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大甲溪流域的山崩在颱風與地震事件中與地質環境之對應關係

The relationships between geological environment and landslides-induced by typhoon and earthquake along the Tachia River

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摘要

本研究以大甲溪流域在 1996 年賀伯颱風、1999 年 921 地震、2001 年桃芝颱風與 2004 年敏督利颱風期間受創最爲嚴重的德基壩至馬鞍壩間的集水區爲研究範圍。利用四個事件的 SPOT 衛星影像與航空照片來判釋並圈繪山崩，並以 GIS 軟體進行山崩圖層的區位分析。另外，藉著流量與輸砂量的實測紀錄來估算河流的年度輸砂量與 921 地震前後之單位輸砂量的變化，並輔助岩石單壓強度試驗結果，來探討集水區內山崩與地質環境之相對應關係。

從崩塌判釋的結果發現，921 地震誘發的山崩新生率爲 88 %，桃芝與敏督利颱風後的山崩新生率分別爲 47 %與 49 %，山崩的新生面積分別爲 14 km2 與 19 km2，表示 921 地震後地層的完整性受到了破壞，而加大了山崩的延伸範圍。另外，921 地震的山崩重現率爲 51 %，桃芝與敏督利颱風後之山崩重現率分別爲 59 %與 66 %，山崩的重現面積分別爲 15 km2 與 19 km2，此意義顯示本研究區域之地層因受到地震破壞的影響，在後續豪雨事件中，發生再崩塌的機率相當高。

在岩石強度試驗的結果上，白冷層、佳陽層與達見砂岩的平均單壓強度分別爲 107 MPa、129 MPa 與 137 MPa，而平均節理數則分別爲 11.6、10.9 與 12 條/m3。而 921 地震誘發的山崩面積，以出現在白冷層的 48 %比例最高，佳陽層和達見砂岩的崩塌率最高，分別爲賀伯颱風時的 5 倍與 11 倍，表示岩石強度高且不連續面發達的地層特別容易受到地震的影響而產生破壞。

從大甲溪輸砂量的估算資料中發現，賀伯颱風之降雨量與總逕流量爲桃芝颱風的 1.8 倍，但是輸砂量卻遠不及桃芝颱風的一半。若將 921 地震前後之流量與輸砂量相互比較，可以發現 921 地震後與地震前之單位輸砂量的比值(Dk)均大於 1，此結果顯示 921 地震後單位輸砂量大於地震前，且流量越大，單位輸砂量比值也呈倍數方式增加。

關鍵詞：山崩、重現率、輸砂量、敏督利颱風、大甲溪

Abstract

This study focused on the effects of four events including typhoon Herb in 1996, 921-earthquake in 1999, typhoon Toraji in 2001, and typhoon Mindulle in 2004 along the catchments of Tachia River between Techi Dam and Ma-an Dam.

We used SPOT satellite images and air photos to map landslide and analyzed the landslide data with GIS program. The measurement data of suspended-sediment load was conducted to estimate the annual sediment discharge and comparison of the unit sediment discharge before and after 921-earthquake. The result of rock strength test was used to discuss the relationships between geological environment and landslides-induced by typhoon and earthquake along the Tachia River.

From the result of landslide mapping, we found the newborn landslide rate was 88% in 921-earthquake, 47% in typhoon Toraji, and 49% in typhoon Mindulle. The newborn landslide areas were 14 and 19 square kilometers in typhoon Toraji and Mindulle, respectively. It indicated that the completeness of formation was destroyed by 921-earthquake, so the landslide areas were increased. Besides, the reactive landslide rates were 51% in 921-earthquake, 59% in typhoon Toraji, and 66% in typhoon Mindulle. And the reactive landslide areas were 15 and 19 square kilometers in typhoon Toraji and Mindulle, respectively. It implied that the landslide induced by 921-earthquake was reacted more easily in consequent torrential rain events.

According to rock strength test, the average uniaxial compressive strength of the Paileng Formatiom, Chiayang Formatiom and Tachien Sandstone were 107, 129 and 137 MPa. The average volumetric joint counts were 11.6, 10.9 and 12, respectively. The 48 % landslides induced by 921-earthquake in the Paileng Formation was higher than others. The landslide rate of the Chiayang Formation and the Tachien Sandstone were increased 5 and 11 times than that in typhoon Herb, respectively. It indicated that the high rock strength of formation with dense discontinuities was especially easily collapsed during the earthquake event.

According to the data of the sediment discharge in typhoon Herb and Toraji, we found that the rainfall and total water discharge during typhoon Herb were 1.8 times than that during typhoon Toraji, but the sediment discharge during typhoon Herb was less 50% than that during typhoon Toraji. If we compared the data of suspended-sediment load, we found that the unit sediment discharge ratio was all greater than 1 before and after 921-earthquake. This result indicated that unit sediment discharge in the post-earthquake was greater than that in the pre-earthquake, so the ratio of unit sediment discharge raised in multiple times with the increasing of water discharge.

Key words: landslide, reactive rate, sediment discharge, Typhoon Mindulle, Tachia River