中華水土保持學報, 39(3): 329-344 (2008)
Journal of Chinese Soil and Water Conservation, 39 (3):*329-344* (2008)

集集地震誘發紅菜坪地滑分析

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摘　　要　1999 年發生的集集大地震造成紅菜坪大面積地滑。我們由紅菜坪地滑的調查報告，瞭解其地質狀況及地層的力學性質，及紅菜坪附近的地震測站地震期間所量得的地表加速度資料，利用有限元素法分析與 Newmark 滑動塊體分析，以瞭解其地滑機制。此兩種方法均顯示，邊坡在集集地震時會產生破壞和大量的位移，有限元素法分析顯示上邊坡崩積層與岩盤間的滑動量可達 2 公尺，崩積層地表位移最大可達 10 公尺，Newmark 滑動塊體分析顯示位移量可達 60 公分。滑動面包括上邊坡崩積層與岩盤的界面，及上邊坡與下邊坡崩積層的淺層圓弧形滑動面。另外崩積層本身也受到剪動變形，使得愈近地表位移量愈大。Newmark 理論可粗略的分析邊坡在地震作用下的穩定性，但對於崩積層邊坡會嚴重低估其位移量。有限元素法分析，使用 Mohr-Coulomb 模式得到的位移量，低於前人用影像分析所得約 30 公尺的位移。要準確的分析邊坡在地震作用下的位移，仍需藉由有限元素法，和可有效模擬反覆荷重下土壤行爲的組成模式。

關鍵詞：地震、紅菜坪、地滑機制、有限元素法、Newmark 法。

Analyses of the Huntsaiping Landslide Induced by the Chichi Earthquake

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ABSTRACT　The 1999 Chichi earthquake induced the large Hungtaiping landslide. To understand the slide mechanism, we utilize the finite element method and Newmark sliding block analysis with the data of insitu geologic and mechanical properties and of acceleration records measured at a nearby station. Both methods show slope failures and large displacements. The finite element analysis shows the slide between colluvium and bedrock is at least 2 meters and the shallow slides in the colluvium may be as large as 10 meters, while Newmark sliding block analysis calculates the displacements around 60 centimeters. The slide surfaces include the one between the colluvium and the bedrock in the upper slope as well as the shallow circular ones in the upper and lower slopes. In addition, the colluvium was subjected to shear deformation, which leads to more shallow the depths, resulting in larger displacements. Newmark theory can roughly evaluate slope stability under earthquake loading but greatly underestimates the displacement of a colluvium

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slope. The displacements calculated by the Finite element method with the Mohr-Coulomb model are less than 30 meters obtained from image analysis of previous research. To effectively predict slope displacements, it is necessary to use the finite element method incorporating a constitutive model that can account for soil behavior under cyclic loading.

Key Words: earthquake, Hungtsaiping, landslide mechanism, finite element method, Newmark.