Erosion and Sediment Transport Measurement (Proceedings of the Florence Symposium, June 1981). IAHS Publ. no. 133.

Integrated debris flow observations

SETSUO OKUDA
Disaster Prevention Research Institute, Gokasho, Uji City, Kyoto, Japan
TADAO AOKI & MASAO OKAMOTO
Matsumoto Sabo Construction Office, Ministry of Construction, Motomachi 1-8-28, Matsumoto City, Nagano Pref., Japan

ABSTRACT The Ministry of Construction and Kyoto University began to observe and investigate debris flows in the Kamikamihori Valley east of Mt Yakedake (2455 m) in 1971. In the Kamikamihori Valley debris flows are triggered by rainfall and occur approximately five times each year. Currently, this study consists of investigating the cause of debris flows by using raingauges, directional raingauges, and groundwater level meters in the debris flow source area; investigation of the flow mechanism by using fluid speed meters, impact force recording devices, soil samplers, seismographs, 8 mm cine cameras, video cameras, etc. in the middle sections of the valley; and investigation of the debris flow depositing mechanism by using groundwater level meters, 8 mm cine cameras, video cameras, etc. in the fan area.

Observations d'ensemble de l'écoulement des débris flottants
RESUME Le Ministère japonais de la Construction et l'Université de Kyoto ont commencé en 1971 à observer et à analyser les écoulements de débris dans la vallée de Kamikamihori à la base orientale du Mont Yakedake (2455 m). Dans cette vallée, ces écoulements de débris sont provoqués par les pluies et ils se produisent environ cinq fois par an. Cette étude traite de l'analyse des mécanismes à l'origine des écoulements de débris, analyse effectuée principalement en utilisant des pluviomètres, des pluviomètres vectoriels et des appareils de mesure du niveau phréatique dans la région située à l'amont où est l'origine des écoulements de débris; on y trouvera également des recherches sur les mécanismes d'écoulement par tachymètres pour fluide, des dispositifs d'enregistrement de la force d'impact, des appareils à prélever des échantillons du sol, des séismographes, des caméras de 8 mm et des vidéocaméras dans la partie moyenne; enfin, on a également procédé à des recherches sur les mécanismes de dépôt des débris surtout par l'emploi d'indicateurs du niveau phréatique, des caméras de 8 mm et des vidéocaméras dans la région du cône d'alluvion à l'aval.

INTRODUCTION

The Ministry of Construction has been observing debris flows in the Kamikamihori Valley (basin area 1.6 km^2, length of water course 2.0 km, and valley bed gradient 1:4 to 1:5) at the eastern foot of Mt Yakedake since 1971 in collaboration with the Disaster Prevention Research Institute of Kyoto University. Mt Yakedake is located in the region of Japan where debris flows occur most frequently, and the 53 debris flows observed and reported in this district during the last 10 years have been studied and analysed.

METHOD OF INVESTIGATION

Images

The primary objective of the study when the debris flow observation began was to record the behaviour of debris flows by means of images. The techniques for making such records have been improved.

For the purpose of continually recording the dynamic behaviour of debris flows to study their growth and development, and to record the movement of boulders, 8 mm and 16 mm cine cameras were installed at the points where debris flows would pass, and connected to corresponding sensors. A 8 mm Digitabal camera is used to record changes in the valley floor for a predetermined duration. A 35 mm motor driven camera is used to take single-frame pictures with high resolution at predetermined time intervals which are used in various analyses. A video camera is used repeatedly to record a debris flow for a long period of time; this camera can be moved horizontally or vertically by remote controls installed at the debris flow observatory.

In making observations through recording images it is most important but very difficult to select the best location for the cameras, and a flat area where the camera will never be destroyed by the debris flow is chosen. Where the valley is not deep, the camera must be installed sufficiently low on the valley bank so that the debris flow may be fully photographed.

Debris flows are triggered by rainfall, and in this region rainfall tends to occur during the night, and since rainfall during the day tends to be accompanied by heavy fog, conditions for photography are extremely difficult.

Sensors for starting the cameras

After a debris flow occurs a sensor transmits an electric signal to each instrument to start the instrument and, thus, observation of the debris flow begins when the sensor has detected the debris flow. There are two kinds of sensors: wire and contact sensors.

The wire sensor comprises of an electric wire fixed horizontally under tension about 1 m above the valley floor which transmits an electrical signal when the wire is cut off by the front of a debris flow. The main disadvantage of this type of sensor is that once the wire is cut off it remains inoperative until the wire is reconnected, and so is unable to respond should another debris flow occur before reconnection.

The contact sensor comprises a horizontal electric wire tensioned between both banks across the valley at a level above the top of the anticipated debris flow, with several vertical wires suspended from the central section. When these vertical wires make contact with the raised portion at the front of a debris flow the current in the horizontal wire is earthed and this transmits a signal. There are two kinds of vertical wires: one type has two weights near the bottom of the wire and a current flows when the section between the two weights is cut off by the debris flow; and the other type has a weight from which a bare wire is directly extended. The former is more highly sensitive than the latter.

Sampling of debris flow material

Soil sampling cans for checking concentration and composition of debris flows were installed. These are steel bores with a 30 cm square opening which are installed on the crown of a sabo (erosion control) dam with the opening on the upstream side and fixed in position with Cremona rope. This can has a swing type lid inside it at mid height; one end of a 8 mm diameter wire is attached to this lid and the other end is secured to the downstream slope of the wing of sabo dam. When a debris flow passes through the dam, the Cremona rope is cut off and the soil sampling can knocked off the dam, but the wire will cause the lid to close and the can itself remains safely suspended along the wing of the dam and is not swept away in the debris flow.

Debris flow materials can be sampled relatively well by this soil sampling can, but it cannot sample material at the front of a debris flow larger than the 30 cm square opening of the can, and we must rely upon analysis of the images recorded by the cameras to monitor these larger components of a debris flow.

Measurement of the impact force of a debris flow

In measuring the impact force of a debris flow on Mt Yakedake, several measuring methods were tried such as (a) panel type indentation meter, (b) strain gauge type earth pressure cell, and (c) load cell mounted on a sabo wire net rope: however, only the indentation meter was found to be practical in recording data.

The indentation meter comprises a steel cone attached to a 14 cm square aluminium panel and the impact force is estimated from the size of the concave indentation made on the aluminium panel by the cone. The relationship between the acting external force and the diameter of the indentation is determined from laboratory experiments.

Present observation system

Equipment such as video cameras, 8 mm cine cameras, raingauges, sensors, groundwater level meters, soil sampling cans, indentation meters, fluid speed meters and pickups for seismometers are installed on the valley floor and on valley banks. The observation relay centre is equipped with FM video transmitter, fluid speed meter, oscillograph, seismometer, etc.; while the debris flow observation centre houses and controls the observation equipment and instruments, video recorder, television monitor, digital clock, digital recorder, etc. The power supply is 100 V a.c. and 24 V d.c. and all instruments other than the television unit are able to operate during interruption of the a.c. power supply.

When one of the installed sensors is triggered by a debris flow, the start command is automatically applied, the image transmitted by the video camera installed at the site is displayed on the television monitor unit and recorded, the time when the sensor was broken is automatically printed on the digital recorder, and numerical data are indicated and recorded on the debris flow impact force recording device, fluid speed meter and seismometer installed in the observation relay centre.

Ten command systems are provided in total; four of them are manual video camera systems; and remaining six are automatic command systems, five of which will start 8 mm cine cameras if a particular sensor is broken and the remaining one will operate the instruments if either one of the sensors is broken.

CONCLUSION

Though the acquisition of satisfactory data was difficult during the initial stage of observations because of many problems in the observation methods and equipment, since then considerable improvements and developments have been achieved each year, resulting in greatly improved methods, and more reliable and a larger amount of data. These data will be used in the planning, surveying and construction of sabo works. For this purpose, it seems necessary to clearly distinguish between data obtainable from observations in the past and in the future and those which cannot be determined even if more efforts of observation, survey or analysis are made in the future.