Debris Flow Detection Using LVP Sensors in Japan

Hitoshi KATO[1], Nobuyuki NODA[2], Kazuhiko HASHI[3], Satoshi TAGATA[4],
Takahiro ITOH[5*] and Takahisa MIZUYAMA[6]

[1] Osumi Office of River and Highway, Kyushu Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan (Now in Nara Prefectural Office, Japan)

[2] Osumi Office of River and Highway, Kyushu Regional Bureau, MLIT, Japan
(Now in Yamakuni River Office, Kyushu Regional Bureau, MLIT, Japan)

[3] Osumi Office of River and Highway, Kyushu Regional Bureau, MLIT, Japan

[4] Nippon Koei Co., Ltd., Japan

[5] Research and Development Center, Nippon Koei Co., Ltd., Japan

[6] National Graduate Institute for Policy Studies (GRIPS), Japan.

[*]Corresponding author. E-mail: a6556@n-koei.co.jp

INTRODUCTION

Sakura-jima is an active volcano in the southwest region of Kyushu in Japan. The surrounding area is impacted significantly by large debris flows when rainfall follows an eruption. Various studies have investigated the use of sensors including wire sensors and acceleration sensors to detect such events. Arattano et al. (2008) proposed the use of geophones in Europe but the applicability is not confirmed in Japan, where wire sensors are frequently used. Wire sensors typically incorporate three horizontal wires set at heights of 60, 120, and 180 cm from the river bed and can be used to quantify the magnitude of the debris flow. We have developed an LVP (load, vibration, pressure) sensor (Itoh et al., 2017) and installed it at two test sites to establish its suitability for continuous detection of debris flows. The sensor consists of a load cell, an acceleration meter and a pressure meter. The sensor is mainly for debris flow detection but does not measure weight of debris flow surges, though debris flows try to be measured using a small box with loadcell (e.g., Scott et al., 2011). In this paper, we present the results of an analysis of LVP and wire sensor data that was recorded at the test sites to verify the accuracy of the LVP data.

DEBRIS FLOW DETECTION USING A LVP SENSOR

A proposal for continuous monitoring of debris flow using a combination of wire and LVP sensors was first proposed in Itoh et al. (2017) and it was established that the optimal solution involves the use of both sensor types, because the LVP could detect debris flow occurrences after disconnected wire until installation of new wires. **Fig. 1** and **2** show the location of the monitoring tools that were installed in the Nojiri and Arimura River basins as part of this ongoing study. The design of the LVP sensor was modified after an earlier prototype was destroyed by a debris flow (Itoh et al., 2017), and the modified version was installed on the bed of the Nojiri No. 7 sabo dam on February 6th, 2015 and at the Arimura No. 3 sabo dam on October 11th, 2016.

The LVP sensors detected 11 occurrences of debris flow without missing any events between January 2016 and March 2017. The wire sensors also detected all 11 events. There were occurrences when the

LVP sensor detected debris flow events at approximately the same time as the wire sensors. The LVP sensors also detected several surges after the wires disconnected and could not detect the debris flow perfectly because of channel shifting of debris flow surges. Flow depth, load and vibration data were recorded. The results showed that debris flows could be well detected using a combination of wire and LVP sensors. The threshold load and vibration values for debris flow events were 400 kgf/m^2 and 200 mV, respectively, when the lowest wire was disconnected. The values for the 2nd magnitude of disconnected wire could be 2400 to 2500 kgf/m^2 and 2800 to 3000 mV, respectively.

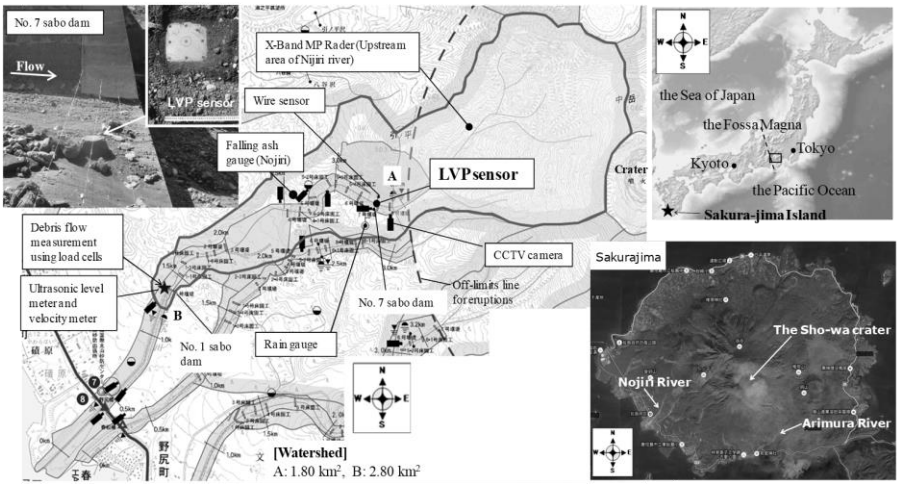

Fig. 1 Debris flow monitoring positions in Nojiri River basin.

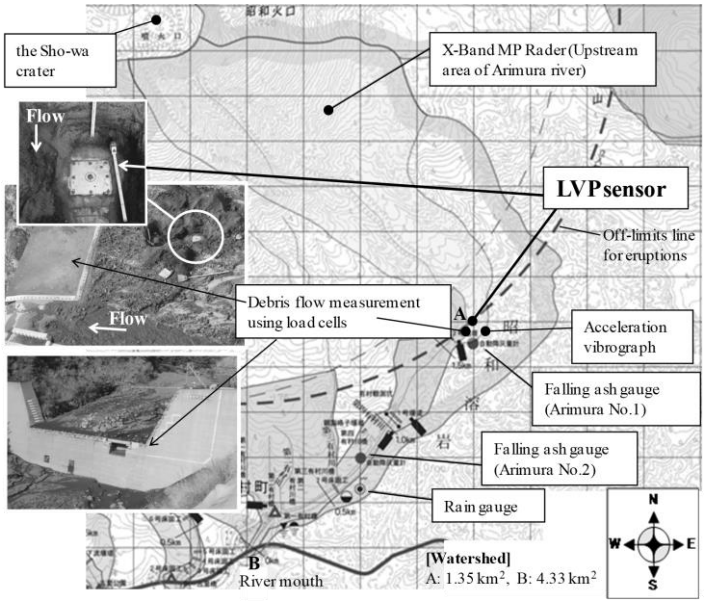

Fig. 2 Debris flow monitoring positions in Arimura River basin.

CONCLUSION

A system comprising both wire and LVP sensors detected 11 occurrences of debris flow in two river basins without missing any events. Threshold values were determined by recording temporal changes in flow depth, weight and vibration by the LVP sensors. The load and vibration values were 400 kgf/m^2 and 200 mV, respectively, at the first wire level, and 2400 to 2500 kgf/m^2 and 2800 to 3000 mV at the second wire level.

Acknowledgements: The authors are grateful to Hydrotec Co., Ltd. and Dr. Koji Yokoyama for their support during the development of the LVP sensor.

REFERENCES

Arattano, M *et al.* (2008). Systems and sensors for debris-flow Monitoring and Warning, Sensors 2008, 8, pp. 2436-2452.

Itoh, T. *et al.* (2017). Detection of debris flows by combination of LVP and wire sensors, Proceedings of the 37th IAHR World Congress, 13-18 August 2017 in Kuala Lumpur, Malaysia: pp.1125-1131, 2017.

Scott, W. M. *et al.* (2011). Observations of debris flows at Chalk Criffs, Colorado, USA: Part1, Italian Journal of Engineering Geology and Environment, 1: pp. 65-75.

Keywords: Debris flow, Debris flow detection, Bed pressure, Vibration, LVP sensor