Case Study of the Debris Flow Disaster and Influence Zone Simulation in Renhe Village, Taiwan

Chia-Hsing Lin (林家興), Jyun-Wei Chen(陳均維), Kuo-Wei Chen(陳國威), Chen-Yu Chen(陳振宇)
Soil and Water Conservation Bureau, Taiwan (台湾水土保持局)

1. INTRODUCTION

On 16 Aug, 2019, a debris flow occurred at 5:40 AM and rush into downstream village in Nantou County and caused 5 residential house and 2 bridges were destroyed. The in-situ survey showed that the amount of deposited sediment was estimated 45,000 m3. A two-dimensional debris flow model based on the constitutive equation derived from energy conservation and is suitable for debris flow and sediment laden flow was applied. To analyze the debris flow disaster and influence zone, this study uses the digital elevation model (DEM, Fig. 1) prior to the event was set as initial topographic data and field investigation data and the posterior DSM (Fig. 1) was produced by UAV aerial-photo to verified the simulation result. The numerical model can estimate the characteristics of debris flow hazard zone, flow velocity, and deposition depth. The simulated result can provide public agencies with necessary information for disaster prevention and mitigation plan

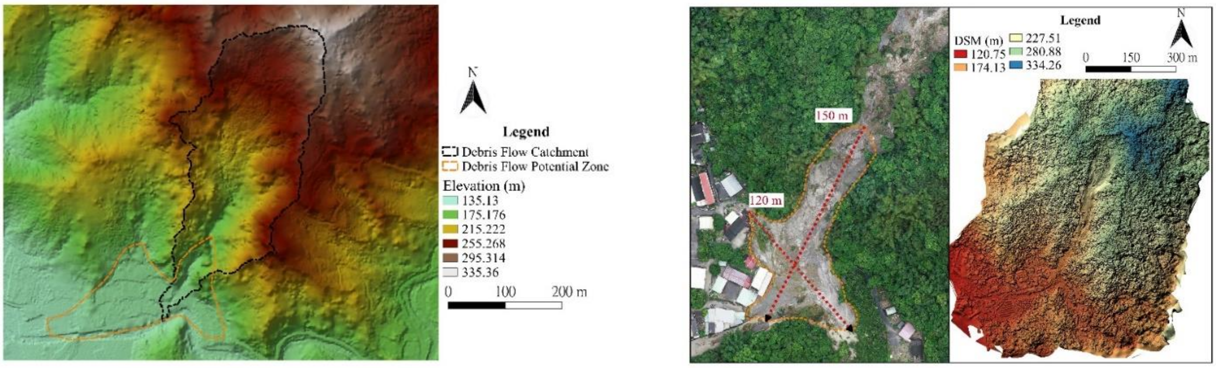

Fig. 1 Location of the study area: (left) Digital Elevation Model, (right) Aerial-photo and Digital Surface Model.

2. MATERIALS AND METHOD

(1) Site condition

The debris flow occurred in the early morning at 5:40 AM (August 16, 2019) and the precipitation was accumulated up to 274 mm (ZhongLiao Rain Gauge, C0H950) and 261 mm (MingJian Rain Gauge, C0I410) over two days. The landslide area was 1.44 ha with 240 m in length, 60 m width, and about 5 m depth in averaged. The amount of landslide volume was estimated 72,000 m^3. The debris flow formed a deposition zone of 150 m long, 120 m width, and averaged deposition depth 4 m in downstream village. To analyze the debris flow influence zone, this study uses the digital elevation model (DEM, resolution 1 m x 1 m) and high-resolution digital surface model (resolution 0.1 m x 0.1 m) data derived by UAV-photo.

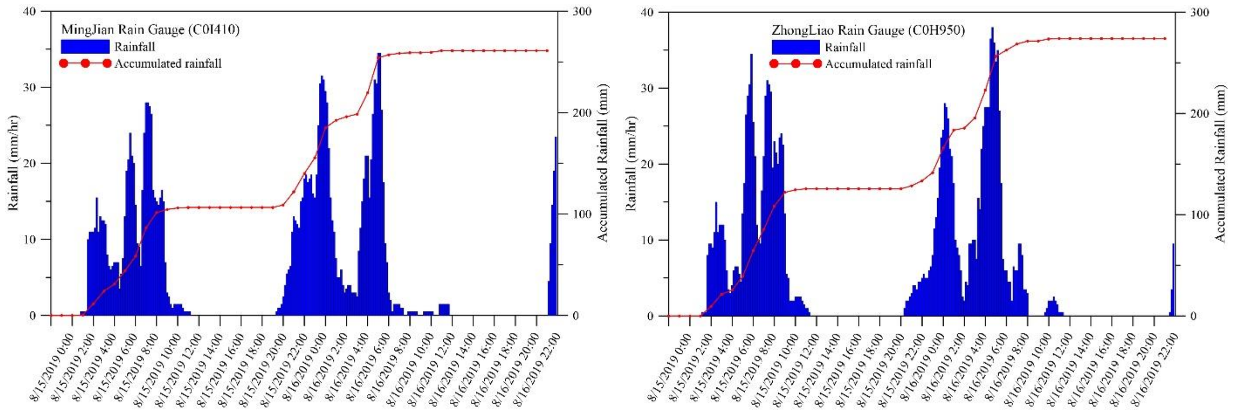

Fig. 2 Rainfall hydrograph: (left) MingJian Rain Gauge, (right) ZhongLiao Rain Gauge.

(2) Scenario of debris flow simulation

This study applied the Hyper KANAKO 2D system for debris flow disaster simulation with consider the narrow notch effect. The Hyper KANAKO model can be divided into three steps to setup debris flow numerical simulations. The geometry data was obtained from digital elevation model and convert into a gridded mesh format with considering altitude, river width, movable bed, and Sabo dam condition. The boundary condition is supplied hydrograph and sediment concentration at upstream. Once the simulation was complete, the model estimated result including flow depth, riverbed variation, and discharge of flow and sediment. The results can be viewed within QGIS for debris flow deposition thickness, flow depth, maximum value, and fluid force.

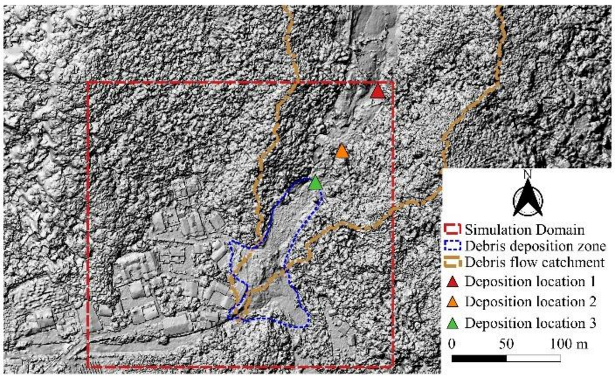

Fig. 3 Study map of the simulation domain

Table 1 Parameters of the simulation

Case Number	Deposition location	Water supply discharge	Model parameter		
		Q_p (m^3/s)	n	d	C
Run 1	Location 1	10	0.03	0.001	0.2
Run 2	Location 2	10	0.03	0.001	0.2
Run 3	Location 3	10	0.03	0.001	0.2
Note	Q_p: Peak discharge; d: Diameter of material(m); C: Concentration (-); n: Manning's roughness coefficient (s/m$^{1/3}$)				

The simulation has been made consider the different particle size and debris flow started to deposit location. Based on the field survey data, the simulation domain could be identified as **Fig. 3**. The parameters used in the model were listed in **Table 1**, the mesh size is 1 m x 1 m and the number of grid point is 39204. The hydrograph of the discharge could be estimated by the rational formula and imposed as the upstream boundary condition for debris flow influence analysis.

3. RESULTS AND DISCUSSIONS

The result of the simulation indicates that deposition fan is observed in the outlet of debris flow potential creek. The maximum deposition thickness is near the narrow notch of the creek is about 9 m and in the village is 5 m. The result showed that the different deposition location affects the debris flow transport and deposition formation. The debris flow started to deposit upstream and near the narrow notch didn't fit the field survey results and just near the downstream narrow notch fits well. In case Run 1, the deposition occurred above the narrow notch, the sediment trap mostly upstream of the notch. In case Run 2, the deposition occurred just about the narrow notch, the sediment trap evenly upstream and downstream of the notch. In case Run 3, the deposition occurred just downstream the narrow notch, the sediment transport along the creek and into the village (Fig. 4).

4. CONCLUSIONS

Hyper KANAKO 2D has a graphic-user-interface combined with QGIS for debris flow disaster analysis and it can easily setup the model to estimate impact of a potential debris flow creek. In this preliminary study, the simulating of deposited area, depth, flow velocity, and outflow were calculated. The result indicates that the narrow notch affects the debris flow deposition zone. Through this case study, the debris flow impact simulation depends on the detail field survey and also need to consider the effect of narrow notch and house. The simulation results can support necessary information for officials to planning evacuation plan.

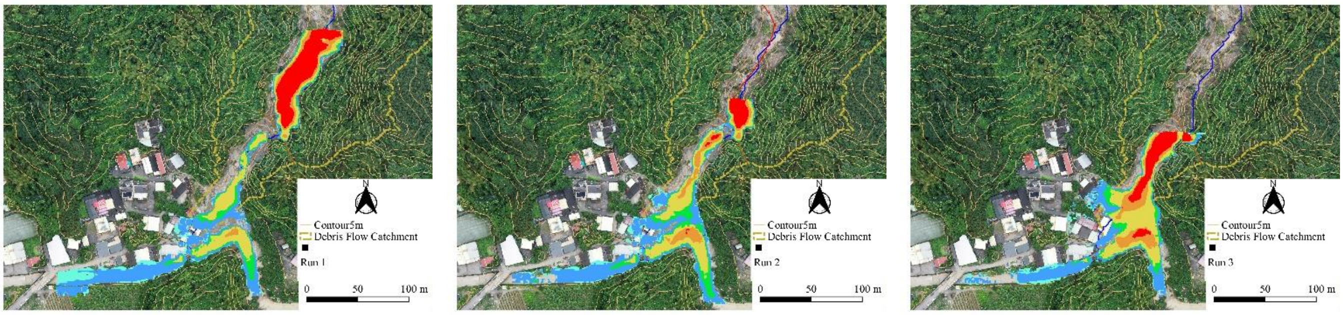

Fig. 4 The Hyper KANAKO simulation results: (up-left) Run 1, (up-right) Run 2, (down-left) Run 3, (down-right) Run 4

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Keywords: Debris flow, Field survey, Effect of notch, Two-dimensional simulation.