STREAM BED DEFORMATION AND DISCONTINUITY OF DEBRIS FLOW

by

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SUMMARY

This report is concerned with the actual situation of bed load movement in a torrent stream that still defies full understanding because of the complex nature of the variables involved. We investigated the actual situations of deposition in sabo-dam reservoirs and surveyed the deformation of stream beds for this report. Deposit materials by debris flows were assumed to be moved mainly from the section below the upper dam because of the division of deposits in sabo-dams. The surveyed sections were distinguished into two categories namely: deposited sections and scoured ones as an effect of the survey. Debris flows were classified under two types: one that flowed down from the upper section, and the other that began to flow in the section. It was assumed that debris flow did not flow down continuously but occurred in a few discontinuous sections. We described the characteristics of a stream section according to the volume and the frequency of debris flows that had occurred in it.

Keywords: deformation, debris flow, discontinuity, characteristics

INTRODUCTION

Recently in Japan, the progress of development into the interior area of mountains and the upper reaches of drainage basins has been increasing, so disasters caused by mass movement such as debris flow show a tendency to increase. Therefore public engineering works are needed for the protection of lives and objects such as equipment, establishments and other facilities from the damage caused by torrent streams. Lately civil engineering has been progressing very much, so various types of structures for disaster prevention can be built at almost any place we want. But such constructions that are built for erosion control often produce bad effects upon stream channels, because those constructions are not always adapted to bed load movement. Solutions of the problems encountered in improving natural channels depend more on a thorough knowledge of channel characteristics than on the development of civil engineering. Therefore studies of channel characteristics are necessary as well as studies about building structures in streams for adaptation between structures and stream channels.

METHOD

We are studying about channel charcteristics dealing with repetitions of bed load movement in torrent streams as one of the processes of geomorphological transition. We have investigated a certain series of stream bed fluctuations which were influenced by repetitions of bed load movement especially such as debris flow in practical torrent streams. For this report, we regularly investigated the actual situations of deposition in sabo-dams and surveyed the stream bed level that had changed during flood conditions. We chose the Nukkakushi-Furano River that is located in the central part of Hokkaido for our study (Fig.1). There is active volcano nearby, Mt.Tokachi(2077m), which last erupted in 1926 and 1962. The Nukkakushi-Furano River flows into the Sorachi River that is included in the Ishikari River basin. We investigated particularly the section of about 4km above No.5 sabo-dam(D-5, an elevation of 870m). The precipitation was 1031mm/year(1966~75)

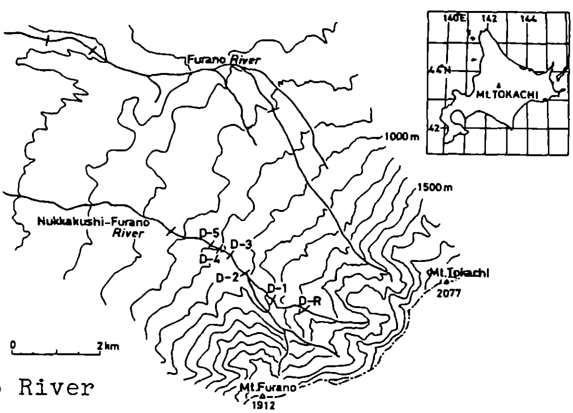

Fig.1 Locality of the Nukkakushi-Furano River

Table 1 Outline of Sabo-Dams

Dam	Constructed in	Watershed Area km^2	Distance from Upper Dam m	Height m	Length m	Volume of Deposited Sediments / Sediment Capacity 10^3m^3 / 10^3m^3
D-R	1974	1.83		12.0	72.0	40 / 58
D-1	1967	2.07	1,200	10.0	75.0	28 / 30
D-2	1969	6.98	950	12.0	101.0	33 / 63
D-3	1970	7.52	600	12.0	126.0	21 / 53
D-4	1971	7.62	300	8.0	82.0	12 / 19
D-5	1973	7.72	250	8.0	129.0	12 / 19

at the point(an elevation of 220m) about 13km below D-5. In that section(an average slop of 12.3%, a watershed area of 7.72km²), six sabo-dams were built from 1967 to 1974 (Table 1). We surveyed the level of the stream bed in the section about 450m from D-1(S-1) and in the section about 660m from D-R(S-R), setting 12 cross-lines each.

RESULTS

Actual situation of deposition in sabo-dams

Fig.2 shows the configuration of the deposits on the upper side of sabo-dams in Jul.1980. Dams except D-R were built from the upper stream one after another and their deposits had already reached the dam height level. It shows the year of completion and d_{max}.(maximum diameter of pebbles, cobbles and boulders on the surface of deposits).

The surfaces of deposits in sabo-dams except the ones in D-R and D-1 were divided into two parts; upper parts and lower parts. Lower parts consist mainly of sand and gravel, whose maximum diameters are in the approximately range of 20~50cm. On the other hand, the upper parts consist mainly of sieve-deposits or grouped boulders, whose maximum diameters are

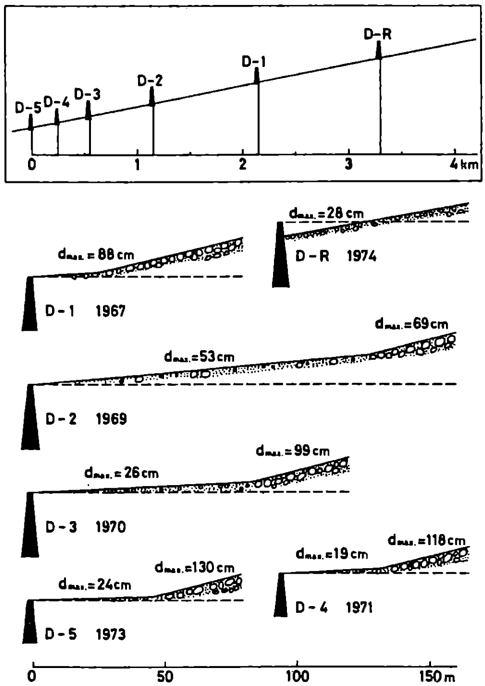

Fig.2 Configuration of the Deposits in Sabo-Dams

Table 2 Outline of Stream Bed Deformation

Section	Period of Survey	Distance m	Times of Occurrence	Deposited		Scoured		Deformation Volume in Cross-Section (max.)m²	H(max.) m
				Length m	Volume x10³ m³	Length m	Volume x10³ m³		
S-R	1974 ~ 1980	660	7	40 ~ 270	0.9 ~ 20	40 ~ 470	0.2 ~ 10	12 ~ 84	0.3 ~ 2.2
S-1	1972 ~ 1980	450	8	25 ~ 290	0.4 ~ 6	25 ~ 165	0.5 ~ 1	6 ~ 48	0.2 ~ 1.4

* H=Deformation Volume in Cross-section/Stream Bed Width

in the approximately range of 70~130cm. The surfaces were also divided into two parts according to slop, 1/56~1/22(lower parts) and 1/13~1/11(upper parts).

Deposition and scouring

Stream bed deformation occured seven times in S-R from 1974 to 1980, eight times in S-1 from 1972 to 1980(Table 2). Some lines went up(deposition) and others went down(scouring) wholly, or partially. And deposition and scouring often occurred simultaneously on one cross-line.

Degree of deformation was measured by cross-sectional area(deformtion volume in cross -section) that was enclosed by the cross-lines before and after deformation. Fig.3 shows two typical examples of deformation volume in cross-section and the distance that was represented by this volume. The surveyed sections were classified into deposited sections and scoured ones, and they were various in length. In Jul.1974, deposited and scoured sections occurred alternately in a length of shorter than 100m. In sept.1974, the deposited section was longer than 200m and the amount of deformation volume in cross-section was larger than in Jul.

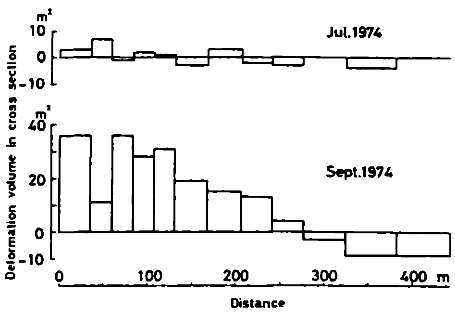

Fig.3 Deposited and Scoured Sections

DISCUSSION

Discontinuity of debris flow

Fig.4 shows the presumed volume of debris flows in S-R and S-1. In Jul.1974, Sept.1974 and Aug.1975, debris flows occurred in both sections, S-R and S-1. Volume of debris flows were calculated based on the balance of the deposited and scoured volume (refer to Fig.3).

As may be seen from Fig.4, peaks in the volume of debris flow(Vp) were presumed in the range of 3,000 to 18,000m^3 in S-R and in the range of 400 to 6,000m^3 in S-1. In Jul.1974, debris flow with the volume of about 3,000m^3 flowed in S-R and was interrupted,while another debris flow occurred in S-1. In Sept.1974, debris flow with the volume of nearly 18,000m^3 flowed in S-R and was interrupted, while another debris flow with the volume of about 5,000m^3 occurred and increased its volume to nearly 6,000m^3 by the scour stress exerted by it in S-1. In Aug.1975, debris flow with the volume of about 1,800m^3 was presumed to have flowed out from S-R, but it did not reach S-1. Because another intermittent debris flow occurred in S-1.

From the above, debris flows may be classified under two types; one is the flow from the upper section(S-R: Jul.1974, Sept.1974. S-1: Sept.1974) and the other is the flow that occurred in the section by bed load scouring(S-R: Aug.1975. S-1: Jul.1974, Aug.1975). Therefore this figure leads to the following: debris flows that moved in S-R and in S-1 were not continuous.

The fact that the surface of deposits in sabo-dams(D-2~ D-5) were divided into two parts means the same thing. For it is presumed that most of the mass of debris did not flowed down below each dam even after the deposits reached the dam height level. And the fact that sabo-dams except D-R were built from the upper stream one after another means the following: deposit materials by debris flows were supplied from the stream bed between dams. Thus the section where the stream bed was deformed may be divided into a few sections where debris flows occurred.

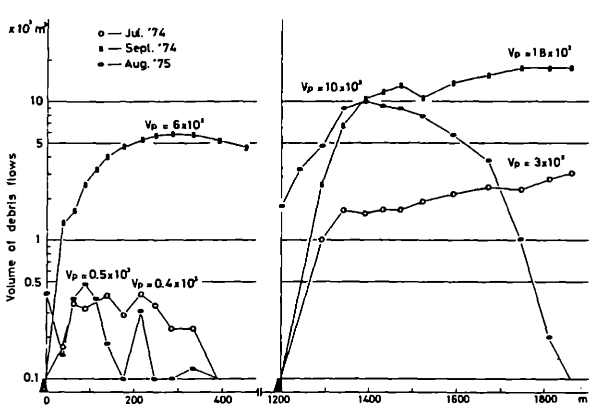

Fig.4 Volume of Debris Flows

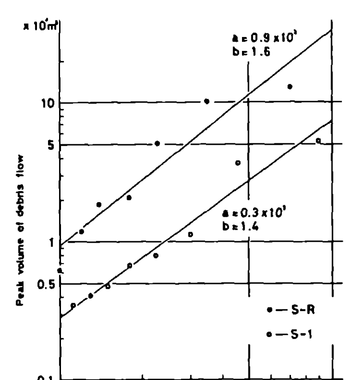

Fig.5 Peak Volume of Debris Flows and Frequency

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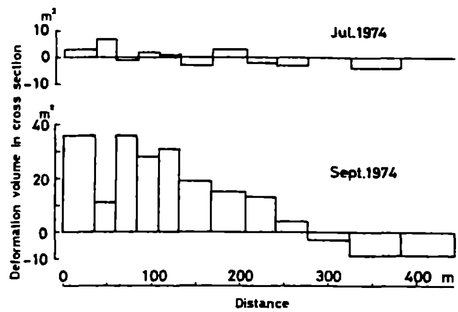

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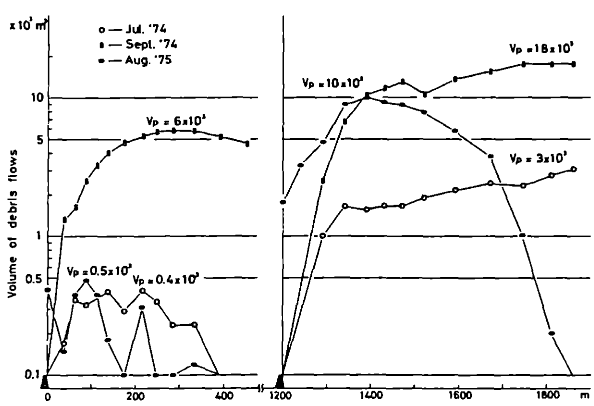

Fig.4 Volume of Debris Flows

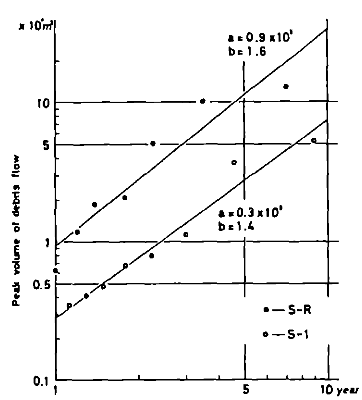

Fig.5 Peak Volume of Debris Flows and Frequency

CONCLUSION

Fig.5 shows the comparison of S-R and S-1 that were characterized by the peak volume of debris flows(ordinate) and the period(abscissa). The period in the figure is the investigation period divided by the times of occurrence of debris flows having more than a certain volume. Therefore it seems to show something like a frequency or a probability of debris flows in each section. It suggest that each section has specific characteristics, which means here the measure of the probability of debris flow or the measure of the instability of the bed load. For example, the debris flow with the volume of 5,000m^3 corresponds to the one that occurs once in 3 years in S-R but once in 7~8 years in S-1. Thus Fig.5 shows that the bed load layer in S-R may be more mobile or removable than that in S-1.

Much further investigation is evidently needed for a thorough knowledge of channel characteristics, related to the discontinuous occurrence and movement of debris flow, including the affect of sabo-dams that change or improve the characteristics.

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