MEASUREMENT OF BEDLOAD WITH THE USE OF HYDROPHONE IN MOUNTAIN TORRENTS

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INTRODUCTION

Actual sediment outflow rate depends not only on the sediment transport capacity of the flow but also the movable sediment volume produced in mountain streams. In most cases the amount of sediment on to torrent beds and banks is limited. Torrent beds are often covered with an armor coat. When the discharge rate is small, the actual sediment transport rate is less than the sediment transport capacity that is given by sediment transport equations for the sediment grain size, torrent gradient and flow discharge rate of flow depth. When the flow discharge rate exceeds the critical condition of the incipient motion or the rainfall exceeds its critical one creating landslides or the occurrence of debris flow, sediment is produced and supplied to the torrent. The sediment transport rate increases sharply and approaches the sediment transport capacity. The actual sediment transport has to be observed to determine a reasonable sabo (erosion and sediment control) plan. Monitoring of the sediment transport rate is necessary to operate the sediment control gates of sabo dams being developed. Suspended load is relatively easy to measure with samplers or suction tubes. The measurement of bedload on the other hand is difficult. Some bedload samplers have been used for mountain streams. It is actually difficult to set the samples on the torrent bed, because the bed is rough, has large rocks, and the flow velocity is high. Hydrophones counting the impacts or sound of sand and gravels against plates or pipes are appropriate in mountain torrents. They measure not absolute sediment transport rate but rather the relative sediment transport rate (intensity). Hydrophones with pipes and microphones were developed for isolated mountain torrents and they were installed on the bed of slit sabo dams. The system and data observed using hydrophones are reported in this paper.

HYDROPHONE SYSTEM

A slit sabo dam has one or more vertical slits several meters wide. It dams up water during high water and makes the sediment inflow deposit temporally at an upper reach of the dam. When the discharge rate decreases the degree of dam-up disappears and the trapped sediment is eroded and released. The behavior of slit sabo dams have been known through flume experiments and computer simulations although the actual function must be verified in the field. The hydrophones were applied to measure the actual sediment which flowed out from slit sabo dams.

A block diagram of the hydrophone system is illustrated in Figure 1. A hydrophone was installed at the Tsuno-ura-Karyu slit sabo dam (Figure 2) constructed by the Tateyama Sabo Work Office in the Joganji River. The sabo dam is 13.5 meters high and has two slits, each 16.0 meters wide and 7 meters deep. The water level is also measured using a pressure gauge. The water level can be converted into the flow discharge rate. Measured data is stored in the data logger and also transmitted to the work office through a cellular phone every five minutes. The hydrophone system is powered by solar batteries.

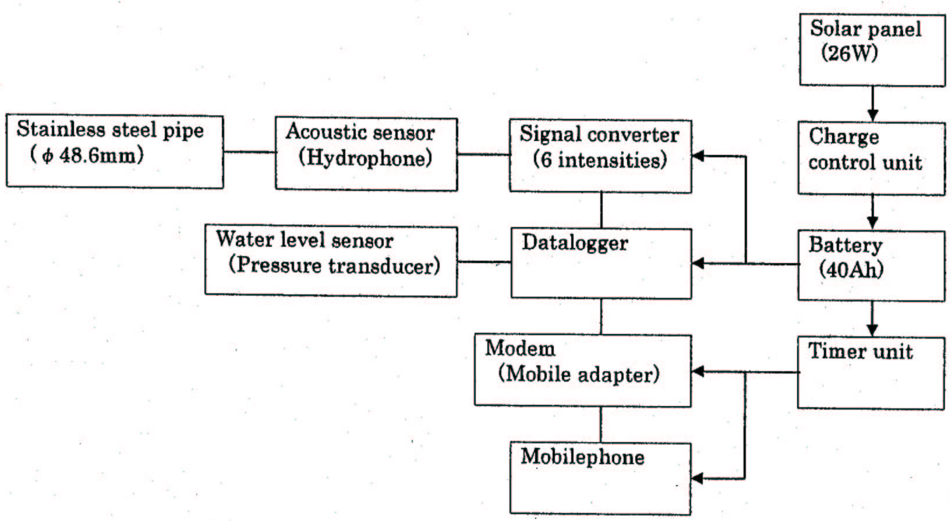

Figure 1 A block diagram of the hydrophone system.

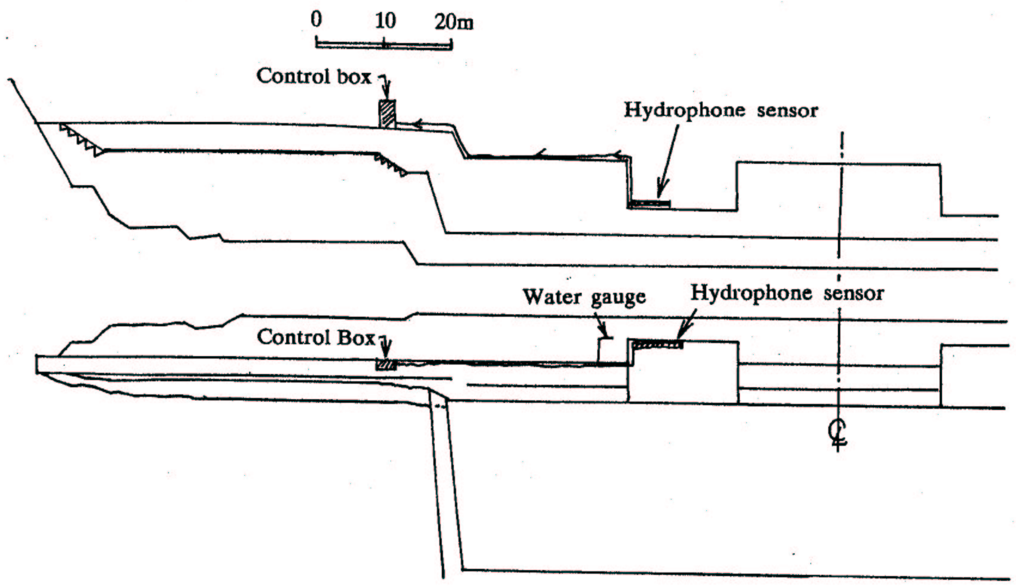

Figure 2 Installation of a hydrophone at the Tsuna-ura-Karyu slit sabo dam.

RESULTS OF MEASUREMENTS

Measurements using the hydrophone system started at the Tsuno-ura-Karyu slit sabo dam on June 16, 2001. They have been continued to date except during snow seasons. The gain of the hydrophone was set 2 times (L5), 4 times (L4), 8 times (L3), 16 times (L2) and 32 times (L1). Measured data of incoming signals and the water level of a storm in 2001 is shown as an example (Figure 3). The storm was not large enough to dam up the flow. Recorded data indicates that sediment was transported with a small flow discharge during the rising stage of the storm and disappeared rather early in the falling stage. The movable sediment which was produced before the storm was not large enough to be transported by the flow. It is expected that more information can be obtained from an analysis of this kind of data.

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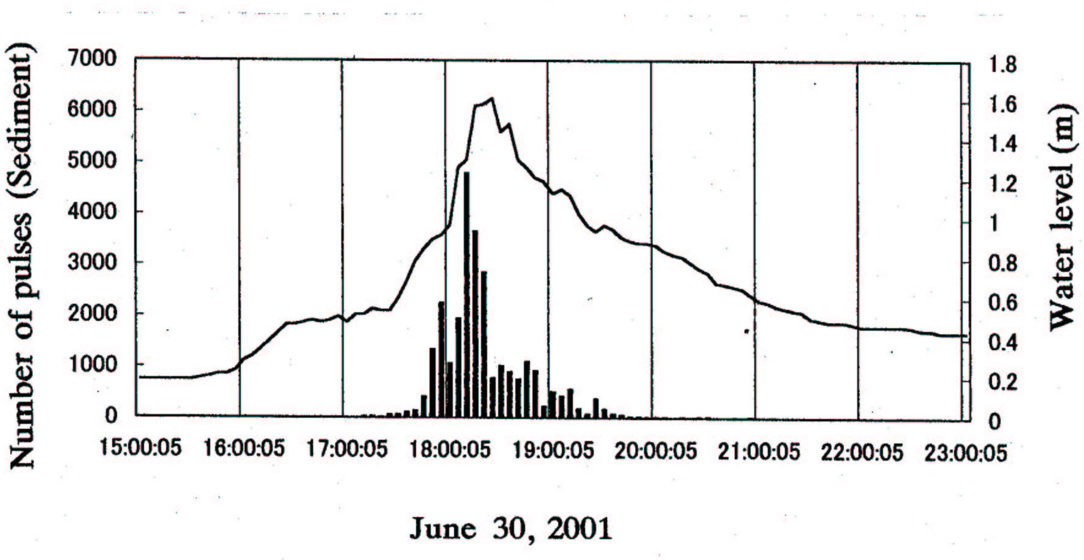

Figure 3 An example of the recorded data of hydrophone and water level