Evaluation of Hydraulic Characteristics from Observation of Surface Profiles of Debris Flows

Yuya TAKAHASHI,[1*] Naoki FUJIMURA[1] and Hideaki MIZUNO[2]

[1] Erosion and Sediment Control Research Group, Public Works Research Institute, Japan
[2] Faculty of Agriculture, Kyusyu University, Japan
[*]Corresponding author. E-mail: yy-takahashi@ctie.co.jp

INTRODUCTION

Coefficients, such as the Manning's roughness coefficient, are specified based on former observations of debris flows and experiments. Among such the coefficients, the Manning's roughness coefficient is one of the most important coefficients to estimate velocity of debris flows and it is considered that the coefficient varies according to sediment concentration, mixture density of debris flow, particle size distribution, and so on. Therefore, the Manning's roughness coefficient apparently changes with respect to time. This study aims to clarify the change of the Manning's coefficient in time by using the velocity which estimated from surface geometry of debris flow. The surface geometry of debris flows has been collected at the Arimura No. 3 sabo dam in the Sakura−jima volcano, Kagoshima, Japan by using the laser profile scanners (LPSs) under the cooperation with the Osumi office of rivers and highways, Kyusyu regional development bureau, MLIT. This paper reports the field observation with LPSs and temporary continuous estimation of debris flow velocity.

OBSERVATION

Observations are carried out at Arimura No. 3 sabo dam constructed on Arimura River that located on the south−east slope of Sakura−jima volcano (**Fig. 1**). The catchment area is 1.55 km2 and the average slope of the river bed around the dam is 3.4 degrees. The density and the sediment concentration of the unstable sediment on the river bed at Arimura No. 3 sabo dam are 2.689 g/cm3 and 0.644, respectively. Two LPSs (UXM−30LX−EW, Hokuyo Co., Ltd.) are installed 9 m above the Arimura No. 3 sabo dam to observe longitudinal and cross−sectional profiles of debris flows. The resolution of the LPSs is 0.25 degrees in space and 0.05 seconds in time. Also, the force plate is installed at spill way of the dam by Osumi office of rivers and highways to observe the flow loads.

Six debris flows are recorded at Arimura River in 2016. Among those events, the debris flow occurred on June 19 is evaluated in this report because the surface profiles are clearly recorded.

EVALUATION OF HYDRAULIC CHARACTERISTICS

The free−falling time and the nappe length are measured from longitudinal profile and assigned to the semi−theoretical formulation to estimate the flow velocity[1)]. The Semi−theoretical formulation for the velocity estimation is expressed as follows;

$$v = 0.6\frac{L}{\alpha}\sqrt{g/\{2(H+h_e)\}},$$

where, v, L, α, g, H and h_e are flow velocity, nappe length, coefficient, gravitational acceleration, drop height and exit flow depth, respectively.

The velocity estimated by the formulation above is surveyed by comparing with the Manning formula, assuming that the flow is locally uniform, expressed as follows:

$$U = R^{2/3}(\sin\theta)^{1/2}/n.$$

Evaluated flow velocities are compared in **Fig. 2**. Looking at comparison with Manning formula, the plots of early stage of debris flow distributed near the line of n=0.03, then the plots shift to the higher roughness exceeding 0.1 around the peak. This shift is supposed to be due to the change of internal energy loss with respect to time.

CONCLUSIONS

Flow velocity is estimated from the surface geometry of debris flow observed by using LPSs in this study. Temporal change of the Manning's roughness coefficient is clearly obtained by comparing the velocity estimated from semi−theoretical formulation with Manning's formula. The coefficient shows higher values at the peak discharge of debris flow and relatively low values around initial rise and decaying period. This trend shows good agreement with a former report[2], which was carried out by using video analysis with visual judge, and that the velocity is obtained much higher resolution in time. The authors will continue evaluation of hydraulic characteristics of debris flows, such as sediment concentration[3], combining other observations and try to clarify the mechanisms of changing characteristics of debris flow with respect to time.

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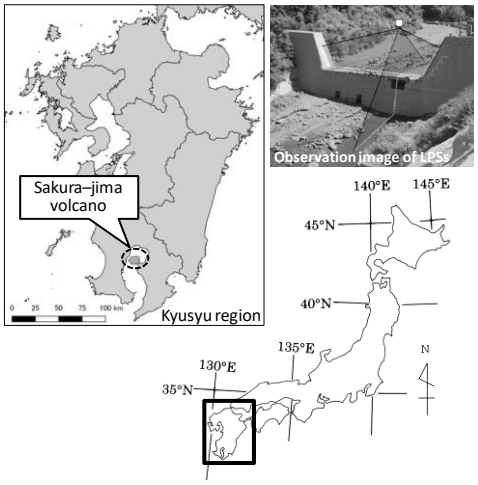

Fig. 1 Location of Observation

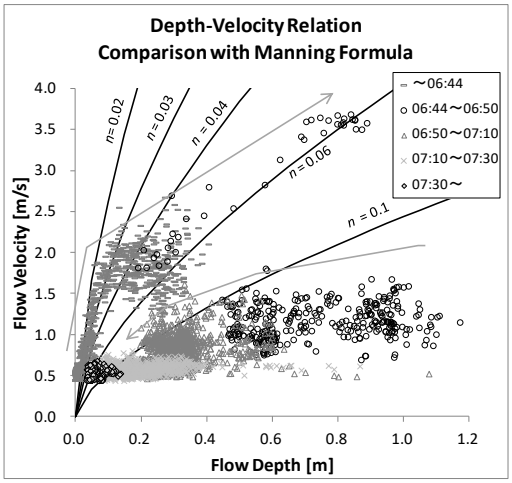

Fig. 2 Comparison of Depth−Velocity Relation

Keywords: Field observation, Laser profile scanner, Flow velocity, Manning's roughness coefficient