

颱風降雨期間梨山地滑區邊坡穩定性之數值評估

林德貴^[1] 張國欽^[2] 蘇苗彬^[3]

摘要 梨山地層滑動整治計畫於 2002 年大底完成。地滑區之地質與水文條件十分複雜，採用簡單或簡化之傳統分析方法並無法評估地滑區降雨期間實際之穩定性。一般而言，對於暴雨對邊坡穩定之影響分析大多侷限在靜態地下水水位或固定孔隙水壓之條件下來進行，而未考量地下水滲流及降雨延時之孔隙水壓變化對邊坡之影響。本研究所提之降雨滲流數值模擬方法，可即時呈現梨山地滑區趨近實際之滲流行為及其對邊坡穩定性之影響。

為探討梨山地滑地潛勢滑動面在降雨期間之穩定性，本研究進行二維有限元素滲流分析，針對梨山地滑地東南區 Y4 邊坡剖面在 4 個颱風事件（桃芝、碧利斯、艾莉、敏督利）之降雨期間，輸入現地降雨資料及初始地下水水位，進行暫態降雨入滲數值分析。在求得上述降雨入滲分析結果後，再結合 Morgenstern-Price 之極限平衡邊坡穩定分析方法，可分析邊坡潛勢滑動面在降雨期間每個時階之穩定性。本研究所提之分析模式之可靠性及有效性，可藉由梨山地滑地東南區 Y4 邊坡剖面 B11 及 B13 地下水水位監測井之水位監測資料與數值分析結果之比對來予以確認。此外，由梨山地滑區 4 個颱風事件之實際驗證與分析成果，可利用降雨延時 T 與地滑區地下水水位變化量 Δh_w 之觀測值及計算值，迴歸求得兩組相近之 $\Delta h_w(T) \sim T$ 關係式，供作後續相關整治工程之參考。

關鍵詞：降雨滲流數值分析、集水井、地下水水位、穩定分析。

Numerical Assessment of Slope Stability at Li-San Landslide during Typhoon Rainfall

Der-Guey Lin^[1] Kuo-Ching Chang^[2] Miao-Bin Su^[3]

ABSTRACT The Li-San landslide Restoration Project was largely completed at the end of 2002. The geological and hydrological conditions are extremely complicated for Li-San landslide and it's almost impossible to evaluate the actual slope stability of landslide during the rainfall merely employing conventional analysis or the simplified method.

In general, the relevant analyses to slope stability are mostly restricted in the analyses of conventional type which frequently consider groundwater as a hydrostatic distribution rather than a varied groundwater table. The infiltration, seepage effect of rainfall and the pore water pressure varied with elapsed time were

-
- [1] 國立中興大學水土保持系副教授（通訊作者）
Associate professor, Department of Soil and Water Conservation, National Chung-Hsing University, Taichung 402, Taiwan. (Corresponding Author)
E-mail: dglin@nchu.dragon.edu.tw
- [2] 行政院農業委員會水土保持局臺中分局技士
Associate Technical, Taichung Branch, Soil and Water Conservation Bureau, Council of Agriculture, Executive Yuan
- [3] 國立中興大學土木工程系教授
Professor, Department of Civil Engineering, National Chung-Hsing University, Taichung 402, Taiwan

completely ignored in the analysis. This study proposed a numerical procedure to encompass the immediate effect of rainfall seepage on the slope stability which is commonly encountered in the engineering practice.

Incorporating two dimensional finite element transient seepage analyses with limit equilibrium analysis of Morgenstern-Price slice method, this study examines the infiltration and seepage effects on the slope stability of Li-San landslide under the precipitation condition resulting from 4 typhoons events (Toraji, Bilis, Aere and Mindulle) during the typhoon season. Subsequently, the pore water pressure distribution resulted from the seepage analysis were imported into the slope stability analysis. From the numerical results, the tendency of time-dependent groundwater table variation of monitoring stations B11 and B13 are in good agreement with those from the measurements and eventually the proposed numerical procedures can be verified based on the aforementioned comparisons. In addition, according to the calculation results of 4 typhoon events at Li-San landslide, two sets of $\Delta h_w(T) \sim T$ regression curves can be obtained. The curves correlate the rainfall duration T with the groundwater upwelling Δh_w at Li-San landslide and can be readily furnished to provide a quick reference in engineering practice.

Key Words: rainfall induced seepage analysis, drainage well, ground water table, stability analysis.