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臺灣西部台地礫石層組織、剪力強度與邊坡穩定關係之研究

Relatiionships of Fabric, Shear Strength and Slope Stability of Terrace Gravel Deposits, Western Taiwan

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摘要

從礫石層邊坡現場調查資料顯示，礫石層邊坡的坡角及其疊瓦狀排列傾角會影響礫石層邊坡臨界穩定性，亦即礫石的排列方式（逆向或順向）對於礫石層邊坡的穩定性有相互的影響關係。當傾向夾角（Dip Direction Cross Angle，簡稱 DCA）分佈於 0 至 30 及 150 至 180 兩個區間中有特殊的意義存在。當傾向夾角(DCA)介於 150 至 180 （逆向坡）時，坡面法線(Sn)及礫石傾向法線(Gn)間的夾角等於坡角(Ψ)與礫石傾角(dg)的總和；當傾向夾角介於 0 至 30 （順向坡）時，坡面法線及礫石傾向法線間的夾角等於坡角與礫石傾角的差值，其相關數學意義可用 $Sn \Lambda Gn-(\Psi \pm dg) \leqq 10$ 表示。

在礫石拉拔試驗的結果中顯示，礫石層的剪力強度與礫石間的淨間距（S）有相當密切的關係，當顆粒淨間距逐漸收斂於 2 至 3 公分以內時，剪力強度會明顯增加至 2 至 10 倍；當顆粒淨間距大於有效淨間距時（Smax 介於 6.09 至 6.93 公分），礫石顆粒與礫石層剪力強度間將不會有相互的影響關係。從拉拔試驗結果並可將礫石的破壞方式以一數學式 $\tau f = c \cdot \alpha e\text{-}\beta S+\sigma n\tan\psi r+\omega(1-S/Smax)$ 作爲其破壞準則的參考。其中 α,β 爲無單位常數；ω 的單位爲「度」，代表因礫石受剪時之最大膨脹角。

從拉拔試驗結果所求得礫石顆粒間之剪力強度，與前人所求得之現地直剪試驗值結果相互比較，雖然進行試驗的地質材料有區域性差異，但是上述兩者間剪力強度的差值多在 10%以內。以本研究試驗所取得之剪力強度參數應用在礫石層邊坡穩定性分析結果，大致都符合現地邊坡所存在的穩定狀況。

關鍵詞：礫石層、傾向夾角、疊瓦狀、拉拔試驗、顆粒有效淨間距、破壞準則

Abstract

Measured field data are plotted by lower hemisphere stereographic projection, and results of these projections prove the geometric point of view. Dip Direction Cross Angle (DCA) plots are concentrated at intervals of 0°~30° and 150°~180° which exist special features. When DCA plots are between 150° and 180°, angle through slope normal (Sn) to grain dip-directiion normal(Gn) equals to sum of slope angle (Ψ) plus dip angle (dg) .While DCA plots are between 0° and 30°, angle through slope normal (Sn) to grain dip-directiion normal(Gn) equals to value of slope angle minus dip angle . The relevant mathematical relations could be described as" $Sn \wedge Gn-(\Psi \pm dg) \leqq 10$". It is also found slope angle and imbricated gravel dip angle is in relation with DCA, that means arrangement of gravels and stability of gravel slopes are influenced each other.

A series of gravel pull-out tests were designed and conducted to realize failure and interlocking behavior in relation with field data. Pre-placed concrete grains and remolded matrices were tested under different grain spacings and confined stresses. General equation of failure criteria from the gravel pullout tests is〝$\tau f = c \cdot \alpha e\text{-}\beta S+\sigma n \tan\psi r+\omega(1-S/Smax)$〞. and are constants without units and is the maximum dilation angle during shearing. S is grain spacing and Smax represents the existence of effective grain spacing.

Gravel shear strengths from gravel pull-out tests are compared with in-situ direct shear data and in good agreement. Results of slope stability by the shear strength from this study are generally in coincidence with stable condition of gravel slopes.

Key words: gravel deposits, dip direction cross angle, imbrication, pullout test, effective grain spacing, failure criteria