A study of field methods for measuring sediment discharge

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ABSTRACT Sediment discharge in a mountain region depends on not only the runoff pattern but also on the quantity of sediment detached from either the slopes or the channel bed. In addition, grain size ranging from clay to boulder plays an important role in the process of sediment transportation. The parameters involved in sediment yield and transportation are so numerous that it is not easy to estimate the quantity of sediment discharge reliably. Therefore it is necessary to develop appropriate measures to monitor sediment discharge in the field in mountain regions. Two categories of measuring system, direct and indirect, were developed and outlined in this paper.

INTRODUCTION

In Japan, many sediment-related disasters occur every year in and around mountain regions. Basically, the major cause of sediment-related disasters is a change in bed height, either aggradation or degradation, due to an imbalance between influx and outflow of sediment in a reach of a channel. Many parameters, such as runoff pattern, quantity of sediment yield from the slopes, river bed configuration, grain size distribution, bed material, etc are involved in sediment discharge. It is therefore rather difficult to estimate the quantity of sediment discharge without monitoring in the field. Monitoring practices in the field are rather difficult because of many problems such as the limited period available for measurement, high flow velocity, large quantities of sediment, the wide range of grain size and dangerous field conditions. Although various techniques have been developed in Japan, most of them have not proved successful in measuring continuously and safely. Surveys of topographic changes either on the bottom of a dam reservoir after each flood event or on a sand trap connected to an intake on the crest of a sediment check dam, and samplers (Guy & Norman, 1970) to be put in the flood water are a few examples. Automated systems which ensure safe and continuous measurements are introduced and discussed in this paper.

APPROACHES TO MEASUREMENT

Two different approaches to measurement, direct and indirect, can be considered. The former means of measuring involves gauging the quantity of sediment trapped, while the latter involves analyzing the signals produced by a sensor which can respond to acoustic pulse, supersonic pulse, micro wave, X-ray or γ-ray.

A direct method has an advantage for measuring the quantity of sediment fairly easily because the basis of the system is, in general, simple. The total system for direct measuring is, however, likely to be large and heavy. While an indirect system requires no large and heavy facility so that it is easy to install in the field, its operation maybe more complex.

A measuring system, either direct or indirect, must ensure automatic and continuous monitoring and the sampler and sensor must be set up at a location where no river bed change takes place. The sampling facility of a direct measuring system is installed on the front face of a dam, while the sensor of an indirect measuring system is set up on or above the crest of a dam.

SYSTEMS OF DIRECT MEASUREMENT

There are two ways to measure the quantity of sediment, by weight and by volume. It is difficult to measure the quantity of sediment by volume automatically and continuously, and this paper deals with the weighing method. It is essential to separate the sediment from the water which is trapped at the same time. The system therefore consists of four sub-systems; intake, separator, weighing device and outlet.

The location of the direct measuring systems discussed in this paper are shown in Fig.1.

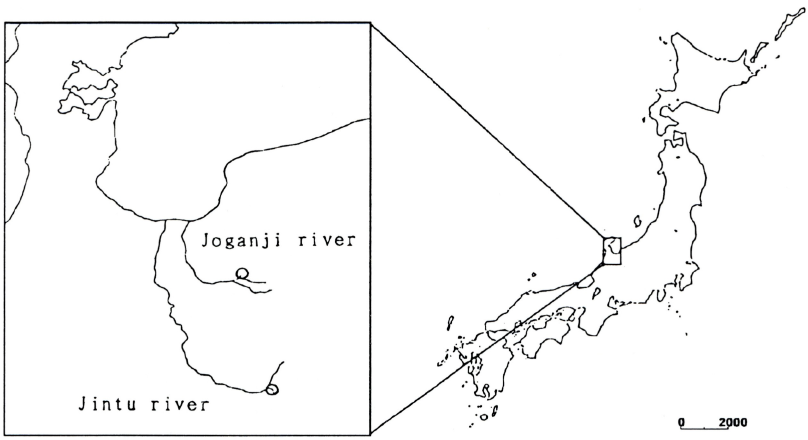

FIG. 1 Location map of the direct measuring systems described in the paper.

The system installed on the Jintu River is located at the outlet of the Hirudani basin in the Hodaka Experimental Basin of the Hodaka Sediment Observatory of Kyoto University (Ashida et al., 1976). Figure 2 shows the plan of the experimental basin and the location of the system. The catchment area of the Hirudani basin is 0.85 km^2, and its altitude is 1200m at the outlet and over 2000m at the highest point.

Figure 3 shows a plan view of the measurement facility. In addition to the four sub-systems, the system is equipped with a loading part which connects the intake to the separator.

The intake which has a 20cm x 20cm opening is fixed in a 1 m wide concrete channel. Water which contains the sediment runs through intake and loading elements and reaches the separator (trammel). Sediment is then loaded onto the rotary bucket (scale). The separated water and sediment passing the scale are discharged from the outlet. A small part of the sediment is automatically sampled in the buckets on the turn table in order to measure the grain size distribution. The front and side views are shown in Fig. 4.

Two examples of the results obtained along with rainfall data for the events are presented in Fig. 5. Figure 6 illustrates the grain size distribution of the material sampled.

The system installed on the Joganji River is located near the outlet of the Hitotsudani basin as shown in Fig.7. The catchment area of the basin is 3.89 km^2.

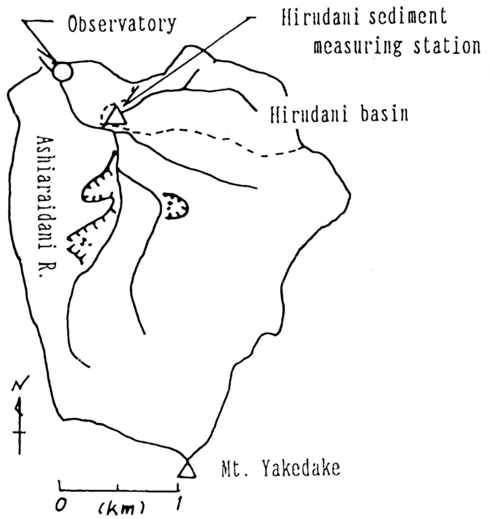

FIG. 2 Plan of experimental watershed and location of sediment measuring station

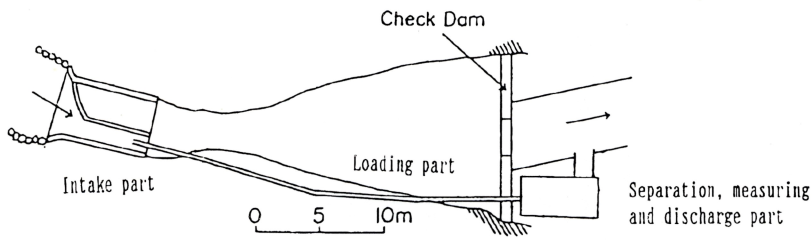

FIG. 3 Plan view of facility for the measuring of sediment discharge at Hirudani

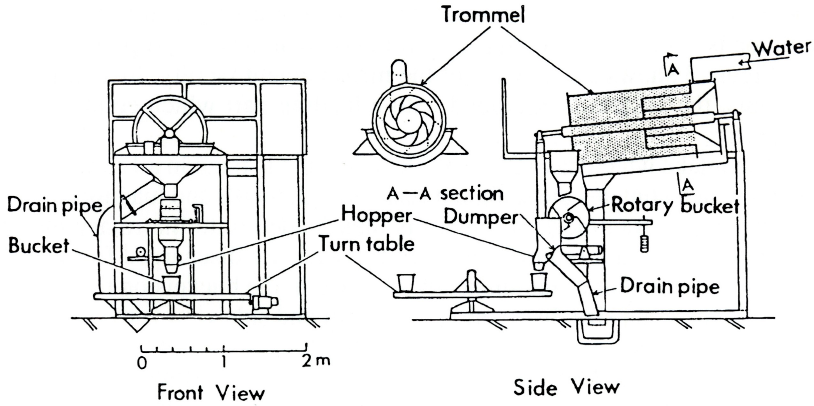

FIG. 4 Equipment for direct measurement of sediment discharge.

Figure 8 provides a picture of the whole system. The catchment area of the basin is greater than that of Hirudani and it is characterized by more active sediment yield and transportation than Hirudani. Furthermore, the grain sizes involved cover a wide range and a method similar to the one used in the Hirudani basin cannot be employed in the Hitotsudani basin. All the facilities are therefore located together and the system is set up on the front face of the dam.

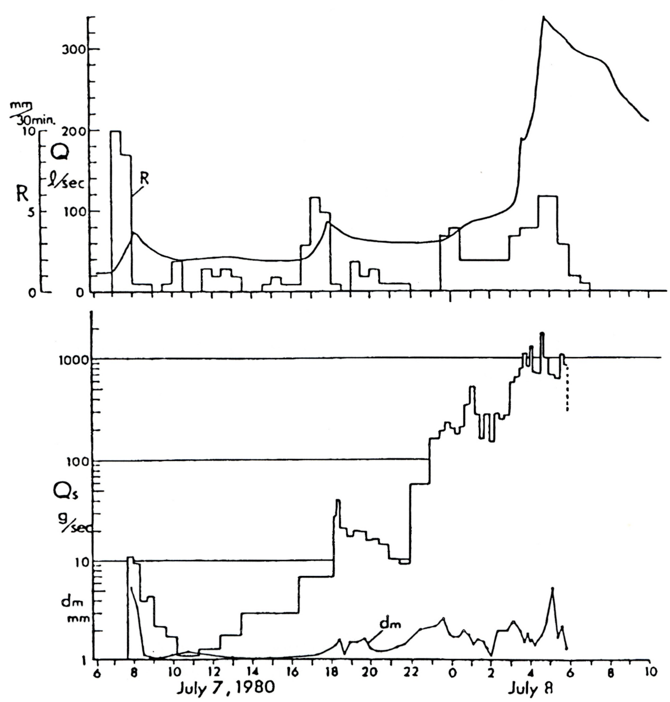

FIG. 5(a) Results of measurement of sediment discharge(Qs), rainfall intensity(R), water discharge(Q) and mean size of sediment(dm).

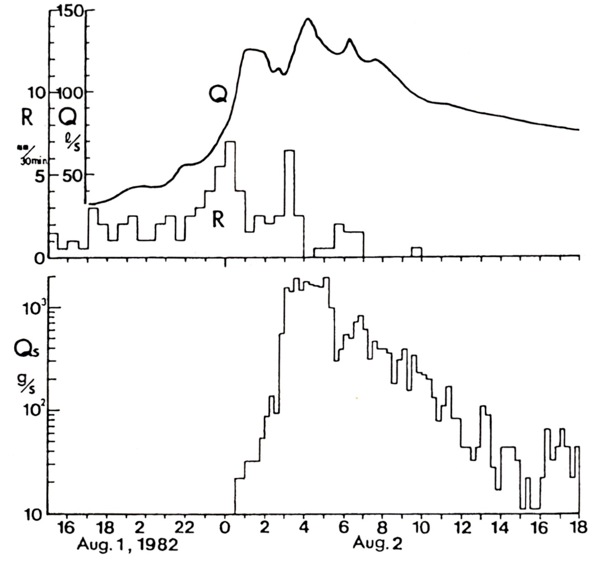

FIG. 5(b) Results of measurement of sediment discharge (Qs), rainfall intensity(R), water discharge(Q) and mean size of sediment(dm).

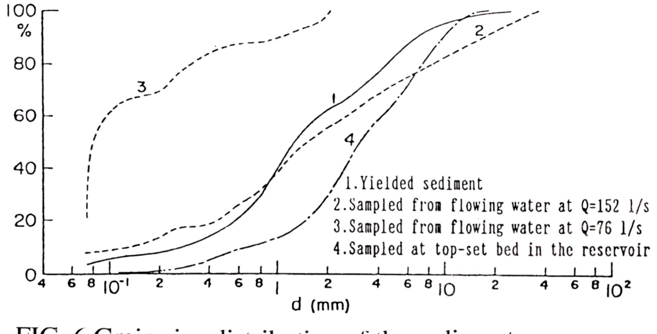

FIG. 6 Grain size distribution of the sediment.

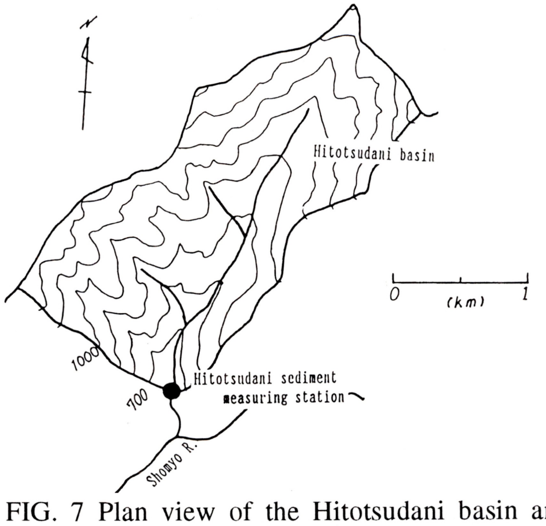

FIG. 7 Plan view of the Hitotsudani basin and the location of the Hitotsudani sediment measuring station.

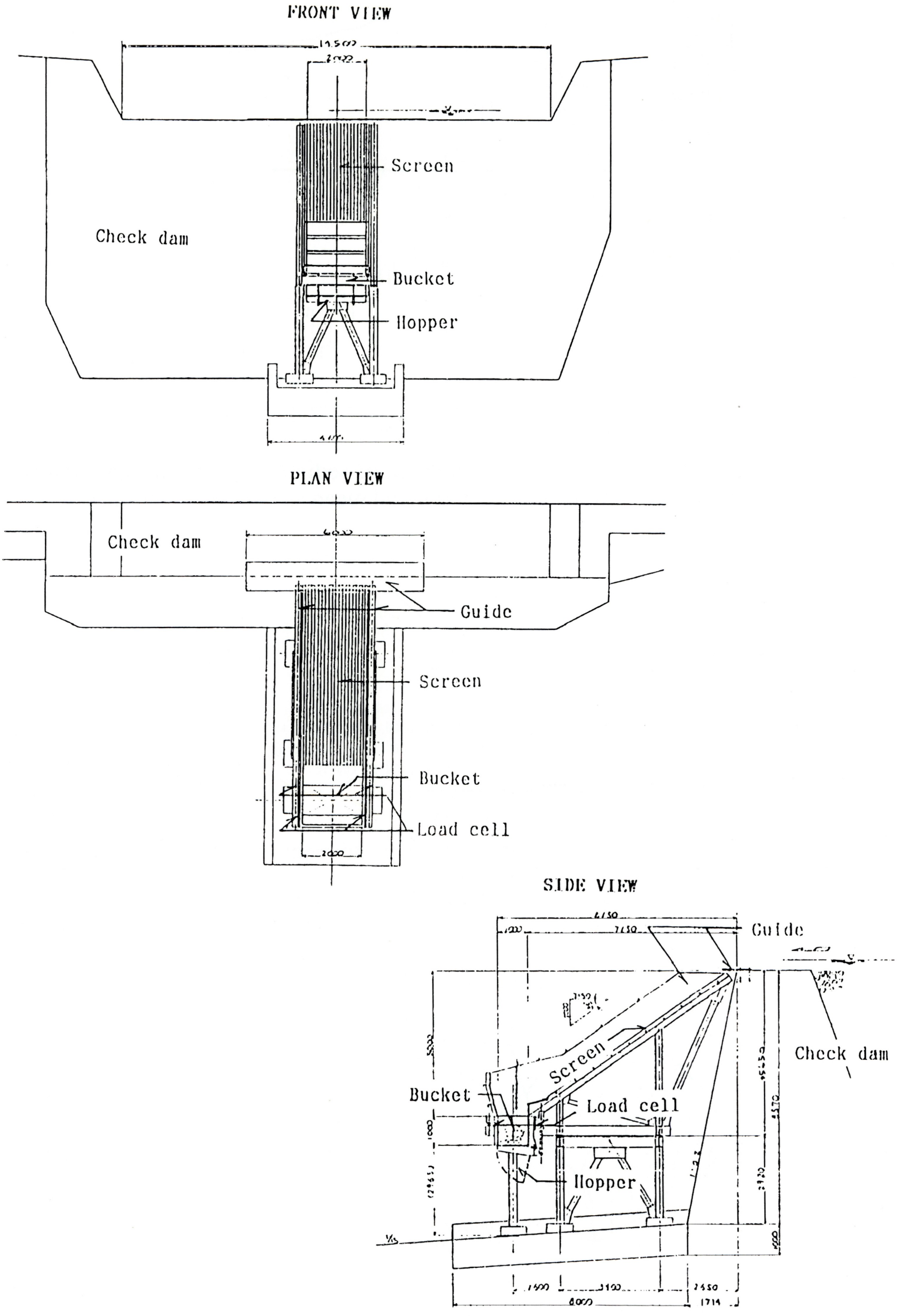

FIG. 8 Equipment for direct measurement of sediment discharge at the Hitotsudani sediment measuring station.

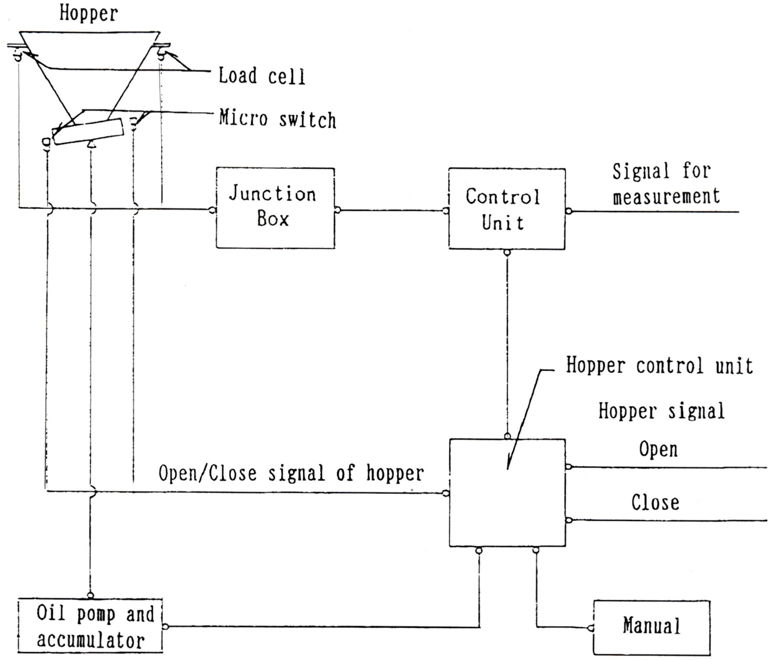

FIG. 9 Diagram of hopper control and flow of signals.

Sediment-laden water runs through the intake and is then screened. Sediment falls into the measuring bucket which is 2m wide, 1m long, and 1m high. The weight of the bucket is measured by four load cells. As soon as the weight of sediment reaches a certain limit the bucket automatically discharges the sediment. The weight of sediment and the frequency of discharge versus time are automatically recorded. Figure 9 provides a schematic diagram of the measuring system. The system, along with an indirect measuring system, was in operational since 1991, but there has been no flood event which resulted in sediment discharge. We are ready to conduct a comparative study by means of two independent systems.

FINAL REMARKS

Although the paper does not deal with indirect methods, we are ready to establish an acoustic sensor system and we have started to develop a system with a supersonic sensor. The establishment of reliable and cost-feasible systems for measuring sediment discharge remains an important requirement.

REFERENCES

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