EFFECT OF EXISTENCE OF HOUSES ON INUNDATION AREA OF DEBRIS FLOW

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ABSTRACT

It is expected that the number of occurrences of debris flow will increase due to the effects of global warming, in residential area, it is required to understand the flow characteristics of debris flow. In this study, two dimensional debris flow numerical simulation considering destruction process of houses is performed and effect of houses on the inundation area of debris flow is discussed. The simulated debris flow was occurred in Yagi 3 Chome, Asaminamiku, Hiroshima, Japan in 2014 and it destructed a lot of houses. The developed numerical analysis model can reproduce the horizontal distribution of complete/partial destruction of houses. If the houses in the inundation area are neglected, debris flow spreads widely and forms debris flow alluvial fan. As a result, the difference of inundation area between with house case and without house cases becomes large. This information must be important for evacuation act, when it is difficult to evacuate to far refuge under heavy rain conditions.

Keywords: Debris flow, Destruction of house, Numerical analysis, Hazard map, Sediment disaster

1. INTRODUCTION

In recent years, sediment disasters that houses are destructed by debris flow are occurred frequently. In the future, it is expected that the number of occurrences of debris flow will increase due to the effects of global warming, in residential area, it is required to understand the flow characteristics of debris flow, and to take effective measures and evacuation based on it. In this study, focusing on the debris flow that occurred in Yagi 3 Chome, Asaminamiku, Hiroshima , Japan in 2014 (Figure 1) when some of the houses in the residential area were completely or half destructed, two-dimensional debris flow numerical simulation considering the destruction process of houses is performed, and the effect of the existence of houses in the inundation area of debris flow is discussed.

Figure 1. The debris flow that occurred in Hiroshima in 2014 (by MLIT)

2. OVERVIEW OF NUMERICAL SIMULATION

2.1 Overview of the model

In this analysis, the constitutive equations of Egashira *et al.* (Egashira *et al.* 2004) and the two-dimensional debris flow analysis model (Takabayashi *et al*. 2020) considering the turbulent flow region over the laminar flow region are used. The debris flow is generated by the slope failure. The development, transport and deposition processes are analyzed with the two-dimensional model. The shape of a house is represented by multiple analysis grids, and the stress acting on the house is determined by calculating the force acting on each analysis grid and is used to determine the destruction/non-destruction of the house. This is because many houses that were actually destructed by debris flow were half destructed, the house shape was easily changed, and the entire house did not behave like a single rigid body. The stress F_{hx} per unit width of the flow direction, acting on the analysis grid of the house, is evaluated by the sum of the static pressure due to debris flow and the fluid force by kinetic energy acting on the house as follows.

$$F_{hx} = \frac{1}{2}\rho_m g h^2 \cos\theta + \rho_m h u^2 \tag{1}$$

where, ρ_m is the density of mixture of water and sediment, g is the gravity acceleration, h is the flow depth, θ is the bed slope, and u is the depth integrated flow velocity. The house destruction critical stress per unit width seems to vary depending on the house structure. In this analysis, 800 kN/m was applied to all wooden houses as the house destruction critical stress per unit width.

2.2 Analysis conditions

The analysis grid is 2 m square grid. Three types of analysis conditions were used: Case1: analysis considering the destruction of houses; Case2: analysis treating houses as impervious non-destructive structures; and Case3: analysis that disregarding the existence of houses. The destruction of houses was assumed to occur only in wooden houses, and not in RC structure houses. A house is represented by multiple analysis grids, and only the part exceeding the destruction critical is determined to be destructed. Therefore, the half or partially destructed house can be evaluated.

3. RESULTS AND DISCUSSION

Figure 3 shows the horizontal distribution of the amount of change in ground height in the residential area after the debris flow obtained in Case 1, which was superimposed on the photograph after the disaster. The portions shown in blue in the figure 3 are the portions where houses are determined to have been destructed. In the house area A located directly downstream of the mountain stream exit, the analysis results show that all houses were completely destructed. In the house area B located further downstream, some houses were completely destructed, and others were half destructed. In the house area C located further downstream, no house was determined to be completely destructed, but some houses were partially destructed. Therefore, we can see that the calculated results match the photograph after the disaster.

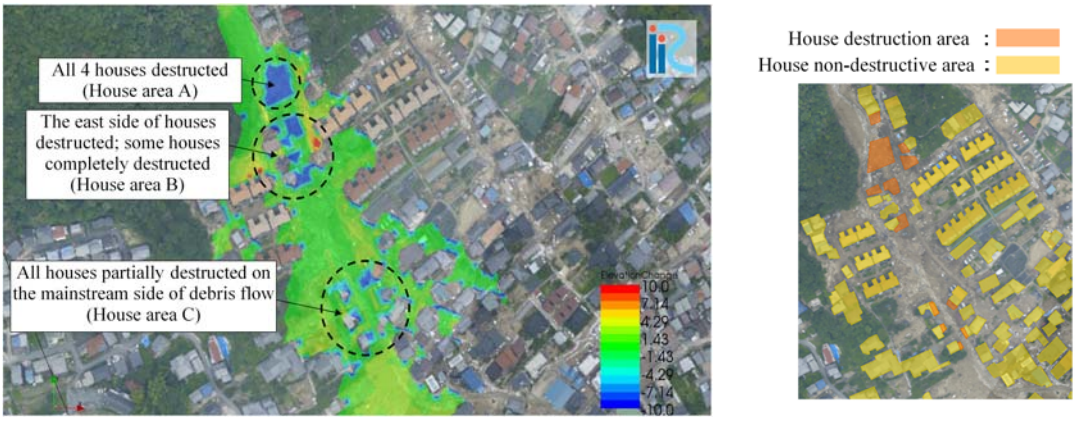

Figure 3. Reproduction of house destruction (Case 1)

4. CONCLUSIONS

In this study, focusing on the debris flow that occurred in Yagi 3 Chome, Asaminamiku, Hiroshima in 2014 when some of the houses in the residential area were completely or half destructed, two-dimensional debris flow numerical simulation considering the destruction process of houses was performed, and the effect of the existence of houses on the inundation area of debris flow was examined. As a result, this numerical simulation model seems to be able to reproduce the state of complete or half destruction of houses relatively well, and to some extent to be able to evaluate the possibility of complete or half destruction of houses due to debris flow.

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