On Strength of Granular Material in Simple Shear

Nobuchika MOROTO*

Abstract

This contribution investigated the strength of granular material in simple shear from a fundamental point of view. The theoretical derivation between the simple shear angle ϕ_s and the plane strain angle ϕ_p presents a useful information for engineering purpose. The theoretically derived relationship between the direction of major principal axis to the vertical ψ and tan ϕ_s made clear that the expression of $\tan \phi_s = \chi \tan \psi$ (χ is a constant) is an apporoximate one. The direction of the slip plane to the horizontal was also theoretically obtained. This angle is related to the difference between ϕ_p and ϕ_s and the slip plane is never coincident with the horizontal at any instance. The relationship between ϕ_p and ϕ_s based on the author's S model yields more realistic result than that based on the sliding block model. In this paper, the assumption of coaxiality for the deformational stages after the most compactive point is employed. The present results show the usefulness and validity of the author's method.

Key words: shear strength, sand, angle of internal friction simple shear, plane strain, drained shear, granular material

Introduction

For the study of shear strength of granular materials, to begin with, the strength in simple shear must be appreciated. In this case, attetion must be paid to the following: (1) the rotation of the principal axes of stress and strain increment during shear and the deviation of the slip plane from the horizontal; and (2) the difference between the shear strength in plane strain and in simple shear.

This contribution, first, derives theoretically: (1) the rotation of the major principal stress direction from the vertical; and (2) the angle of slip plane from the horizontal. Secondly, the relationship between the rotation of the major principal stress axis and the stress ratio is evaluated by using published experimental data on sands.

Next, the theoretically obtained relationship between the angles of shear strength in the plane strain and that of the simple shear is numerically analyzed and the result is compared with experimental data avairable for cohesionless materials. To do this, Rowe (1969) employed his stress-dilatancy theory. In this paper, the author tries to use his S model and examines its usefulness and validity. The stresses and strains are taken as positive for compression and the stress indicates the effective stress.

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* Professor, Dept. of Civil Engg