Effect of Torsional Shear Stress History on Drained Plastic Stress-Strain Behavior of Loose Sand

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1.Introduction

The effect of torsional shear stress history on the strain-stress behavior of the sand in plastic region is one of the interests in the geotechnical engineering. In this paper this effect has been studied by means of a series of hollow torsional shear test with and without torsional shear stress history .

2. Apparatus and test procedure

A hollow torsional shear apparatus was used in this study (Fig.1). The soil specimen of Japanese standard Toyoura sand was a hollow cylinder with 19.3 cm height, 6 cm inner diameter and 10 cm outer diameter. The outer and inner cell pressure, torsional and vertical forces can be controlled independently. All the specimens prepared by air-pluviation method and their void ratio at one same stress point which is illustrated as point A in Fig. 2 , was in the range of 0.841-0.869. The isotropic consolidation pressure for all of the specimens was 70 Kpa .

During the first step of loading two different stress paths used to going to the stress point A . The point A is located in the plastic range and before peak strength point in triaxial compression mode (Fig. 3).

After point A the type of loading control was changed to the strain path control method and as it shown in Fig. 2 , different monotonic strain paths in strain plane with components $(\varepsilon v - \varepsilon h)/2$ and εvh were applied to the specimen and the stress increment components $(\sigma v - \sigma h)/2$ and τvh were measured. During these two steps of loading the drainage valve of specimen was opened.

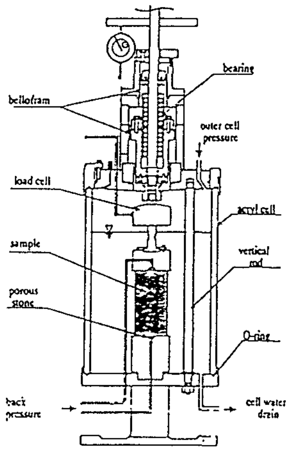


Fig. 1. Hollow torsional shear test apparatus

3. Test results

Table .1 shows the results of 22 tests including the void ratio (a), the torsional shear stress history (b), the length of incremental stress vector per unit length of incremental strain vector (c) , the angle of stress vector (d),

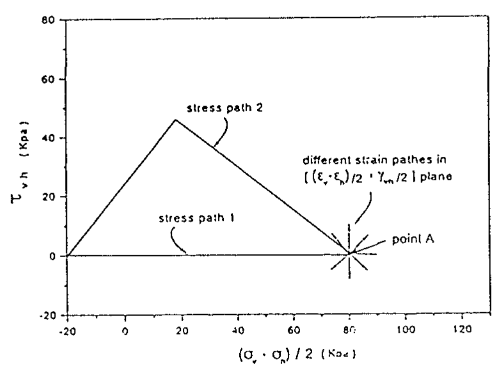


FIG. 2. Illustration of different steps of tests

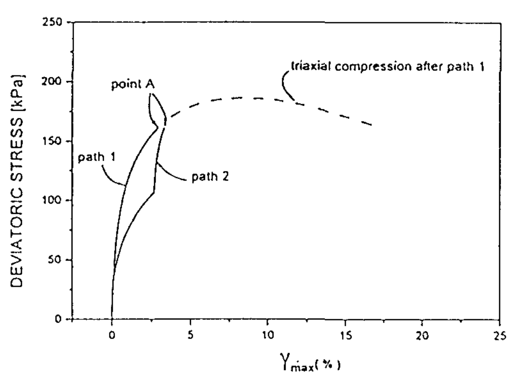


Fig. 3. Location of stress point (A)

Key words: Torsional shear , stress history , stress-strain

and the angle of strain vector (e) , which both of these two angles are measured to horizontal axis in stress or strain plane which was introduced in Fig. 2. The test results are presented also in Fig. 4 and Fig. 5. In this two figures all the incremental stress and strain vectors are normalized by the value of the incremental stress vectors.

4. Conclusion

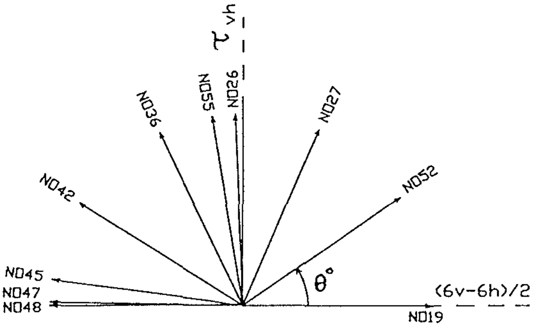
The following conclusions can be drawn from the results

1) Torsional shear stress history affects the incremental stress-strain behavior of sand after pint A in the loading direction region of $(\sigma v - \sigma h)/2$ axis. In this region the incremental stress vectors for same strain vectors rotate positively due to torsional shear stress history.

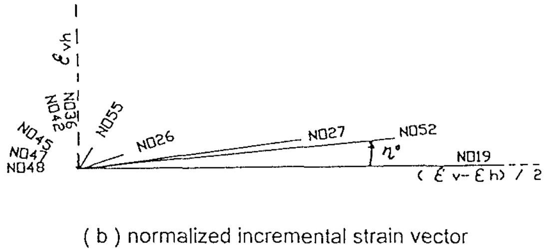
2) In the mentioned region besides the rotation of stress vector, soil behaves stiffer due to shear stress history which is effect of the torsional shear stress history on sand behavior.

Table 1. Summary of test results

TEST NO	VOID RATIO (a)	STRESS HISTORY (b)	STRESS VECTOR LENGTH (Kpa) (c)	θ, ANGLE OF STRESS VECTOR (d)	η, ANGLE OF STRAIN VECTOR (e)
NO19	0.855	NO	9.1	1	0
NO34	0.842	*YES*	17.4	43	-2
NO52	0.856	NO	12.1	34	5
NO51	0.868	*YES*	12.1	14	-5
NO50	0.852	*YES*	26.2	65	6
NO27	0.869	NO	17.4	67	7
NO38	0.869	*YES*	39.2	73	9
NO26	0.862	NO	83.4	92	17
NO31	0.86	*YES*	78.2	77	24
NO55	0.865	NO	154.7	99	58
NO54	0.857	*YES*	168.2	86	60
NO53	0.859	*YES*	179.4	103	-51
NO36	0.841	NO	245	116	94
NO37	0.842	*YES*	323.4	108	90
NO42	0.841	NO	431	147	104
NO43	0.848	*YES*	409.8	147	110
NO45	0.861	NO	894.8	172	143
NO44	0.855	*YES*	716.1	170	145
NO47	0.841	NO	1778.6	179	170
NO46	0.846	*YES*	1219.8	179	167
NO48	0.841	NO	1511.5	0	0
NO39	0.842	*YES*	1942.5	0	1

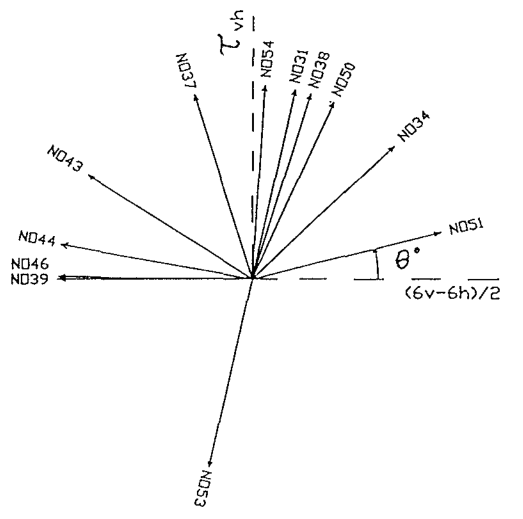


(a) incremental unit stress vectors

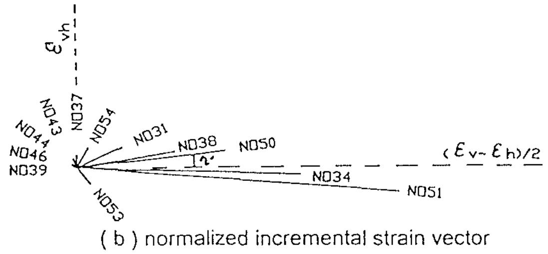


(b) normalized incremental strain vector

Fig. 4.Normalized incremental strain and unit stress vectors in tests without torsional stress history



(a) incremental unit stress vectors



(b) normalized incremental strain vector

Fig. 5.Normalized incremental strain and unit stress vectors in tests with torsional stress history

References

[1] I. Towhata and K. Ishihara, Modeling soil behavior under principal stress axes rotation, Fifth Int. Conference on Numerical Methods in Geomechanics, Nagoya, 1985