

# Evaluation of Slope Effects on the Debris Flow Deposition Length by Using Kanako-2D

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## INTRODUCTION

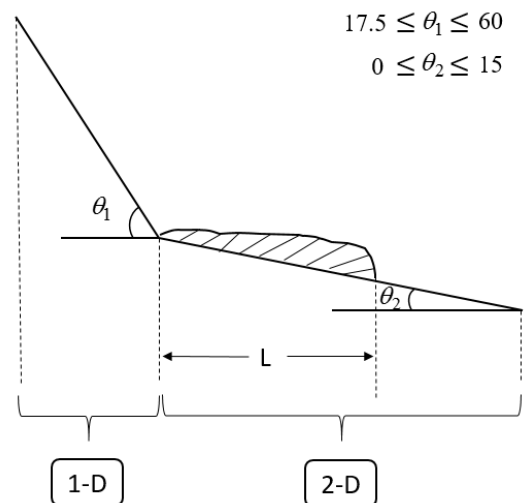
Debris flows have been causing serious disasters in the world. They are considered one of the most dangerous mass movements due to their high destructive power, high velocities, and long reaching distances. The most strongly-affected areas by debris flow are the deposition areas over the alluvial fans, which requires more efforts to improve the prediction of the length that a debris flow can reach.

Factors that influence on the debris flow development are: soil characteristics, flow properties, topographic conditions, and so on. And the terrain declination (slope) is one of the main factors for such conditions. Over many decades various researchers have explained the influence of terrain declination on the debris flow length, and now it is well known that topography strongly affects this phenomenon. In general, these attempts have been done with physical models and not computational ones. Hence, it is noted that the prediction of the debris flow length in the deposition area have not been completely accomplished.

In order to evaluate the slope effects on the debris flow deposition length, the present study used the computational model Kanako-2D proposed by Nakatani et al. (2008). The model was chosen because it is free available and GUI-equipped, which allows greater access of the communities that need to increase the mapping of susceptible areas to debris flow occurrence, especially in countries that do not have good management of sediment-related disasters. For a convenient analysis, hypothetical terrains characterized by different transport channels and deposition areas whose declinations altered were adopted.

## MATERIALS AND METHODS

The Kanako-2D approaches the debris flow from its entrance into the transport channel with one-dimensional equations and its propagation and deposition over the alluvial fan with two-dimensional equations. The model is governed by equations of continuity, momentum, deformation at bed channel, erosion/deposition and shearing stress at bed channel. The present study considered hypothetical terrains ideal, which means that they have constant declination along the transport channel (1-D) and deposition area (2-D). **Fig. 1** shows a scheme of hypothetical terrains. The slope values used for the transport channel ( $\theta_1$ ) were 17.5, 20.0, 22.5, 25.0, 27.5, and 30.0° meanwhile the values for the alluvial area ( $\theta_2$ ) were 0, 5, 10 and 15°. The deposition length ( $L$ ) is defined as the horizontal length from the transport channel end to the final depositional point.



**Fig. 1** Hypothetical terrain used for simulations.

A combination between  $\theta_1$  and  $\theta_2$  resulted in 24 simulations. The values of all the input parameters for the simulations were exactly equal to those of the default presented in Kanako-2D (<http://www.stc.or.jp/10soft/003Eframe.html>), and the mesh-size of 2-D area was 2.5 x 2.5 m. For each simulation the  $L$  value was measured. It was considered a triangular hydrograph with 20 s ascension and 40 s recession. The peak discharge considered was 160 m<sup>3</sup>/s.

## RESULTS AND DISCUSSION

**Table 1** demonstrates the  $L$  values corresponding to 24 different combinations of  $\theta_1$  and  $\theta_2$ . It is clearly observed that the  $L$  value is more dependent upon the deposition area declination than the transport channel slope. When  $\theta_2$  is constant, the variation of the  $L$  values is very small even though  $\theta_1$  is changed. The relation between  $\theta_1$ ,  $\theta_2$  and  $L$  can be expressed as follows:

$$L = 7.41 \cdot \theta_1^{-0.0761} + 0.53 \cdot \theta_2^{2.0048}$$

The results presented  $R^2 = 0.97$ . The steeper the deposition area, the larger the deposition length of debris flow.

**Tab. 1** Simulation results

| $\theta_1$ (°) | $\theta_2$ (°) | $L$ (m) | $\theta_1$ | $\theta_2$ | $L$   | $\theta_1$ | $\theta_2$ | $L$   |
|----------------|----------------|---------|------------|------------|-------|------------|------------|-------|
| 17.5           | 0              | 54.6    | 22.5       | 0          | 52.5  | 27.5       | 0          | 52.5  |
| 17.5           | 5              | 75      | 22.5       | 5          | 65    | 27.5       | 5          | 67.5  |
| 17.5           | 10             | 120     | 22.5       | 10         | 87.5  | 27.5       | 10         | 87.5  |
| 17.5           | 15             | 182.5   | 22.5       | 15         | 170   | 27.5       | 15         | 170   |
| 20             | 0              | 60      | 25         | 0          | 60    | 30         | 0          | 60    |
| 20             | 5              | 80      | 25         | 5          | 82.5  | 30         | 5          | 80    |
| 20             | 10             | 122.5   | 25         | 10         | 117.5 | 30         | 10         | 122.5 |
| 20             | 15             | 182.5   | 25         | 15         | 185   | 30         | 15         | 187.5 |

## CONCLUSIONS

Applying the Kanako-2D to the hypothetical terrains, the present study investigated the effects of slope conditions on the deposition length. The simulation results permit to confirm that the debris flow deposition length becomes larger when the alluvial area is steeper. It is necessary to carry out more investigation on the runout conditions in order to comprehend the reasons why the transport channel slope does not significantly affect the deposition length of the debris flow.

## REFERENCE

Nakatani, K.; Wada, T.; Satofuka, Y.; Mizuyama, T. (2008) Development of “Kanako 2D (Ver.2.00),” a user-friendly one- and two-dimensional debris flow simulator equipped with a graphical user interface. *International Journal of Erosion Control Engineering* 1(2): 62-72.

**Keywords:** Kanako-2D, debris flow, slope, deposition length, hypothetical terrain.