

Development of Visualized Integrated Rainfall-Infiltration-Slope stability (IRIS) model

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1. INTRODUCTION

Rainfall is one of the most common causes of landslides. To understand the mechanism, occurring time and scale of landslides triggered by rainfall, the environment survey, setting up monitoring systems and establishing numerical simulation are the essential method to reduce casualties. According to the past case studies, the integrated rainfall-infiltration-slope stability model (IRIS model) can be applied to simulate the process of landslides during rainfall, and it is able to predict the occurring time and scale of landslides. This study improves the existing unfriendly user interface of IRIS model, and develops the visualized tool to display the change of water pressure in the soil and critical slip surface of landslide simultaneously.

2. MATERIALS AND METHODOLOGY

(1) Integrated Rainfall Infiltration Slope stability (IRIS) model

This study used the Integrated Rainfall-Infiltration Slope stability (IRIS) model to conduct the slope stability analysis. The IRIS model is divided into three stages. Firstly, the variation of water content is described by Richard's equation, performing finite-element method to solve the process of rainfall-infiltration. Secondly, the concept of limit equilibrium using Janbu's simplified method is utilized for slope stability analysis. Afterward, the critical slip surface is determined by dynamic programming method. (**Fig. 1**).

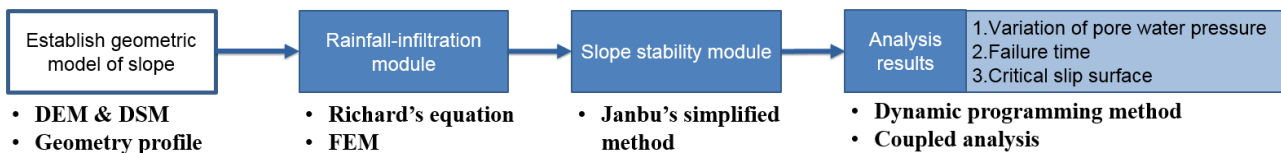


Fig. 1 The operating procedure of Integrated Rainfall Infiltration Slope stability (IRIS) model.

(2) Framework of visualized IRIS model

While the IRIS model had been verified the applicability for the simulation of landslides triggered by rainfall, its user interface was unfriendly (Tsutsumi and Fujita, 2008; Chen and Fujita, 2014). This study established a visualized user interface for IRIS model, and it is easy to use based on step by step procedure (**Fig. 2**). Moreover, the program of visualized IRIS model also offers the function of exporting dynamic GIF which can not only express the change of water content of soil but also the critical slip surface during simulation.

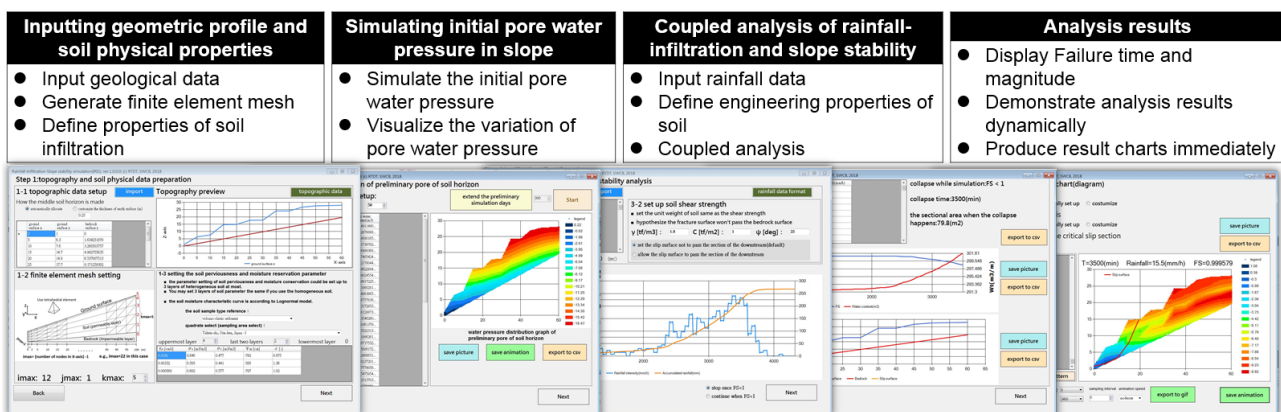


Fig. 2 The framework of visualized IRIS model.

(3) Case study

In this study, a landslide occurred at Wushen temple in Nantou, Taiwan will be introduced. During the torrential rainfall, a landslide near Wushen temple in Guoxing township, Nantou was occurred at 3:00 p.m. on 15th June in 2017. According to the precipitation in Changfeng rainfall station, which was the closet rainfall station to Wushen temple, the accumulated rainfall at slope failure time was 275 mm. In order to establish a post-disaster survey report, an unmanned aerial vehicles (UAV) has been used to investigate and measure the spatial information of this landslide. Afterward, a digital surface model (DSM) would be produced and used

to map the landslides zone. Moreover, the digital elevation model in 2011 which before disaster is used to compare with the digital surface model mentioned in post-disaster survey for estimating the landslide volume. Therefore, the landslide volumes can be estimated by the area and change of height. After estimating, the area of erosion equals 2,729 m² and the landslide volume equals 19,278 m³ (**Fig. 3**). The parameters used in the simulation were listed in **Fig. 4** and **Table 1**.

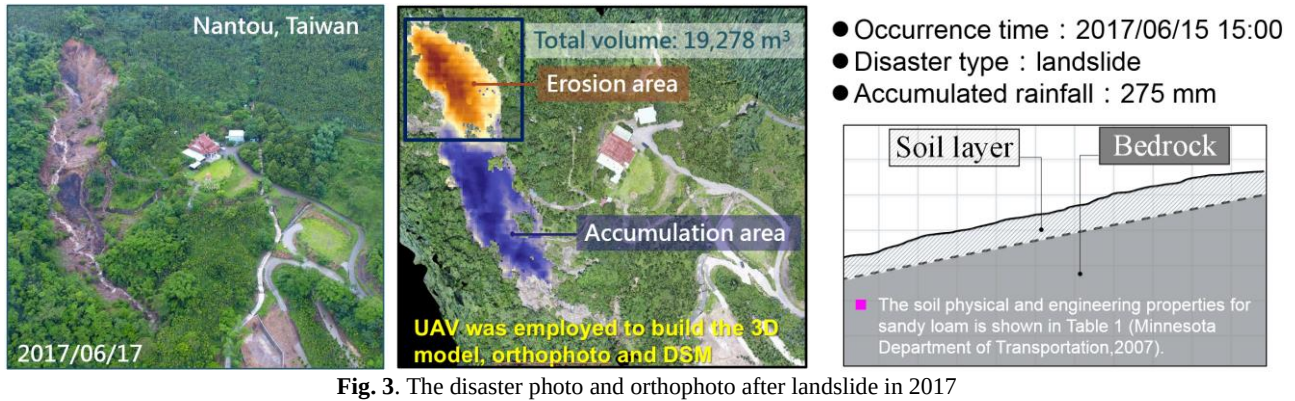


Fig. 3. The disaster photo and orthophoto after landslide in 2017

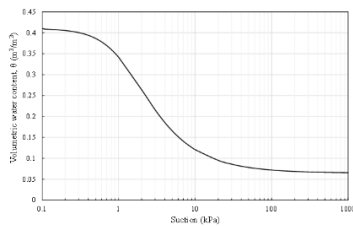


Fig.4 Soil-water characteristic curve of typical sandy loam

Table 1 The typical soil properties of sandy load

Soil properties	Max.	Min.	Avg.
Unit weight, γ (t/m ³)	2.04	1.73	1.89
Cohesion, c' (t/m ²)	2.04	1.02	1.53
Friction angle, ϕ' (degrees)	32	25	28.5
Permeability, k_s (m/s)	10^{-4}	10^{-5}	10^{-6}

(Minnesota Department of Transportation, 2007).

3. RESULTS AND DISCUSSIONS

Because of the inhomogeneity and uncertainty in geology, this study tests different values based on the typical properties of sandy loam for back analysis. The test models of different values have 48 cases as shown in **Fig. 5**. Therein, SWCC is constant in each simulation case, and c' , ϕ' and k_s is variable for 48 simulation cases. The best fitting result was shown as **Fig.6** ($k_s = 10^{-6}$ m/s, $c' = 1.52$ t/m² & $\phi' = 31^\circ$). The landslide occurrence time of the simulation result was similar with the actual landslide event. However, because the actual collapse maybe be formed by multi-stage, the landslide scale of simulation result was less than actuality.

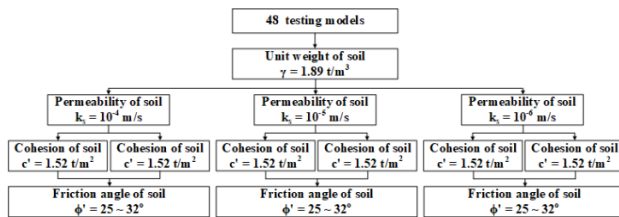


Fig.5 Flow chart for model testing

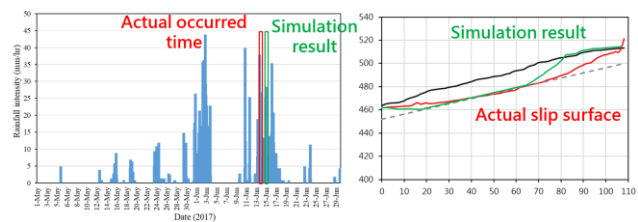


Fig.6 The simulation results

4. CONCLUSIONS

Applying the terrain data and soil parameters, IRIS model can simulate the scale and occurring time of landslide. The results showed that the visualized IRIS model cannot only predict the landslides well, but also provide useful teaching aids. (Download IRIS software: <https://tech.swcb.gov.tw/Results/ResultsIRIS>)

Keywords: Landslide, simulation, IRIS, Visualization.

References

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