Simulation of Landslides and the Following Sediment Runoff in a Basin Scale

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1. INTRODUCTION

While the sediment disaster in mountain area usually occurred as multi-modal type, most of the existing warning system only considered the single sediment disaster individually. In past years, some casualties, e.g. deep-seated landslide in Shaolin village in Taiwan during Typhoon Morakot in 2009, showed the single disaster prevention plan cannot tackle the risk under the extreme climate situation. This study integrated the slope stability analysis, discharge, and sediment runoff model to simulate the multi-modal sediment disaster in a basin scale. The results not only offered the verification of the disaster prevention plan but also provided the foundation of developing the multi-modal disaster warning system.

2. METHOD

The study established the structure of multi-modal sediment disaster simulation by integrating the several modules (**Fig.1**). The rainfall-infiltration module adopts the Richard's equation to simulate the infiltration and water flow through the soil. The result of infiltration analysis which was calculated by the finite element method will be used to conduct a slope stability analysis simultaneously. A simplified Janbu method and dynamic programming (DP) method were used to determine the critical slip surface and the factor of safety Fs. The surface runoff and sub-surface runoff from the slopes in the basin offered the input discharge to calculate the river discharge, sediment runoff, and the change of the riverbed elevation. Moreover, the landslides in the simulation also provided the sediment in the riverbed evolution.

The case study area was located in Senokuchi area, Taketa, Oita Prefecture, and 50 slopes as well as 37 sub-watersheds were used to simulate. Two kinds of extreme rainfall data, i.e. high rainfall intensity and long rainfall duration, were exploited in this study (**Fig. 2**).

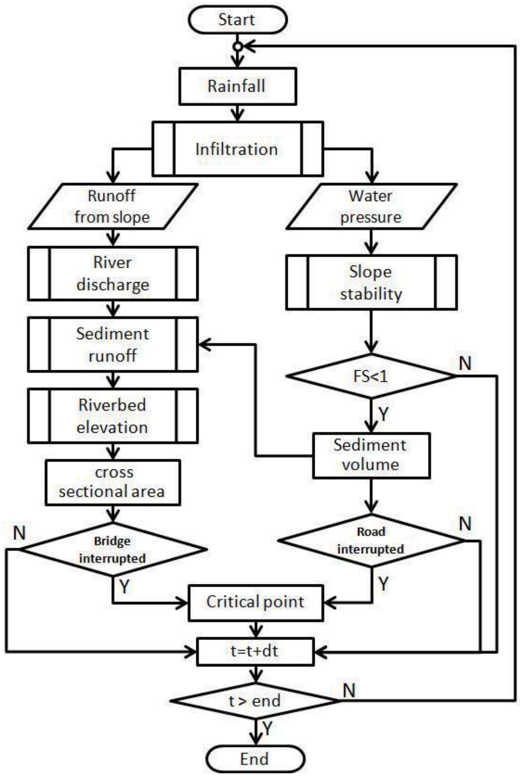

Fig. 1 The structure of multi-modal sediment disaster simulation

3. RESULTS

3.1 Case1: High rainfall intensity

The peak of river No.37 discharge was 2 hours later than the peak of rainfall, and 6 landslides occurred in 52~58 hours (**Table 1** and **Fig. 2)**. Due to the larger landslide sediment from the slope and higher rainfall intensity, the river No.30 had remarkably much sediment runoff. The main rivers and landslide places were shown as **Fig. 3**.

3.2 Case2: Long rainfall duration

Comparing with case1, the discharge and sediment runoff in case 2 was less evidently. In addition, although the number of landslides was less than case1, the scale of landslide in case2 was obvious larger than in case1 (**Table 1**).

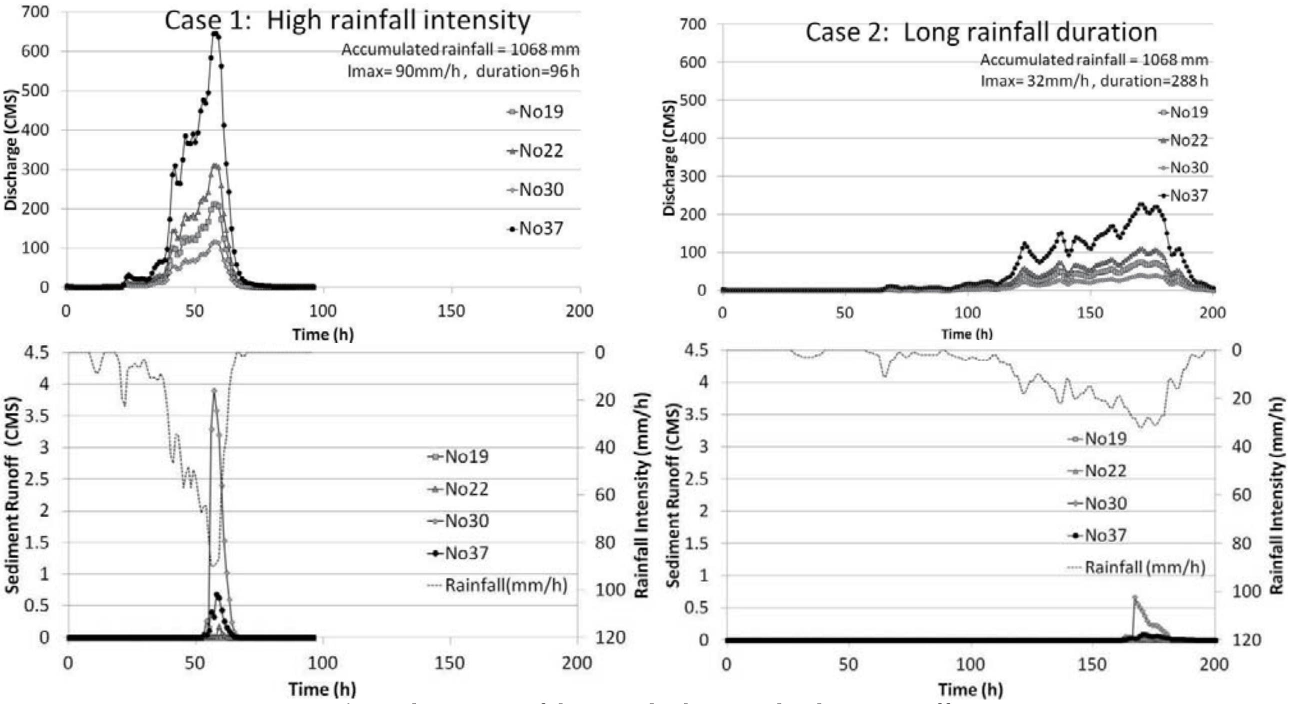

Fig. 2 The process of the river discharge and sediment runoff

Table 1 The occurring time and sediment volume of the slope failure in the basin

Case 1			Case 2		
No.	Occurring time [h]	Sediment volume [m^3]	No.	Occurring time [h]	Sediment volume [m^3]
20	52.45	13,392	20	161.85	54,450
29	53.08	30,567	30	166.23	1,015,560
30	53.47	249,984	29	167.50	212,220
4	54.93	46,816	4	173.33	79,800
34	57.57	84,000	-	-	-
22	58.23	145,530	-	-	-

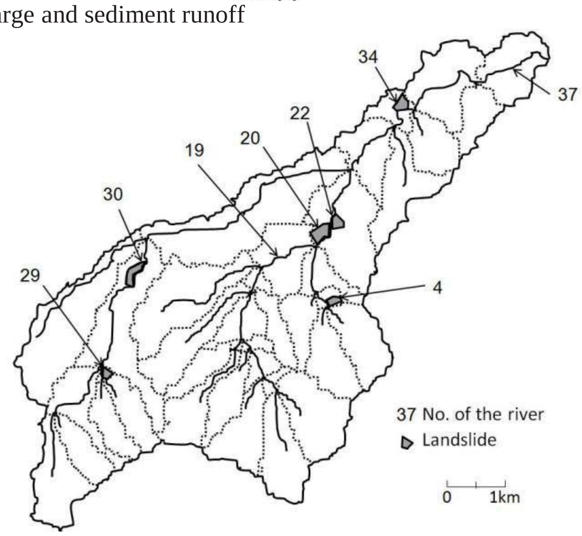

Fig. 3 The main rivers and landslide places

4. DISCUSSION

Although the accumulated rainfall was same in case 1 and case 2, the discharge and sediment runoff was totally different. According to the simulation result, the max discharge of the river No.37 in case1 was about 2.8 times as large as in case2. In spite of the larger scale landslide from the slope next to the river No.30 in case2, the sediment runoff in river No.30 is only about 1/6 of the case1 because of the less water discharge. It is worth noticing that the landslide sediment into the river No.30 is up to 10^6 m^3 in case2. Such huge landslide sediment coming down the river, the natural dam maybe occurred.

Keywords: Sediment disasters, simulation, evacuation, warning system

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