A Study of the Stability of Sabo Dams Against the Debris Flow by Deep-seated Catastrophic Landslides

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INTRODUCTION

Many disasters occur due to deep-seated catastrophic landslides, such as a disaster in the Kii Peninsula of 2011. A deep-seated catastrophic landslide causes serious damage as it creates debris flows.

Regarding the Sabo plan for deep-seated catastrophic landslides, it is hard to say that enough proposals have been given to feasibility. An advanced evaluation technique is required to clarify of the disaster situation posed by the occurrence of a deep-seated catastrophic landslide and the potential ability of the Sabo plan to avert disaster.

In this study, we evaluated Sabo plans against a disaster due to a deep-seated catastrophic landslide in the Hayakawa River basin (**Fig. 1**). The Hayakawa River basin is located along the Itoigawa-Shizuoka Tectonic Line, to the west edge of the Fossa Magna where the Japanese Islands are divided into the Northeastern and Southwestern parts. The geology in this area is very fragile by the influence of faults, and sediment-related disasters occur frequently. There are many large sites of collapse in this area, such as the large-scale collapse of Mt. Shichimenzan.

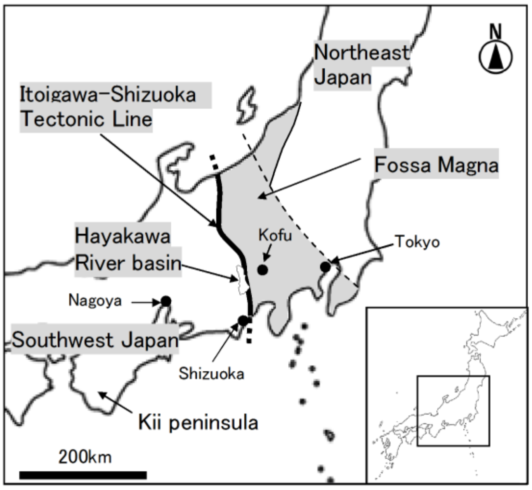

Fig. 1 Location map of the Hayakawa River basin

DISASTER DAMAGE SCENARIOS

The Harukigawa River basin is in the lower part of the Hayakawa River basin and has over 300mm/month rainfall on average in summer. The large-scale collapse of Mt. Shichimenzan is also located in this area.

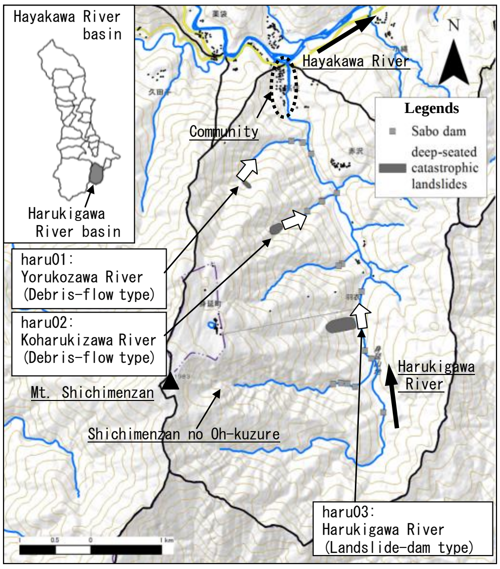

Fig. 2 Information map of disaster damage scenarios in the Harukigawa River basin

We proposed three types of disaster-damage scenarios (**Fig. 2**). The damage in a disaster scenario is related to the location of the deep-seated catastrophic landslide, volume, and disaster type. Disaster type is further divided into debris flow type (haru01, haru02) and landslide dam types (haru03).

NUMERICAL STUDY

(1) Debris flow hydrodynamic force

We calculated the debris flow hydrodynamic force by performing numerical calculations for each disaster damage scenario. We also estimated the debris flow hydrodynamic force at the upper site of the Sabo dam.

(2) Stability of the Sabo dams

We evaluated the stability of the Sabo dams against a debris flow hydrodynamic force due to a deep-seated catastrophic landslide.

RESULTS

(1) **Fig. 3** shows changes in debris flow hydrodynamic force with travel distance of scenario haru02 (debris flow type) for the existing Sabo dams. The debris flow hydrodynamic force occurring as a result of a deep-seated catastrophic landslide is much greater than that caused by heavy rainfall such as 150-years return period. In the steep grade section of the basin's upper Sabo dam (2), the debris flow hydrodynamic force would exceed 10,000 kN/m. The debris flow hydrodynamic force gradually decreases downstream at some distance from the Sabo dam (2). In community areas, the debris flow hydrodynamic force is projected to be less than 100 kN/m.

(2) The results obtained for all Sabo dam locations showed that the dams do not satisfy the critical stability requirement against calculated debris flow hydrodynamic force (**Table 1**). In the event that this disaster damage scenario occurs, all facilities would be destroyed, with damage extending into community areas.

Tab. 1 Debris flow hydrodynamic force acting on each Sabo dam in case of haru02

	Sabo dam(1)	Sabo dam(2)	Sabo dam(K1)	Sabo dam(K2)	Sabo dam(K3)
Peak dischrage (m^3/s)	1125	4681	5255	5331	5888
Maximum debris flow hydrodynamic force (kN/m)	242.2	4805.3	17894.5	7876.2	21583.6
Stability	N.G	N.G	N.G	N.G	N.G
Reconstruction plan	Possible	Impossible	Impossible	Impossible	Impossible

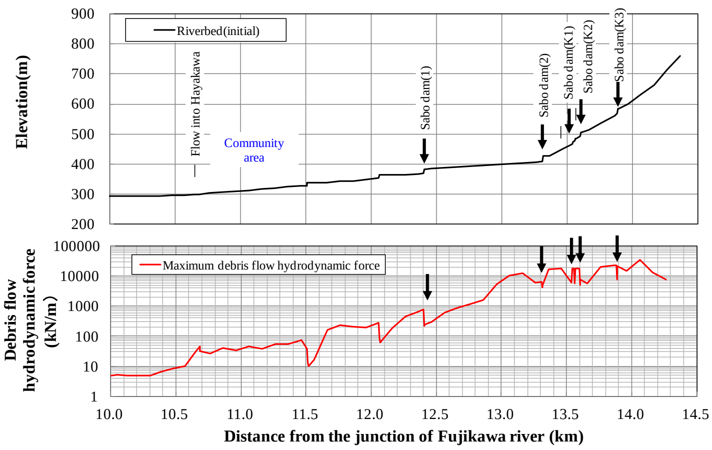

Fig. 3 Distribution of the debris flow hydrodynamic force along the river in case of haru02

CONCLUSIONS

In this case study, we examined locations around the Hayakawa River basin along a stream prone to deep-seated catastrophic landslides to evaluate the effects of debris flow hydrodynamic force and the stability of Sabo facilities.

Our results showed that steps should be taken to prepare appropriate reinforcement plans for locations where the Sabo dams fail to satisfy the stability requirement criteria against debris flow hydrodynamic force. Furthermore, it is desirable to plan new Sabo structures downstream, as our results confirmed that the debris flow hydrodynamic force would be greatly reduced downstream.

Keywords: Deep-seated catastrophic landslide, Stability of the Sabo dam, Sediment control works