Pre-peak and post-peak creep test using torsional ring shear machine

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1. INTRODUCTION

Many researchers have studied the creeping behavior of landslide soils in the laboratory using both odometer and triaxial tests, however in most cases; they only concentrated on the pre-peak creep behavior of soil. A ring shear machine is capable of shearing a soil sample up to an infinitely large shear deformation without bringing any changes in the area under shear. Skempton (1985) mentioned that the field residual strength value for the slip surface soil of landslide should be 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 a landslide soil is supposed to have already reached its residual state, creeping behavior of a landslide may be understood by post-peak creep test, especially residual-state creep test on landside soils. Pre-peak and post-peak creep test procedures were developed by the authors using torsional ring shear machine which is capable of measuring displacement with respect to time under the application of constant creep load. This paper briefly describes pre-peak and post-peak creep test on three typical landslide soils which contain the higher percentage of Smectite, Chlorite and Mica using the newly developed creep test device and the procedure.

2. MATERIAL AND METHOD

In this study, three typical samples were collected from the landslide areas in Japan and Nepal. Shikoku, Japan landslide soils conformed to have comparatively high amount of Chlorite; named “Chlorite-rich sample” and Kobe, Japan landslide soils was conformed to have comparatively high amount of Smectite; named “Smectite-rich sample”. Similarly a Krishnabhir, Nepal landslide soil was conformed to have comparatively high amount of Mica mineral called “Mica-rich sample”. 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 is 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.

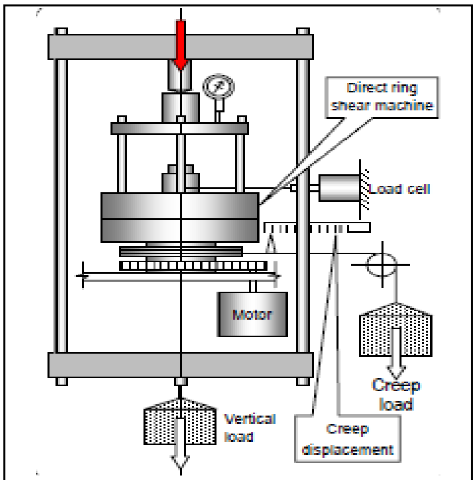

Fig. 1: Modification of torsional ring shear machine

In this study, the modification of an existing direct shearing (Bishop et al.1971) type ring shear machine based on transitional change of strain-controlled motor-driven shear into creep load shearing without completely releasing the applied shear stress shown in Fig.1. The main difference of pre-peak creep test and post-peak creep test is the shearing of specimen before starting the creep test. In pre-peak creep test, specimen is consolidated state before begun the creep test but in post-peak creep test, the specimen should be shear before the creep test. Fig.2 shows the experimental flow of pre-peak and post-peak creep. In pre-peak creep test, when the specimen is end of consolidation, then, the creep load is applied which is equivalent to residual strength. When there is no change in displacement, the creep load is gradually increased in several steps upon peak state. In post-peak creep test, shearing of the specimen is done up to peak to residual state in different points where the creep test is going to be done. For a creep test on a particular point, shearing of the specimen is done upon that point, then, shearing (motor) is stopped and application of creep load is

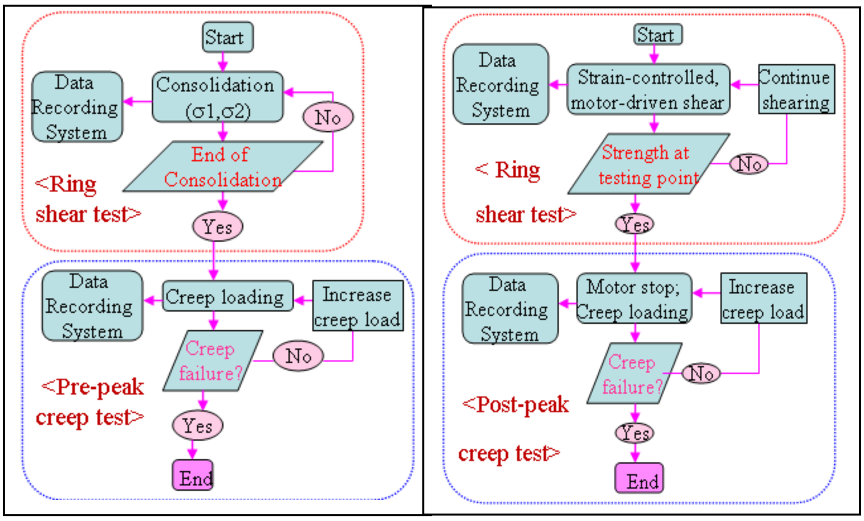

Fig. 2: Experimental flow of pre-peak and post-peak creep test

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begun from 85% of its residual strength at that point, i.e., value of creep stress ratio (CSR) is 0.85, where CSR is the ratio of applied constant shear stress to shear strength at that point. The application of creep load is slightly increase in different steps and wait a couple of hours until the specimen is failed.

3. RESULT AND DISCUSSION

Location of pre-peak and post-peak creep test of "Chlorite-rich sample" is shown in Fig. 3. In pre-peak creep test, when the creep load is applied at 'a', the specimen does not shows the creeping behavior. When the creep stress is increase unto the equivalent to the shear strength of 'b', then it shows primary and secondary creeping behavior. Similarly, points 'b', 'c', 'd', 'e', 'f' and 'g' also show the stage of primary and secondary creep but peak state point 'h' shows the state of tertiary creep as shown in Fig. 4. Similarly, "Smectite-rich sample" and "Mica-rich sample" show the state of tertiary creep at peak state. Test results show that "Smectite-rich sample" is failed in short period of time (i.e. after 3974 sec) with compare to other tested sample.

Fig. 5, Fig. 6 and Fig. 7 show the post-peak creep test results at different points 'd'', 'b'' and 'a'' respectively, where 'a'' represent the residual-state creep test. Tested points 'd'' and 'b'' show the state of tertiary creep when the value of CSR is 0.9150 and 0.9400 respectively. But at point 'a'', there is no significant creeping behavior when residual state creep stress ratio (RCSR) is less than one. However, when RCSR is greater than one; it shows the state of tertiary creep which lead to fail the specimen, where RCSR is the ratio of applied constant shear stress to residual shear strength. Similarly, in "Smectite-rich sample", specimen is failed at points 'd'' and 'b'' when the value of CSR is 0.9000 and 0.9200 respectively. "Mica-rich sample" is failed with the value of CSR 0.9250 and 0.9500 respectively. The results show that the value of CSR is in increasing order from peak state to residual state in case of tertiary creep. Value of CSR is higher in case of "Mica-rich sample" and is followed by "Chlorute-rich sample" and "Smectite-rich sample" respectively.

4. CONCLUSION

A new procedure for pre-peak and post-peak creep test was developed by the authors using modified torsional ring shear machine. The test results show the creeping behavior begun from residual state, i.e. when RCSR ≤1, the soil does not show creeping behavior where, as the soil undergo creeping behavior when RCSR>1. In pre-peak creep test, state of tertiary creep shows at peak state but the specimen undergoes tertiary creeping when CSR is less than one in post-peak creep test. Series of test results shows that zone of creep lies in between peak state and residual state.

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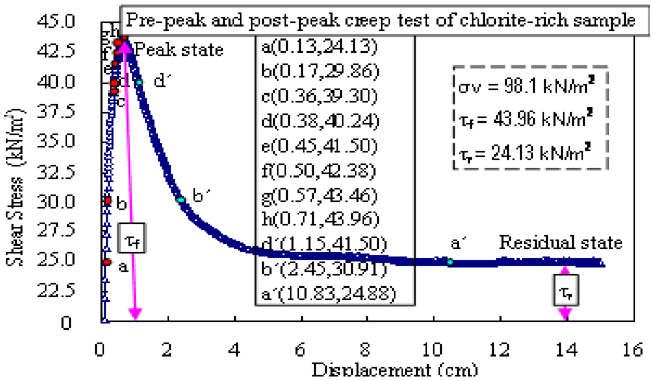

Fig. 3: location of pre-peak and post-peak creep test

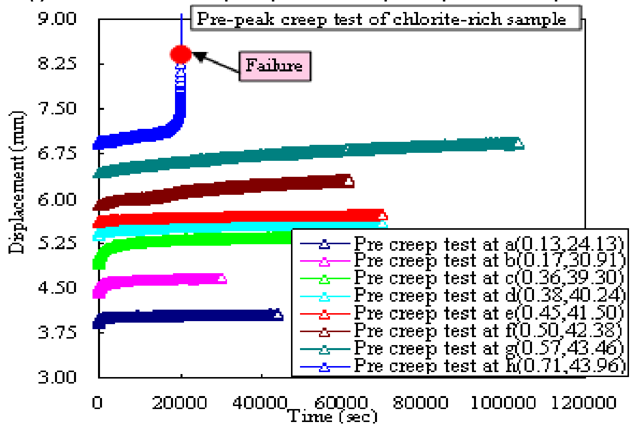

Fig. 4: Pre-peak creep test result

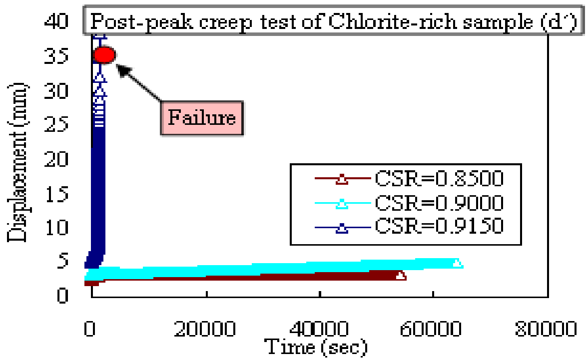

Fig. 5: Post-peak creep test at d´

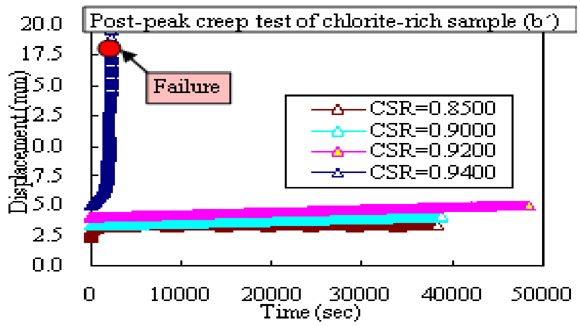

Fig. 6: Post-peak creep test at b´

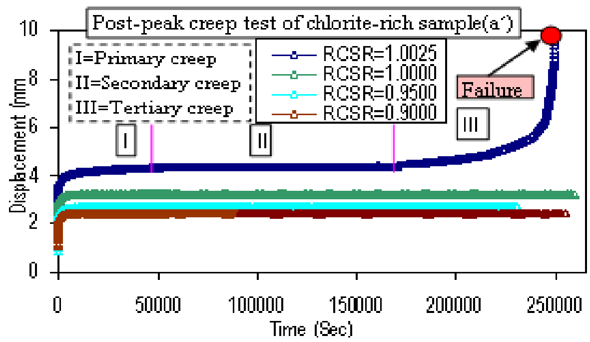

Fig. 7: Post-peak creep test at a´