Influence of Rainfall Characteristics on the Occurrences of Shallow Landslides in Four Areas

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INTRODUCTION

Large-scale shallow landslides and debris flows are occurring frequently. To mitigate the damage caused by these disasters, it is important to know hydrological processes occurring at the slopes and to estimate the possibility of the landslides using rainfall intensity data. Additionally, it is necessary to predict the scale and the density of these landslides. In this study, four disasters have been analyzed to clarify the relationships among landslide density, landslide scale and rainfall by using a tank model.

Tab.1 Precipitation characteristics of four disasters

Disaster name	Hiroshima disaster - 2014	Nachi River disaster - 2011	Hofu disaster - 2009	Hiroshima disaster - 1999
Total rainfall (mm)	247	833	332	234
Duration (hr)	10	88	21	23
Maximum 1 hour precipitation (mm)	87	132	64	81

Tab.2 The density and size of landslides for four disasters

Disaster name	Hiroshima disaster - 2014		Nachi River disaster - 2011	Hofu disaster - 2009	Hiroshima disaster - 1999
Geological features	Granite	Mudstone	Granite porphyry and mudstone	Granite	Granite
Basin area (km^2)	1.7	1.8	13.4	1.8	4.0
Landslide density (Number/km^2)	65	35	5	77	21
Rate of landslide area (%)	3.5	3.6	0.5	2.8	1.2
Average landslide depth (m)	1.1	1.2	2.1	1.0	1.1

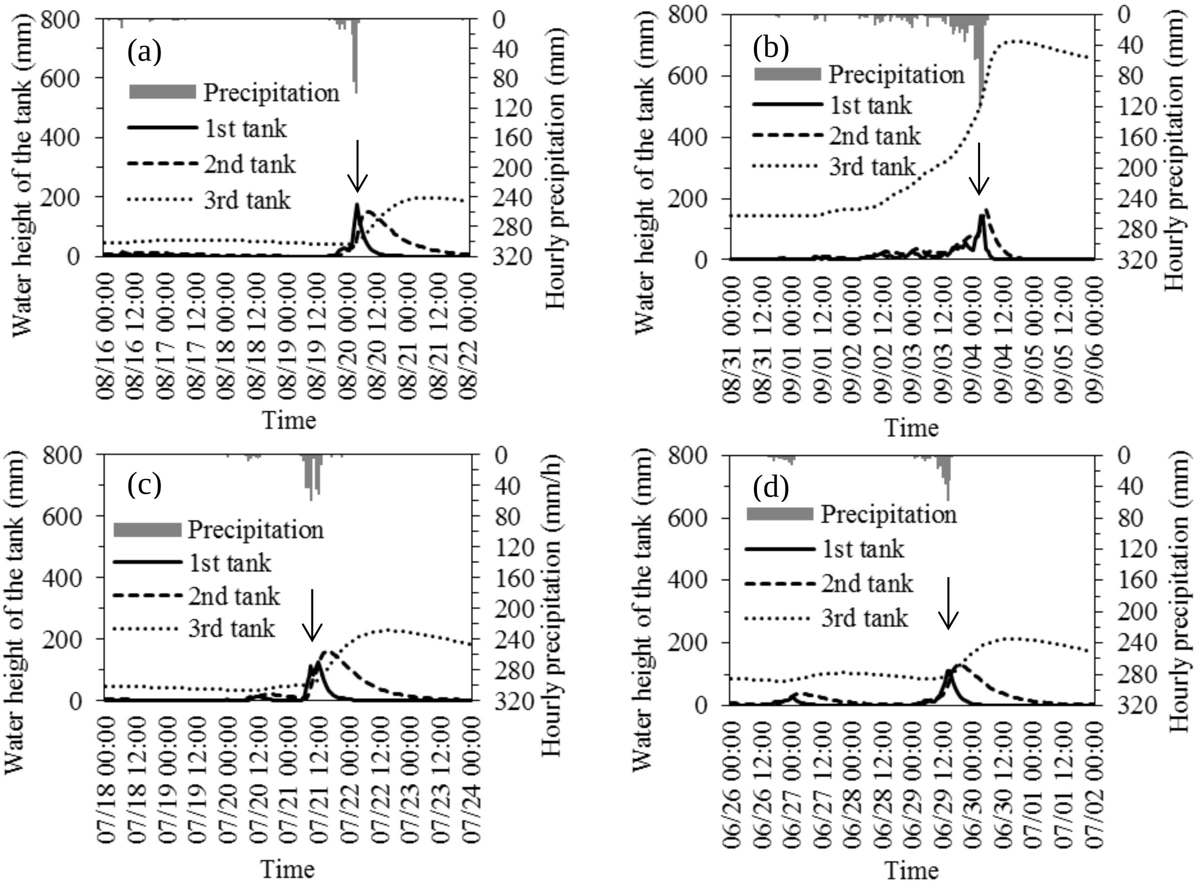

Fig.1 Calculation results of the tank model. (a) Hiroshima disaster in 2014, (b) Nachi River disaster in 2011, (c) Hofu disaster in 2009, (d) Hiroshima disaster in 1999. The arrow in the figure shows the time that the landslide occurred.

RELATIONSHIP BETWEEN RAIN PROPERTIES AND LANDSLIDE

The rain properties are shown in **Tab.1**. And, the landslide density, the rate of landslide area and the average landslide depth are shown in **Tab.2**. Although the Nachi River disaster was the most prominent, having the largest ‘total rainfall’ and ‘maximum 1 hour precipitation’, the ‘landslide density’ and ‘rate of landslide area’ were the smallest. However, the average landslide depth was much larger than that of the other disasters. These results suggest that hydrological processes exert a significant influence on the density and the depth.

CALCULATION RESULTS OF THE TANK MODEL

We calculated the hydrological processes of the slopes at the disasters using the tank model. We observed the water discharge of the sites and we determined the parameters. The calculation results are shown in **Fig.1**. About all disasters, the water height of the three tanks rose in response to the rainfall. Especially, the 2011 Nachi River disaster and the 1999 Hiroshima disaster, the water height of the third tank was high. Comparison with **Tab.2**, when the water height of the third tank was correspondingly low, the landslide density and the rate of the landslide area were high. Otherwise, when the water height of the third tank was correspondingly high, the landslide density and the rate of the landslide area were low. But, we could not explain why the landslide depth of the Nachi River disaster was thick.

Keywords: shallow landslide, precipitation, tank model, SCE-UA method