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Estimation of the shear strength of gravel deposits based on field investigated geological factors

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ABSTRACT

A gravel deposit is a composite material composed of gravel and soil matrix. The largest size of gravel in the study areas generally ranges from 100 mm to 300 mm. The estimation of the shear strength of gravel deposits often requires large-scale in situ direct shear tests or large-scale triaxial tests in laboratory. Both kinds of the large-scale tests are expensive, and the triaxial tests using remolded specimens with reduced-size gravel may lower estimate the shear strength of gravel deposits. This study first estimates the shear strength of gravel deposits employing their topographic characteristics, which are the envelopes of slope inclinations and slope heights. Each envelope corresponds to a strength parameter of a gravel deposit. Then, field investigation is conducted to obtain geological factors such as the diameter in the grain size distribution curve corresponding to 50% finer (D_{50}), gravel content, and the unconfined compressive strength of matrix. The strength parameter and the field investigated geological factors are correlated through linear regression. The geological factor that most influences the shear strength of the studied gravel deposits is the unconfined compressive strength of matrix. The regression model is tested using field investigated data obtained from other locations, and the derived cohesion and friction angles are compared to the results in literature. The study establishes an economic way to estimate the shear strength of gravel deposits in central Taiwan. However, the idea is applicable to gravel deposits, bimrock, alluvium, or colluvium elsewhere in the world, in which large gravels or cobbles exist and shear strength cannot be estimated by conventional methods.

1. Introduction

Gravel deposits are composite materials composed of boulders, cobbles, gravels, sands, and fine grains. Gravel deposits are widely distributed in Taiwan, mainly in the valleys, plains, tablelands, and hills. A large amount of gravel was transported and deposited along with the uplift and erosion of mountains in the Quaternary period. The term gravel herein includes all particles coarser than 4.75 mm such as gravel, cobbles, and boulders, which are mostly very hard quartzite or metamorphic sandstones with high strength. However, the soil filling in between has relative low cementation and strength. Therefore, the overall mechanical properties of gravel deposits are expected to be between those of rock and soil.

Many excavation projects or engineering constructions in gravel deposits need to know their mechanical behavior. Laboratory experiments on a mixture of two different sizes showed that the shear strength of the mixture is controlled by the material with large size if the percentage of the material with large size is over 70%, whereas it is controlled by the material with small size if the percentage is less than 40%. If the percentage is between these two limits, the shear strength of the mixture is between that of the large and that of the small size materials (Vallejo and Mawby, 2000; Vallejo, 2001). However, the material with large size used in the aforementioned experiments is in the range of only a few millimeters.

There are no standard procedures for field investigation and tests for gravel deposits. In general, either large-scale in situ direct shear tests (Chang et al., 1996; Chu et al., 1996; Coli et al., 2011; Xu et al., 2011) or large-scale triaxial experiments in laboratory (Chu et al., 2010) are required to determine the shear strength of a gravel deposit. The laboratory large-scale triaxial tests use remolded specimens with diameters of 30 cm and heights of 60 cm. Despite the grains of larger sizes in specimens than those in conventional triaxial tests, they are still far smaller than the gravel sizes in the field, and the test results may lower estimate the shear strength of gravel deposits. The large-scale in situ test, without disturbance of specimens, is a better way to determine the shear strength of a gravel deposit, but the cost is high. Alejano and Carranza-Torres (2011) used penetrometer and vane tests to empirically estimate the shear strength of decomposed granite, which is considered as a heterogeneous material. Coli et al. (2011) conducted in situ shear tests on the rock composed of clayey matrix and rock fragments, which is named bimrock (Medley, 1994). The bimrock is characterized by a high friction angle and low cohesion. Unlike Coli et al. (2011), Xu et al. (2011) conducted in situ shear tests on soil–rock mixtures using remolded samples.

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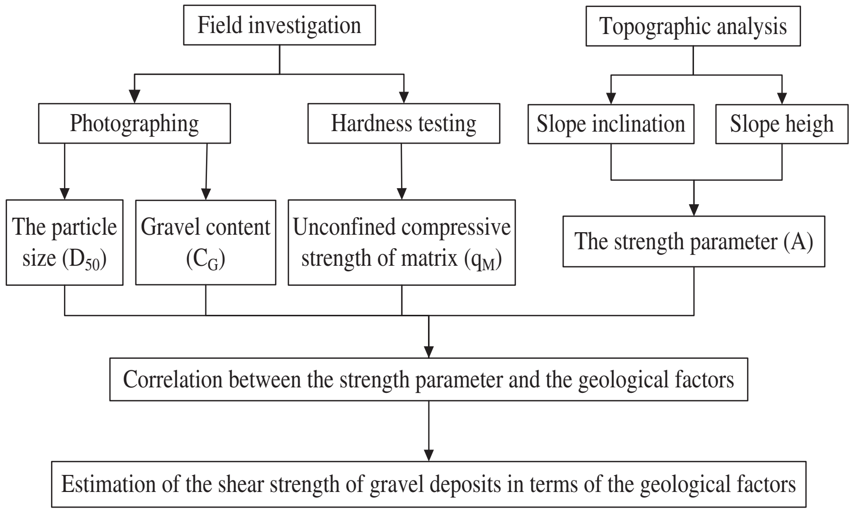

Fig. 1. Flowchart of the study.

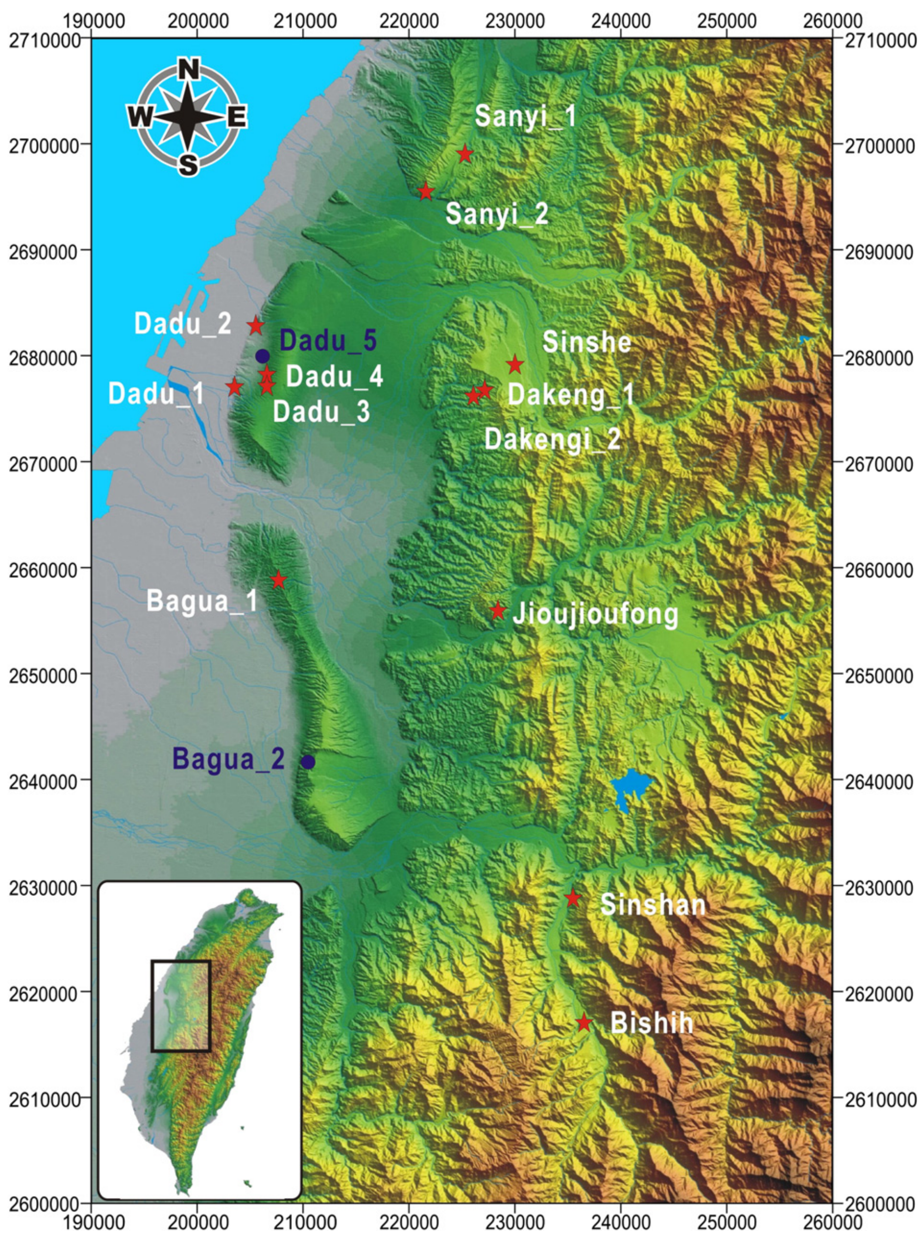

Fig. 2. Locations of field investigation.