ESTABLISHMENT OF THRESHOLD RAINFALL INTENSITIES FOR CRITICAL SLOPES IN SRI LANKA

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All the landslides in Sri Lanka are triggered by excessive rainfall. Sloping grounds in Sri Lanka are formed of; residual soils, rocks at different levels of weathering and colluvial soils. During periods of dry weather, the groundwater table is low and prevailing matric suctions will ensure stability. With rainwater infiltration, matric suction will be reduced or lost, and perched water table conditions may occur developing instability.

Susceptibility to landslide in hilly terrain was assessed by National Building Research Organization considering six terrain factors, and four levels of susceptibility were established. The threshold rainfall values triggering failure in these four regions would be different. Hence, they should be obtained by proper modelling of rainfall infiltration and the subsequent reduction of safety factors. In the absence of such an analysis, threshold values based on experience are currently used in issuing warnings. The process should be improved by identifying site-specific threshold values.

In this research, initially, a parametric study was conducted by applying different rainfall intensities for a typical high slope of uniform residual soil layer and a layer of residual soil overlying a weathered rock using GeoStudio 2018. The threshold values were obtained under different initial conditions (cohesion and matric suction). A strong correlation (R^2 ~ 0.9) between rainfall intensities and duration of instability was observed in all cases. Hence, if the rainfall intensity of a particular event is known, the time taken for instability can be estimated. It will be important to take remedial measures and make decisions on early warning more reliable. Also, the identified dependence of threshold values on the initial conditions highlighted the importance of establishing site-specific threshold values.

The study was then extended to three actual landslides: Pinnawala, Badulusirigama and Ginigathhena. The rainfall records that triggered the landslide at Pinnawala were available. Hence, the failure event was back analyzed using the subsoil conditions that were established subsequently during the rectification stage. As Badulusirigama and Ginigathhena slopes were recently rectified, the threshold intensities were studied separately for the situation before and after the rectification. A clear indication of an increase in threshold rainfall values was established. Hence, these slopes would be able to withstand intense rainfalls that may fall due to climate changes. However, any records of the rainfall events that caused failure at the two locations were not available for any back analysis.

The slopes with varied rectification techniques reveal that subsurface drains, which lower the water table and partially desaturate the topsoil, more efficiently increase stability than surface drains. The surface drains are only effective while raining to facilitate runoff before infiltration.

Keywords: **Landslides; Rainfall Threshold; Unsaturated Soil; Matric Suction; Infiltration**

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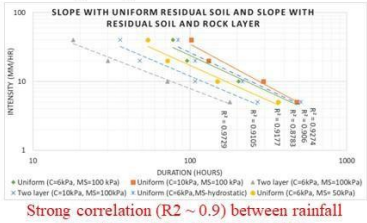
Parametric Study

Key findings

- Threshold rainfall for failure is site dependent and varies with the intensity and duration of the rainfall
- Strong correlations can be established between the rainfall intensity and duration. The correlations established are site specific.
- If a greater cohesion is present the threshold rainfall would be greater. If the matric suction present is greater threshold rainfall is greater.
- Threshold rainfall value increases if a slope rectified with engineering interventions.



Strong correlation (R2 ~ 0.9) between rainfall intensities and duration to instability

Dependence of threshold values on the initial conditions

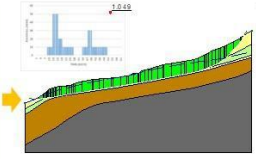
Important to establish site-specific threshold values

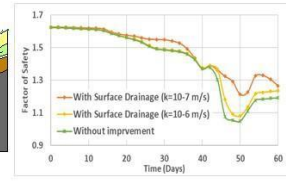
Analysis of Actual Landslides (before and after rectification)

PINNAWALA SLOPE

Subsoil condition & parameters
Water table
Rainfall event

Seepage & Stability analysis



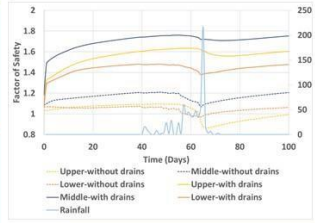


Rainfall event and FOS at failure

By surface drains - FOS improvement – Increases the runoff and reduces the infiltration

BADULLUSIRIGAMA

GINGATHHENA



Intensity (mm/hr)	Threshold rainfall (mm)					
	No drains		Surface drains		Surface & sub-surface drains	
	Without nails	With nails	Without nails	With nails	Without nails	With nails
5	Always Fos < 1.0	Fos > 1.0	Always Fos < 1.0	Fos > 1.0	Always Fos is around 1.1	Always Fos > 1.5
10		840		1440		
20		1360		2640		
40		1360		2640		

The subsurface drains effectively improve the stability than the surface drains