III-215 THE INFLUENCE OF THE INTERMEDIATE PRINCIPAL STRESS AND THE DIPPING ANGLE ON THE STRENGTH OF SAND

LAM, Woon-Kwan: Graduate School of Civil Engineering University of Tokyo

TATSUOKA, Fumio: Institute of Industrial Science, University of Tokyo

(I) INTRODUCTION

The influence of the intermediate principal stress which could be represented by the parameter $b = (\sigma'_2-\sigma'_3)/(\sigma'_1-\sigma'_3)$ on the strength of sand have been reported by many researchers. For example; KO and SCOTT (1968) performed tests on Ottawa sand by using a flexible boundary stress control system; SUTHERLAND and MESDARY (1969) applied a combination of rigid-flexible-flexible boundary loading system and tested on Loch Aline sand. Moreover, PROCTOR and BARDEN (1969), LADE and DUNCAN (1973), READES and GREEN (1976) used a similarly rigid-rigid-flexible boundary system and performed tests on Welland river sand, Montery no. 0 sand, and Ham river sand respectively.

On the other hand, the effect of the bedding plane direction of the soil elements from the projection plane of the major principal stress direction, which was defined as the dipping angle in this paper (see FIG. 1), on the strength of sand have been investigated. For examples; ARTHUR and MENZIES (1972), ARTHUR and PHILLIPS (1975) performed triaxial compression tests on Leighton Buzzard sand and on Ham river sand respectively, ODA el al (1978) obtained the results of the triaxial compression tests and the plane strain tests on Toyoura sand and, recently, SHANKARIAH and MURTHY (1980) performed the triaxial compression and triaxial extension tests on Ottawa sand.

Although there are so many publications showing the effects of the intermediate principal stress or the dipping angle on the strength of sand, yet there is no literature showing the combined effect of the intermediate principal stress and the dipping angle on the strength using the same testing material and the same testing condition. In this research, the combination of the above effects on the strength of sand was investigated by controlling the same testing material, testing method and testing condition.

(II) THE METHOD OF SAMPLES PREPARATION AND THE TESTING CONDITION.

The testing material used in this study was Toyoura sand. The physical properties and the freezing-thawing samples preparation method are described in LAM el al (1985). The samples sizes , lubriaction methods and the effective confining pressure employed are shown in TABLE 1. Although

TEST TYPE DRAINED	SAMPLES SIZE (mm) LENGTH	WIDTH	HEIGHT	SLENDERNESS RATIO H/D	LUBRICATION (TATSUOKA el al , 1984)	σ'_c (kgf/cm²)
TRIAXIAL COMPRESSION	78	78	78	1.0	TYPE 4 (DOW)	1.0
PLANE STRAIN	80	40	105	2.63	TYPE 1 (DOW)	1.0
TRIAXIAL EXTENSION	78	78	160	2.05	TYPE 1 (DOW)	4.0

TABLE 1 SAMPLES SIZE AND TESTING CONDITIONS

the slenderness ratio (H/D) in the triaxial compression tests was different from the other two kinds of tests (namely, plane strain tests and triaxial extension tests), it was reported that the peak strength for dense Toyoura sand was rather independent of the slenderness ratio (LAM el al, 1985). All the tests to be reported here were performed with changing the dipping angle. The sample preparation method for different dipping angles was firstly proposed by ARTHUR and MENZIES (1972) and modified by KAWAMURA el al (1985).

The testing condition for drained triaxial compression tests is described in LAM el al (1985), and for the drained plane strain tests in KAWAMURA el al,(1985), while the testing condition in the drained triaxial extension tests was similar to that in the drained triaxial compressions tests except that the effective confining pressure was equal to 4.0 kgf/cm² and the axial load was reduced to failure. The stress state of the soil elements for different dipping angles and boundary conditions are shown in FIG. 1.

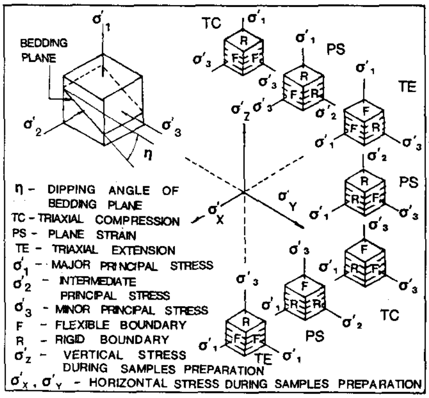

FIG. 1 THE ANALOGUE OF THE STRESS STATE OF THE SOIL ELEMENTS

(III) THE INFLUENCE OF THE DIPPING ANGLE ON THE STRENGTH OF DENSE TOYOURA SAND.

All the results presented in FIG. 2 were obtained for the void ratio equal to 0.65 measured at the effective confining pressure equal to 0.3 kgf/cm² and a minor principal stress σ'_3 equal to 1.0 kgf/cm² at failure.

It can be seen from FIG. 2 that the results of the drained triaxial compression tests and the drained triaxial extension tests show a similar angle of internal friction at failure which gradually increases with the decrease in the dipping angle from 90 degrees to 0 degrees, while for the drained plane strain tests the angle of internal friction has a minimum at a dipping angle of around 56 degrees. It may be noticed that a similar angle of internal friction can be obtained from the drained traixial compression, the drained triaxial extension, and the drained plane strain tests at a dipping angle of around 55 to 60 degrees. Based on FIG. 2 , it is concluded that the boundary conditions have a less influence on the strength of dense sand at a dipping angle of around 55 to 60 degrees, since the boundary conditions were different among these tests.

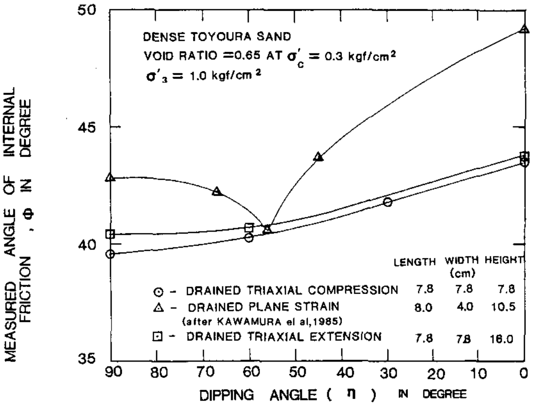

FIG. 2 THE INFLUENCE OF DIPPING ANGLE ON THE STRENGTH OF DENSE TOYOURA SAND

FIG. 3 shows the influence of the intermediate principal stress on the strength of dense sand at a constant dipping angle. The effect of the intermediate principal stress on the angle of internal friction is significant at a dipping angle of 0 degrees. At a dipping angle of 0 degrees, the strength increases from the triaxial compression tests to the plane strain tests ,during which it reaches a maximum and then decreases for the triaxial extension tests, showing a value similar to the one of the triaxial compression tests. On the other hand, the difference in the angles of internal friction among the triaxial compression, triaxial extension and plane strain tests respectively reaches a minimum value at a dipping angle of around 56 degrees.

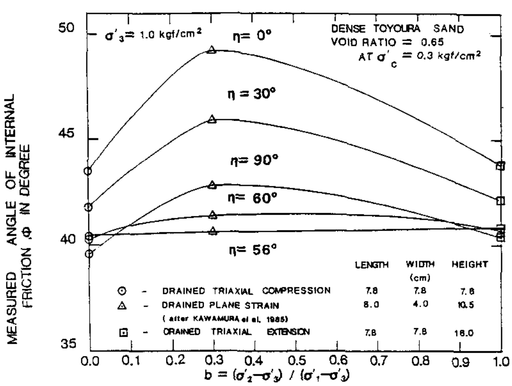

FIG. 3 THE INFLUENCE OF THE INTERMEDIATE PRINCIPAL STRESS ON THE STRENGTH OF DENSE TOYOURA SAND WITH A CONSTANT DIPPING ANGLE

(IV) THE SURFACE OF PEAK STRENGTH OF DENSE TOYOURA SAND.

The combined effect of the dipping angle and the intermediate principal stress on the strength of dense Toyoura sand can be represented by a three-dimensional figure shown in FIG. 4. From the strength surface , the strength of dense Toyoura sand at σ'_3 = 1.0 kgf/cm² can be estimated for any desirable intermediate principal stress and dippping angle by the method of interpolation.

(V) CONCLUSIONS.

1. The strength of dense Toyoura sand was found to be independent of the boundary conditions of the loading systems and the intermediate principal stress at a dipping angle of around 55 to 60 degrees.

2. The strength of dense Toyoura sand at σ'_3 = 1.0 kgf/cm² for any combination of intermediate principal stress and dipping angle can be estimated from the surface of peak strength presented in this paper.

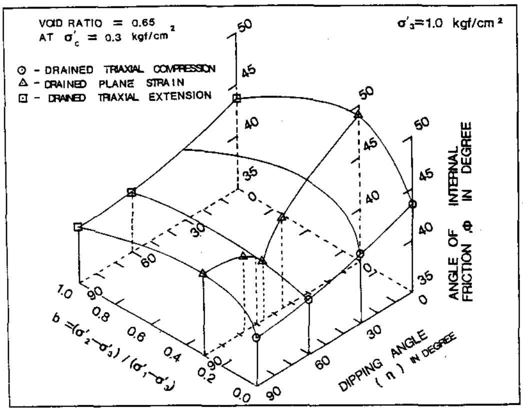

FIG. 4 THE PEAK STRENGTH SURFACE OF DENSE TOYOURA SAND

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