

## 石門集水區優勢植物土-根系統之三維力學轉換模式

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**摘 要** 本研究針對台灣坡地植生工程常用植物山黃麻，進行根系形態調查及根系材料試驗，並建構及驗證土-根系統之三維數值模型、數值模擬程序及各項材料參數輸入值之有效性。再利用上述三維數值模型，來進行土-根系統直接剪力試驗之數值模擬，以決定根系在土-根系統中提供之抗剪強度增量 $\Delta S_r$ 。最後，可建立 $\Delta S_r$ 與地上部植生基徑 $D$ ，以及地下部根系極限拉拔抗力模擬值 $P_{us}$ 等參數間之轉換模式： $\Delta S_r = f(D)$ 以及 $\Delta S_r = f(P_{us})$ ，並採用 $\Delta S_r$ 來評估根系對邊坡穩定性之貢獻度。

**關鍵詞：**土-根系統、三維數值模型、根系之抗剪強度增量、極限拉拔抗力。

### 3-D Mechanical Conversion Model for the Soil-Root System of the Predominant Plant in the Shi-Men Watershed

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**ABSTRACT** Firstly, a series of field surveys of root morphology and mechanical tests of root material were carried out on *Trema orientalis* (L.) Blume (India charcoal trema), a plant species commonly used for slope land vegetation in Taiwan. Subsequently, a three-dimensional (3-D) numerical model of the soil-root system was established to simulate an in-situ pull-out test of the soil-root system. The validities of the 3-D numerical model, simulation procedures and various input material parameters in the model were also verified. Subsequently, a 3-D numerical model identical to the soil-root system used in pull-out test was repeatedly adopted for the simulation of a direct shear test to estimate the shear strength increment of the soil-root system due to root  $\Delta S_r$ . Eventually, a mechanical conversion model was developed to correlate the  $\Delta S_r$  with the basal diameter of plant  $D$  and the simulation of ultimate pull-out resistance of root  $P_{us}$ , namely, the relationship function  $\Delta S_r = f(D)$  and  $\Delta S_r = f(P_{us})$ . In addition, the proposed model can be used to determine the required strength parameters for the stability analysis of vegetated slopes and quantitatively evaluate the contribution of a root system to the stability of a slope.

**Key Words :** Soil-root system, 3-D numerical model, increment of shear strength due to roots, ultimate pull-out resistance.

## 一、前 言

國內現階段在治山防災及坡地整治工程中，基於對生態環境的永續經營，植生工法成為各類工程設計中必要採用之輔助工法。其中，植物之根系除具有抑

制土壤沖蝕及穩定邊坡之效果外，對於景觀及環境綠美化亦具有其不可取代之功能。本研究選用之研究植物山黃麻，為榆科山黃麻屬植物，俗名又稱山羊麻、或麻布樹、或山油麻、或異色山黃麻等，為落葉大喬木。在台灣地區常分佈於平地至海拔 1000 m 以下之開