfoliation rate.

$$foliation\ ratio = \left(\frac{exfoliation\ area}{driftwood\ area}\right) \times 100 \quad (1)$$

5. RESULT OF THE EXPERIMENT AND DISCUSSION

In this study, the experiment performed two patterns. It was a case only for fresh water and a case of the waters with sand. The exfoliation rate of the bark was calculated, and the exfoliation situation was observed.

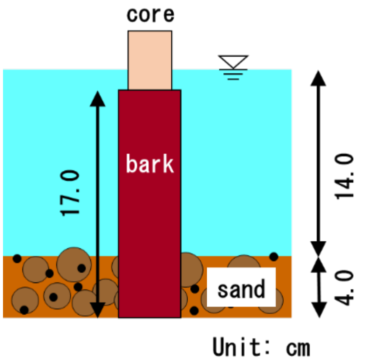


Fig. 13 Experimental condition

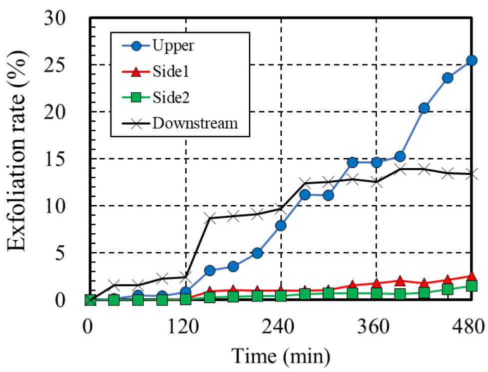


Fig. 14 Relations of experiment time and the exfoliation rate

5.1 Case Only for FreshWater

In the case that only freshwater circulated, the water level was experimented on as 18.0cm. Relations between experiment time and the exfoliation rate are shown in Fig. 11 and the exfoliation situation of the driftwood model (the upper side) is shown in Fig. 12. The exfoliation rate of upper reaches was 0.03% passed for 480 minutes and other sides were 0.00%. In addition, the change except for the exfoliation, including abrasion and breaking, was not seen when looking at the side of

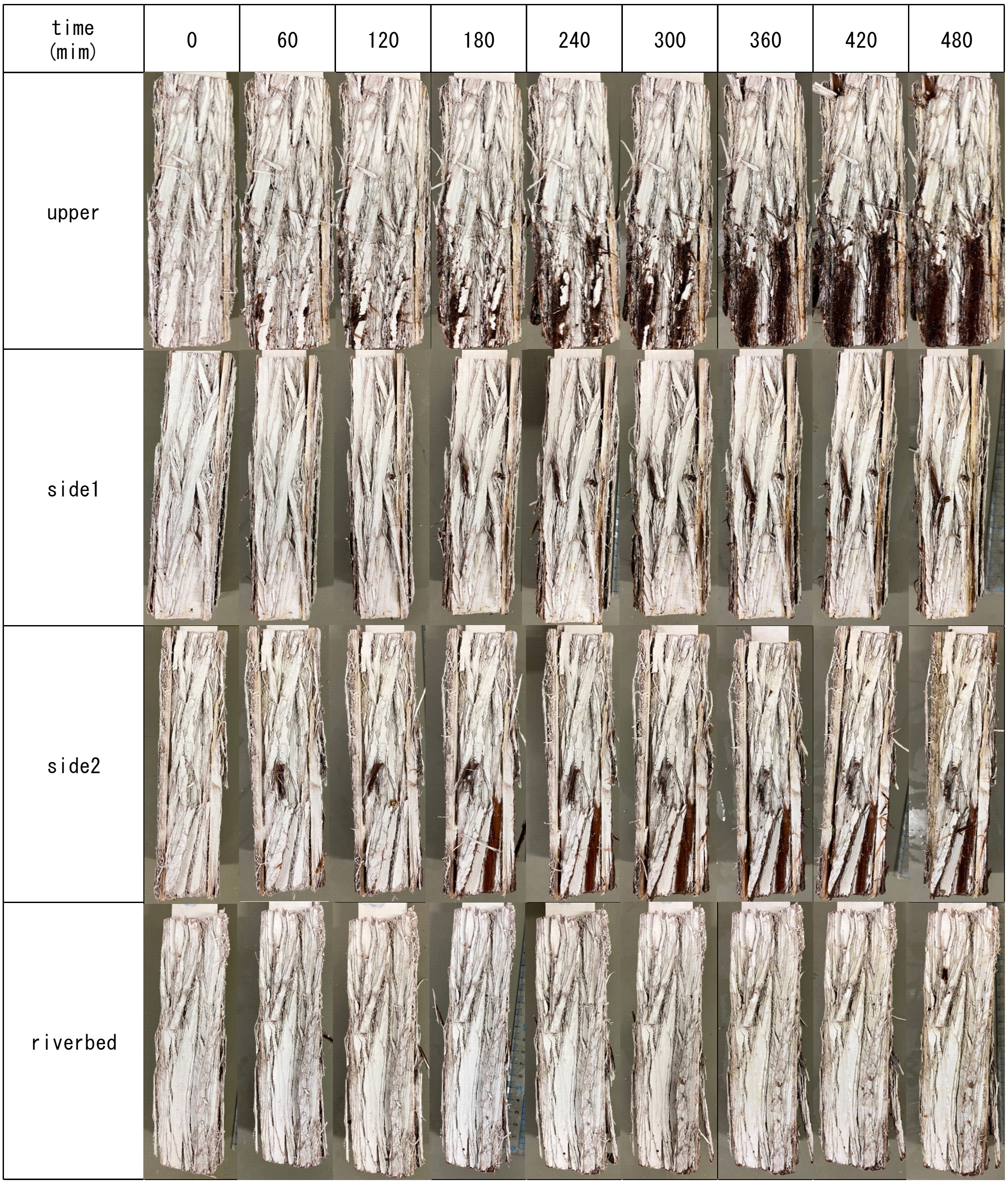


Fig. 15 The exfoliation situation of the driftwood model (fresh water and water with sand)

the driftwood model of upper reaches every 30 minutes. There was the same tendency in the other three. Therefore, it was revealed that the fluid power did not influence the bark exfoliation.

5.2 Case of the Waters with Sand

5.2.1 Influence of the installation surface

Experiment conditions in the waters with sand are shown in Fig. 13. The depth of the water was 18.0cm same as only fresh water. The sand spread layer thickness is 4.0cm in the channel. The time history of the exfoliation rate was shown in Fig. 14. Exfoliation was seen in the upper side and side 2 soon after the experiment started. As for the upper side, where the sand collided with most, it was 25.4% when the exfoliation rate was 480 minutes later. As for side 1 that drifted so that the uppers side and sand, after having collided, rubbed against the bark for 2.5%, and side 2 was 13.4%. Furthermore, as for the downstream side, which friction produced by the complicated basin, including the countercurrent [22] having been formed, it was 1.4%. It was revealed that the

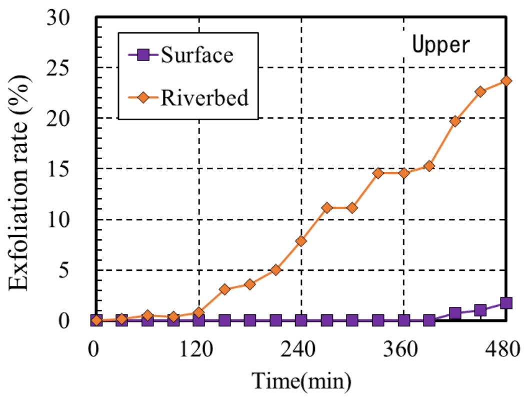


Fig. 16 The time history of the exfoliation rate (Upper)

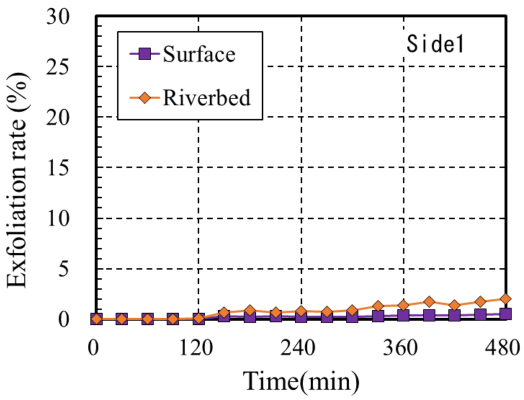


Fig. 17 The time history of exfoliation rate (side1)

influence of the sand was dominant as for the bark exfoliation of the driftwood greatly varies in detachment rate as a result of Fig. 14.

The exfoliation situation of the driftwood model is shown in Fig. 15. Bark exfoliation occurred on the upper side near a riverbed 60 minutes later, and exfoliation progressed to spread after it around the point where exfoliation occurred first. On the other hand, the increase in the exfoliation rate was seen by one piece of the bark exfoliating with side 2 120 minutes later. Sand got into the gap of the bark when observed exfoliation point in detail. Therefore the possibility that the bark exfoliation progressed was suggested by not only the outside but also the inside by the small sand of the particle size.

5.2.2 Influence of the depth direction

The calculation of the exfoliation rate was carried out with a driftwood model as a riverbed and surface side. The time history of the exfoliation rate on the upper is shown in Fig. 16. A exfoliation rate rose 390 minutes later, and the surface of the

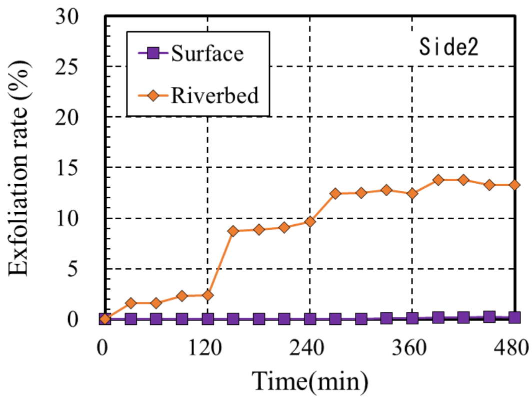


Fig. 18 The time history of exfoliation rate (side2)

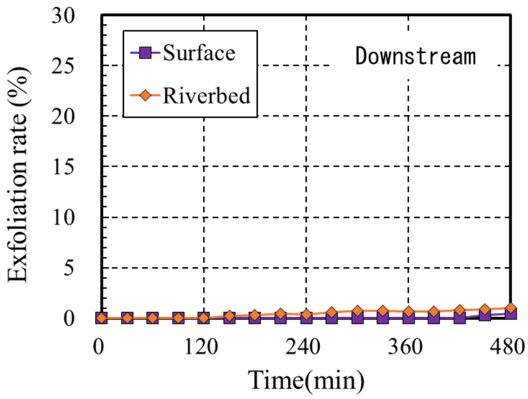


Fig. 19 Time history of exfoliation rate (riverbed)

waterside became 1.8% 480 minutes later, but an exfoliation rate rose to the riverbed side from after 120 minutes, and it was 23.7% 480 minutes later.

The time history of the exfoliation rate on side1 is shown in Fig. 17. On the surface side, the increase of the exfoliation rate was slight together a riverbed side, as for surface of the waterside 0.4% of 480 minutes later, the riverbed side was 2.0%. Although the exfoliation rate was different, in comparison with the side shown in Fig. 17 of upper, the tendency that the exfoliation rate on the riverbed side grew more significant than the surface of the side was agreed.

Because the exfoliation rate became around 2% on the surface side, the small sand floated with a strong flow, but it became clear that it was a factor to cause exfoliation.

The time history of the exfoliation rate on side 2 is shown in Fig. 18. As for 0.1%, the exfoliation rate of the riverbed side was 13.3%, and the exfoliation rate of the surface side 480 minutes later was significantly different from a result of the side 1 to show to Fig. 18.

The time history of the exfoliation rate downstream is shown in Fig. 15. As for 0.1%, the exfoliation rate of the riverbed side was 13.3%, and the exfoliation rate of the surface side 480 minutes later was greatly different from a result of the side 1 to show to Figure 19. The time history of the exfoliation rate downstream is shown in Fig. 19. As for 0.4%, the exfoliation rate of the riverbed side was 0.1%, exfoliation rate of the surface side 480 minutes later became small in four driftwood models, most both.

6. CONCLUSIONS

In this study, the driftwood model was made using the bark of the cedar, which grew up and the exfoliation experiment circulated fresh water and water with sand was performed. The conclusion is shown as follows.

(1) In the case that only freshwater circulated, it was revealed that the fluid power did not influence the bark exfoliation.
(2) Then, only for fresh and water with sand circulated, the exfoliation rate grew large in order of upper side > side view > downstream side. In addition, regardless of the setting aside of the driftwood model, the riverbed side's exfoliation rate was the tendency to become more significant than the surface side.
(3) From observation of the progress of the exfoliation confirmed two cases, exfoliation produced by the friction with sand and lump of the bark exfoliates.

7. ACKNOWLEDGMENTS

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