Small Fish-pond Design for Debris flow Disaster Measure with Kanako-2D

Masato KOBIYAMA[1*], Rossano D.L. MICHEL[1], Maurício A. PAIXÃO[1] and Gean P. MICHEL[1]

[1] Hydraulic Research Institute, Federal University of Rio Grande do Sul, Brazil
[*] Corresponding author. E-mail: masato.kobiyama@ufrgs.br

INTRODUCTION

Without adequate planning, expansions of agriculture, forestry, ecotourism, urbanization, water resources exploration, hydroelectric power plant construction have been accelerated in mountainous regions in Brazil. Then, it results in the significant increase of debris flow disasters in this country.

Japan and other countries tend to construct check dams against these disasters. Mountainous and rural regions in Brazil have farmers´ villages which do not usually receive much support from municipal, state and federal governments. Under such economic circumstances, these farmers have not been able to construct check dams, which requires simple and low-cost measures for Brazilian mountainous and rural communities. Therefore, the objective of the present study was to investigate the simple fish-pond design for debris flow disasters reduction by using the Kanako-2D model. As these ponds are small, simple and popular among farmers, their construction can be one of the solutions for debris flow disaster measures in Brazil.

MATERIALS AND METHODS

The study area is the Böni creek catchment (2.27 km^2) located at the border between São Vendelino and Alto Feliz municipalities, southern Brazil. In December 2000, a rainfall-triggered debris flow occurred in this catchment, causing various damages with the death of 4 persons. In July 2016, field survey with GPS navigator was carried out in order to delimit the scars of this debris flow, to identify its three zones: source, transport (1D channel) and deposition (2D area), to estimate the total sediment volume flowing into the channel, and also to establish the common input parameters for all the simulations which are shown in **Tab.1**.

Tab.1 Input data for Kanako-2D simulation

Parameter	Value	Parameter	Value
Simulation time	1800 s	Angle of internal friction	37º
Simulation time step	0.01 s	Concentration of movable bed	0.65 m^3/m^3
Diameter of material	0.45 m	Manning´s coefficient	0.03 $s/m^{1/3}$
Mass density of bed material	2650 kg/m^3	Interval of 1D calculation points	23 m
Mass density of fluid phase	1000 kg/m^3	1D calculation points	5
Coefficient of erosion rate	0.0007	1D calculation width	15 m
Coefficient of deposition rate	0.05	Mesh size of 2D calculation	2.5 m x 2.5 m
Sediment concentration	50%	2D calculation points	472 x 196

The terrain information files generated from the digital elevation model with an element size of 2.5 m x 2.5 m were used for the Kanako-2D simulations. To determine a locality and size of fish-pond along the channel in the catchment, 5 different scenarios were simulated: Case 0 - no pond;

Case 1 - existing pond P1 (6850 m^3 = 3425 m^2 x 2 m); Case 2 – planned pond P2 (6300 m^3 = 35 m x 45 m x 4 m); Case 3 – planned pond P3 (7000 m^3 = 50 m x 35 m x 4 m); and Case 4 – planned pond P4 (30,000 m^3 = 100 m x 60 m x 5 m). The locality of P2 and P3 is about 100 m upstream from P1, and P4 about 400 m upstream from P1.

For all the simulation, the total sediment volume into the transport channel was calculated 20,000 m^3 with the field survey data. Based on methods of Whipple (1992) and Rickenmann (1999), the present study considered that the triangular hydrograph duration is 99 s and that the peak flow, whose estimated value is 382 m^3/s, occurs at 33 s.

RESULTS AND DISCUSSION

The Case 0 satisfactorily reconstructed the deposition areas occurred in the 2000´s debris flow disaster (**Fig.1a**). Just after this disaster, local farmers constructed one simple fish-pond (P1). Then the Case 1 verified P1´s performance against the same debris flow occurrence, demonstrating that P1 could totally stop the sediment flow. However, it is observed that a part of the sediment reached an existing house (**Fig.1b**), which suggests that the pond should be constructed more upstream. **Fig.1c** demonstrates that the P2 could stop all the sediments and its volume is less than that of P1. The P3 whose volume is larger than that of P2 and whose orientation is different from that of P2 also stopped all the sediment (**Fig.1d**). Though the P4´s volume is very large, it could not effectively store the sediment because of the high flow velocity at P4 (**Fig.1e**). The results permit to say that the P2 is the best design for debris flow disaster reduction in the Böni creek catchment.

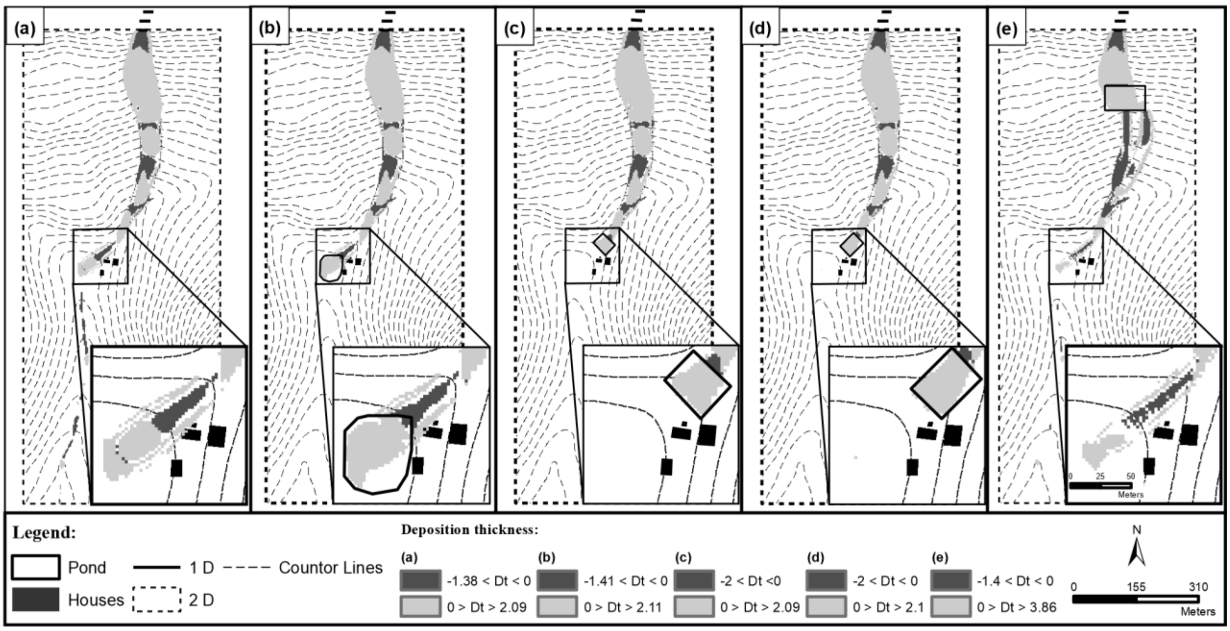

Fig.1 Deposition areas of debris flow in Böni creek catchment with 5 different cases: (a) Case 0; (b) Case 1; (c) Case 2; (d) Case 3; and (e) Case 4.

CONCLUSIONS

The debris flow triggered by a heavy rainfall in the Böni creek catchment in 2000 was investigated with the Kanako-2D. The model showed the good performance to reconstruct the deposition area. The simulation investigation allowed finding the locality and size of simple fish-pond to reduce the debris flow disasters.

Keywords: Kanako-2D, debris flow, fish-pond design, southern Brazil.