University of Tabriz

Journal of Civil and Environmental Engineering
Volume 51 (2021), Issue 2 (Summer), 1-10

EXTENDED ABSTRACT

A Laboratory Study on Rainfall-Induced Landslides

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Received: 02 November 2018; **Accepted:** 25 April 2019

Keywords:
Landslide, Rainfall, Unsaturated Soils, Slope stability, Physical modeling.

1. Introduction

Frequently, rainfalls with high intensity and/or low intensity but lasting for a long time cause landslides in many parts of the world (Lu and Godt, 2013). To be used in early warning systems, rainfall intensity-duration (I-D) thresholds generally are the key to predict the time and location of rainfall-induced landslides (Wieczorek and Glade, 2005). In the current study, the flume experiments are used to develop I-D thresholds and to investigate the effect of soil relative densities on it are described (Ahmadi-adli, 2014).

2. Experimental Study

2.1. Material used & Flume setup

An uniformly graded fine sand with 3% fines was used in current study as soil medium. In Table 1 summary of soil properties are listed.

A flume box of 187 cm (length), 48 cm (width), and 70 cm (height) was constructed and used to model infinite slopes subjected to rainfalls. The box was facilitated with a system of rainfall application with controlled intensity and duration. Also a variety of instrumentation were also used (a) miniature tensiometers, (b) miniature pore pressure transducers, (c) miniature inclinometers, and (d) digital cameras to obtain a video recording of deformations (Fig. 1).

Table 1. Soil properties

D_{10} (mm):	0.09	Coefficient of curvature, c_c:	1.08	$\rho_{d\,max}$ (g/cm^3):	1.648
D_{30} (mm):	0.14	Coefficient of uniformity, c_u:	2.24	$\rho_{d\,max}$ (g/cm^3):	1.332
D_{50} (mm):	0.18	Fines content (%):	3	e_{min}:	0.616
D_{60} (mm):	0.202	USCS soil classification:	SP	e_{max}:	1.536
G_s:	2.663	K_{sat} (m/s):	1.145		

2.2. Sample preparation & Testing

Sample preparation undoubtedly was the most important part of flume tests. Filter placement, Soil placement in layers, trimming surface of sample, droplet drain installation, covering, flume tilting and suction equalization are the main stage of sample preparation. Fig. 2 clearly shows some view of this stage.

In total, ten flume experiments were performed each with different constant rainfall intensities and time to slope failure was recorded in order to create threshold I-D plot. Also. At each test, variation of suction at location of instruments, wetting front progression over time and deformation measurements by inclinometers at the end of tests were also recorded.

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3. Results and discussion

3.1. Test results

Test results obtained from each flume experiment are (i) suction-time response at specific points, (ii) wetting front progress with time, and (iii) deformations and failure surface at the time of failure.

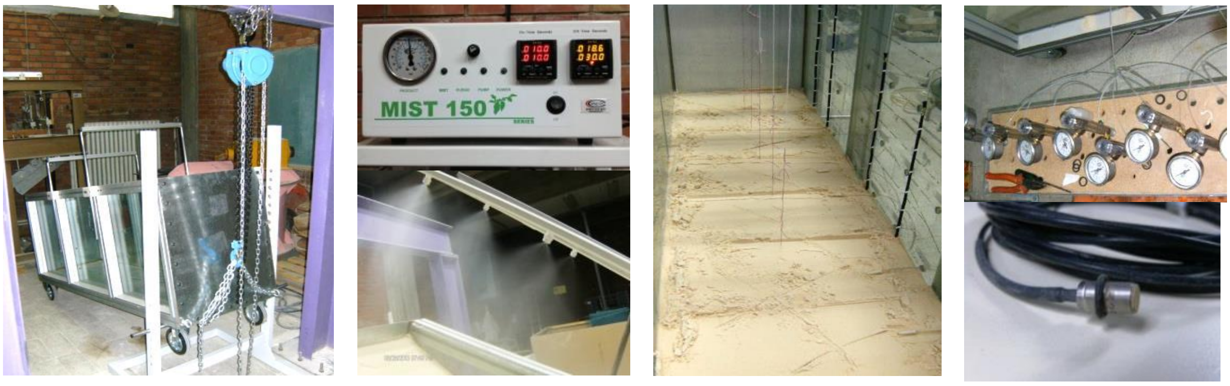

Fig. 1. Test setup: a) Flume box and lifting system, b) Rainfall controlling unit, c) Misting (rainfall) sprinklers, d) instrumentation placed in soil sample, e) gauges of tensiometers, f) pore pressure transducers

3.2. I-D threshold

Plotting time to failure versus average rainfall intensity in flume experiments gives the rainfall I-D threshold that triggers a landslide. Fig. 2 shows the I-D threshold for the two sets of tests with 34 and 48% relative density. Solid-filled symbols represent the experiments that have experienced failure, whereas the experiments in which no failure is observed till the end of the experiment are shown with data points with no filling.

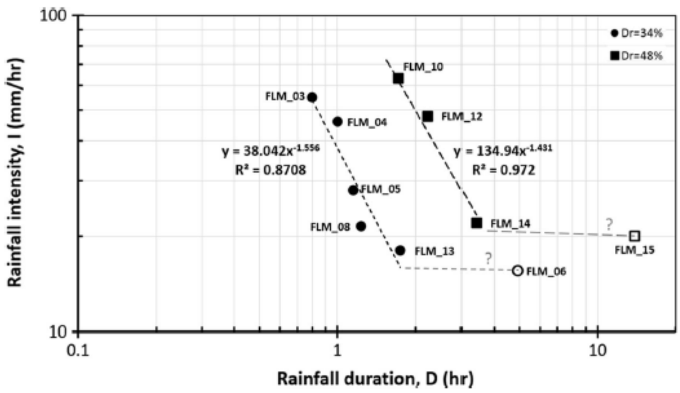

Fig. 2. I-D threshold

4. Conclusions

The major conclusions from the current research can be summarized as follows, for the rainfall-triggered landslides in the fine sand used in this study: (1) The failure surfaces are mostly translational, (2) In almost all flume experiments, the deformations leading to a failure occurred abruptly, (3) The shape of the I-D threshold is demonstrated to be a bilinear relation in log-log plot of rainfall intensity versus duration.

5. References

Ahmadi-adli M, "Shallow landslides triggered by rainfall in unsaturated soils", PhD thesis, Middle East Technical University, Civil Engineering Department, Ankara, Turkey, 2014.

Lu N, Godt JW, "Hillslope hydrology and stability", Cambridge University Press, Cambridge, UK, 2013.

Wieczorek GF, Glade T, "Climatic Factors Influencing Occurrence of Debris Flows", In: Debris Flow Hazards and Related Phenomena, Springer Berlin Heidelberg, 2005, 325-362.