The Influence of Countermeasure on Debris Flow Hazard with Numerical Simulation

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1. Introduction

In Taiwan, debris flows occur frequently in mountain areas during heavy rainfalls or typhoons. Debris flow hazards often cause a lot of damages of infrastructure and loss of property as well as human lives. They are severe threats to people who live near the debris flow torrent. To mitigate debris flow hazards, the government often constructs countermeasures in potential debris flow torrents. The most adopted one is to build one or a series of check dams (also called sabo dam) (Takahashi, 2007).

For decades, researchers have studied the efficiency and design criterion for check dams in different aspects such as types, size, numbers and locations. A brief literature review for numerical simulation for the effect of check dams is given as follows. Busnelli et al. (2001) conducted numerical modeling and experiments to study the erosion and deposition patterns on sediment transport through a slit-check dam. Armanini and Larcher (2001) theoretically derived a relationship among opening width, river geometry, sediment characteristics, and water and sediment discharges for designing a slit-check dam. Then, Catella et al. (2005) applied the above model to analyze the efficiency of slit-check dam. The result agreed with the field evidences collected from 2-years monitoring activities. Remaître et al. (2008) applied the above model to analyze the efficiency of slit-check dam. The calibrated yield stress for in-situ material is 750 Pa. Without countermeasure, the simulated result is shown in Fig. 1(b) and shows that two residential houses and county roads are invaded by debris flow. In order to protect the houses we set two closed-type check-dams downside the masses, see details of locations and dimensions in Table 1. As is in Fig. 1(d) the simulated result shows that the Dam 1 blocked all debris flow (1,968.2 in volume) from its upstream. For Mass 3, only 75.2 % of total volume (i.e., 2585.6) is stopped by Dam 2, and only the county road is covered by debris flow. For this case, the volume behind dam 2 is enough to store all mass from location 3. If using a 1-D program, one would obtain a completely safe result.

2. Case study

The Taipei DF024 debris flow torrent is located at east-northern part of Taipei city. There are three branch tributaries in this torrent with average length of 950 m and average slope of 36 %. The total watershed area is 31 ha. From field survey results (Liu et al., 2013) three potential masses are distributed along the midstream, as shown in Fig. 1(a). The total volume of debris flow in this torrent is 5,406 m³. The simulated result can provide the two-dimensional assessment. As two-dimensional debris flow model is required for more precise evaluation of check-dam design, we adopt the Debris2D (Liu and Huang, 2006), a two-dimensional debris-flow model, to assess the influence of check-dam on debris flow hazards. In Taiwan Debris2D is widely applied to debris flow assessment and proven to be a practical and reliable simulation tool (e.g., Liu et al., 2009; Liu et al., 2013). In this study, a case of Taipei DF024 potential debris flow torrent is presented for studying the influence of countermeasure on debris flow hazards.

3. Concluding remarks

We present the numerical simulation of the influence of closed check-dam on debris flow hazard with case study. As the simulated result can provide the two-dimensional
affected area with or with countermeasure, the efficiency of closed check-dam can be evaluated more accurately according to local geometry.

Acknowledgements

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References


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Fig. 1. a) Aerial photo of DF024 with initial mass distribution, the volumes of Mass 1 to 3 are 1,432.8, 535.4, 3,473.8 m$^3$, respectively. b) final deposition (at 593 second) without countermeasure; c) locations of two check dams (see Table 1 for details); d) final deposition (at 288 second) with two check dams. Blue Rectangles indicate houses; Pink line is county road; Light blue line is center line of DF024. The upper part is the upstream of the debris flows.