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Residual-state creep test with modified torsional ring shear machine

Modified ring shear, Laboratory creep tests, Creep behavior

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1. INTRODUCTION

Among the devices commonly used to measure the residual state of soils, only the ring shear device can shear a soil to virtually unlimited displacements without creating substantial non uniformities in stress and strain distributions. Skempton (1985) mentions that the field residual strength value for the slip surface soil of landslide should be the same as the strength calculated from the back analysis of the landslide in which movement has been reactivated along a pre-existing slip surface. If landslide soils are supposed to have already reached its residual state, the creep-like displacement behavior of the landslide may be understood by studying residual-state creep test on landslide clays. Residual-state creep test procedure was developed by the authors which can simulate the creeping behavior of large scale landslide. The experimental setup is capable to measure displacement with respect to time under the application of constant creep load. This paper briefly described the newly developed creep test device and the procedure. Finally, we present the typical test results obtained by using this device.

2. MODIFICATION OF TORSIONAL RING SHEAR MACHINE

In this study, the modification of an existing direct shearing (Bishop et al.1971) type ring shear based on transitional change of strain-controlled motor-driven shear into creep load shearing without completely releasing the applied shear stress. To reduce the side friction between soils and confining rings, the mechanism is made in such a way that vertical stress is distributed equally in radial direction, for that, a small size 12 cm outer diameter, 8 cm inner diameter and 3.2 cm depth were chosen. Moreover, ring-shear is designed in drained condition so that the evolution of the strength could be made with effective stress consolidations. In drained condition, the generated excess pore water pressure is considered to dissipate instantly and to have no influence on the normal stress. The gap of the upper and lower pairs of confining rings is opened because this gap eliminates contact friction between the upper and lower confining rings. The size of the gap can be controlled relative to a fixed datum by means of a differential screw. However, the friction is measured 0.73 kgf to 1.03 kgf during calibration. Hence, we subtract 0.98 kgf from the Normal and Shear forces measured during test. The normal load applied at A and creep load is applied at B (see Fig.1).

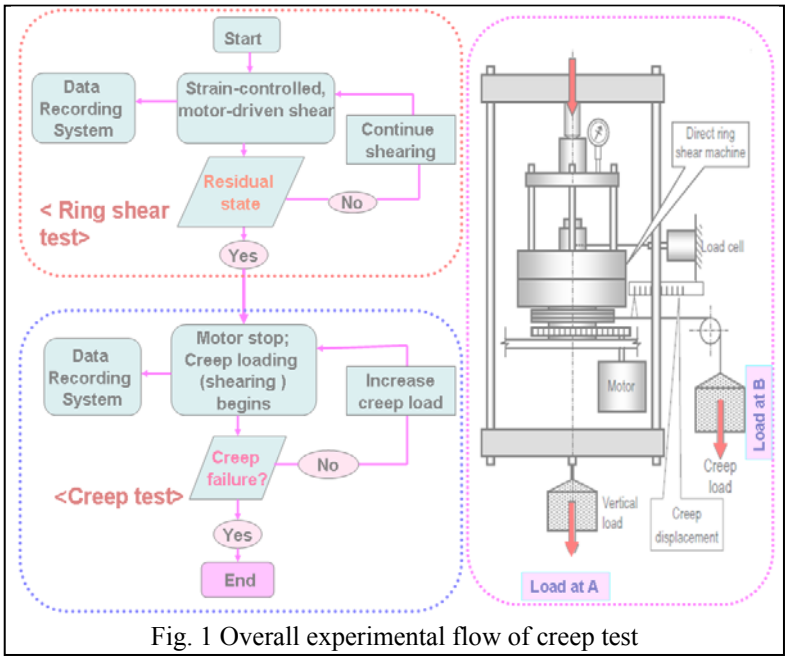

Fig. 1 Overall experimental flow of creep test

3. METHOD OF RESIDUAL-STATE CREEP TEST

In residual-state creep test, there are two steps. The first is ring shear test and next is creep test. Ring shear test is done to determine the peak and residual shear strengths of clayey soils under the fully saturated state. When it is confirmed that the shearing has reached residual state, i.e. constant load-cell reading and dial gauge reading for a large displacement, the specimen is ready for creep test. Before the application of creep load, the lower portion of ring shear apparatus is fixed by three screws so that there is no movement or slip. The lower part of ring shear is made in such a way that the overall effect of creep load is directly applicable on the slip surface of specimen and the small displacement due to the application of constant creep load can read by the same load cell and creep displacement recorder unit respectively. The displacement of the specimen with respect to time; change in volume if any during creep test are recorded in computer automatically. The dial gauge and creep displacement recorder should checked before starting creep test, either they are in working condition or not. In case of creep test, the motor is stopped and creeping load is apply for the same condition. The application of creep load is slightly increase in different steps and wait a couple of hours until the specimen is failed. Fig. 1 shows the overall set up of the creep model test and its experimental flow.

4. INTERPRETATION OF TYPICAL CREEP TEST

To evaluate the new modified torsional ring shear performance, seven tests were done on Kaolin clay with varying

Residual-state Creep Stress Ratio (RCSR) where RCSR is ratio of applied constant shear stress to shear strength.

Kaolin clay properties

Commercially available kaolin clay, of solid density is 2.72 gm/cm^3, plasticity index is 29.96 % and fine grain size distribution <2μm is 24% and 2μm-75μm is 76%, is used as typical test specimen.

Sample preparation and testing procedure

All samples were prepared by remolding below 425μm and over consolidated under the normal pressure 196.2 kN/m^2. To avoid the extra machine friction, all shear tests were conducted under a normal pressure 98.1 kN/m^2.The shearing condition was confirmed to be drained by allowing sufficient time to dissipate excess pore water pressure, for which average rate of displacement through the slip surface was set at 0.16 mm/minutes. The controlled shearing of the sample was done until reached its residual state after large displacement, then shearing process was stopped and this specimen is ready for the creep test. First, the creep load is applied 85 % of its residual state that means the value of RCSR is 0.8500. Then, a couple of hours is leaving it in the same condition and checked either there is significant effect of creep load or not. Similarly, we are applied creep load in different steps such as the value of RCSR are 0.9000, 0.9500, 1.000, 1.0025, 1.0050, 1.0100, 1.0125, 1.01500, 1.0200 etc until specimen tends to failure.

Results

Typical ring shear test result is presented in Fig. 2. The residual-state of shear for all tested samples are obtained after 10.0 cm of shear displacement, but for the conformation of residual-state, the residual-state creep tests are started at 15.0 cm of shear displacement. Table 1 shows summery of ring shear test results. Creep test result is presented in Fig. 3. Series of creep test results are summarized in Table 2. The test results show that when RCSR ≤1, the soil does not show creeping behavior where as the soil undergo creeping behavior when RCSR>1.Although the laboratory value of time to failure are very small (in the range of about 1 minutes to 30 hours 41 minutes) and may seem to have limited use for real-life prediction, the lab test results confirm a linier trend line between displacement and time to failure. However, there are certain limitations in this laboratory study, but the results show potential for the forecasting tools.

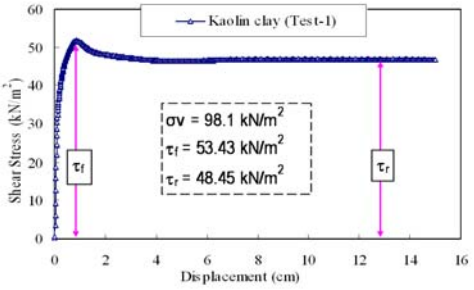

Fig. 2 Ring shear test results of Kaolin clay

Table 1 Summery of ring shear test

Test No.	Normal stress(σ_v) (kN/m^2)	Peak shear stress (τ_f) (kN/m^2)	Residual shear stress (τ_r) (kN/m^2)
7	98.10	53.43	48.45
6	98.10	55.05	47.74
5	98.10	54.68	49.68
4	98.10	53.27	48.21
3	98.10	54.90	48.92
2	98.10	53.66	48.84
1	98.10	51.71	46.50

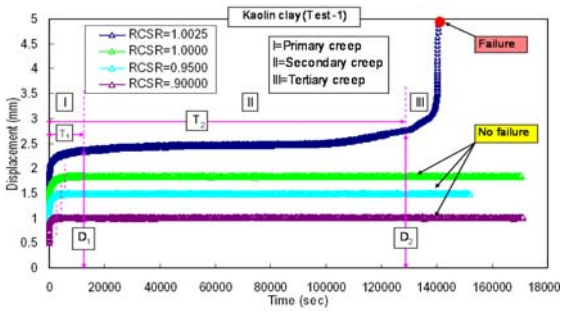

Fig. 3 Creep test results of Kaolin clay

Table 2 Summery of creep test

Test No.	RCSR	T_1	D_1	T_2	D_2	Remarks
7	1.0200	14	1.42	62	2.09	Failure
6	1.0150	24	0.68	182	1.07	Failure
5	1.0125	72	0.81	786	1.14	Failure
4	1.0100	164	0.97	1502	1.26	Failure
3	1.0075	458	1.06	3306	1.29	Failure
2	1.0050	1376	1.48	14010	1.67	Failure
1	1.0025	13036	1.63	110420	2.00	Failure
1	1.0000	7034	0.51	170110	0.51	No failure
1	0.9500	6662	0.83	151840	0.83	No failure
1	0.9000	7034	0.51	170110	0.51	No failure

5. SUMMARY AND CONCLUSION

Geo-Disaster lab, Ehime University, Japan is designed and constructed a new modified ring shear apparatus which can simulate creeping behavior of soil. We obtained the fine data from the typical specimen tests. We hope that our device is very useful to understand creeping behavior of landslide soil. It is expected that our creep test laboratory set up will be useful to develop low cost monitoring system for large scale landslide or landslide displacement prediction in the future.

REFERENCES

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