ASCE Paper No. GTENG-844

SHEAR STRENGTH IN PREEXISTING LANDSLIDES

Closure By:

Timothy D. Stark[1] and Manzoor Hussain[2]

The writers appreciate the insightful comments and Appalachian Plateau experience of the Discussers (James V. Hamel and William R. Adams, Jr.). The writers provide the following responses to the issues or questions raised by the Discussers.

1. The "shear surface samples" for the Silty Clay, Madisette Clay, and Otay Bentonitic Shale were obtained from landslide failure surfaces and sent to the first author for residual strength testing. Presumably a geotechnical engineer and/or engineering geologist identified the failure surface and obtained the samples. The thickness of the failure surfaces for each of these cases is not known. The method used to obtain these samples is also not known but probably excavation not drilling. The sample of Duck Creek Shale was provided by G. Mesri of the University of Illinois at Urbana-Champaign (Mesri and Cepeda-Diaz, 1986) and was obtained from a proposed dam site in Illinois not a landslide. G. Mesri observed the field sampling and transported the sample to the UIUC for testing. The shale was obtained via a tube sample and does not correspond to a failure surface.

2. Clay size fraction on pp. 958-959 of the paper corresponds to the percent finer than 0.002 mm as tested using ASTM D422. Three of the remolded test specimens were not ball-milled or pre-treated (Silty clay, Madisette clay, and Otay Bentonitic shale). The Duck Creek Shale was ball-milled to disaggregate the clay mineral particles by Mesri and Cepeda-Diaz (1986).

3. During this study both ring shear and direct shear strength recovery tests were performed but the focus of this paper is the ring shear strength tests. The results of the direct shear strength recovery tests and their comparison with the ring shear strength recovery test results are presented in Stark and Hussain (2010). Hussain (2010) suggests that a torsional ring shear apparatus is a better device for performing strength recovery tests than the direct shear device because shearing occurs in one direction, the effective normal stress is uniformly applied to the entire specimen, and secondary compression results in a uniform vertical movement of the entire shear surface. In the direct shear test, the area of the shear surface changes with displacement of the direct shear box which affects the

[1] Professor, Dept. of Civil and Environmental Engineering, Univ. of Illinois, 205 N. Mathews Ave., IL 61801-2352. E-mail: tstark@illinois.edu
[2] Professor, College of Civil Engineering, National Univ. of Sciences and Technology, Risalpur, Pakistan (corresponding author). E-mail: mhussain@mce.nust.edu.pk

effective normal stress and measured shear strength so an area correction is required. Furthermore, the limited shear displacement of the shear box in one direction, i.e., about 6 mm, multiple reversals are required to achieve a residual strength.

4. The dimensions of the annular ring shear specimens tested are an inside diameter of 7 cm and an outside diameter of 10 cm. Drainage is provided by two bronze porous discs screwed to the bottom of the specimen container and to the top loading platen. The specimen is confined radially by the specimen container, which is 0.5 cm deep (Stark and Eid, 1993).

5. All four of the soils (Duck Creek shale, Madisette clay, Otay Bentonitic shale, and Silty clay) were tested at an effective normal stress of 100 kPa as shown in Figures 3 and 4.

6. The Discussers are correct that no test data is available for effective normal stresses between 100 and 200 kPa and that only Madisette clay was tested at 200 kPa. These limitations are due to each test requiring about one year to complete. However, testing at effective normal stresses between 100 and 200 kPa is beginning with the assistance of a new graduate student to locate the "transition" normal stress for significant to negligible healing.

7. The writers appreciate the Discussers' agreement to not use the recovered strength for landslide remedial measures at effective normal stresses of 100 kPa or less. The writers are interested in learning more about practitioners in the Appalachian Plateau region relying on "such strength gains". Hopefully this will be an area for future collaboration between the Writers and Discussers.

8. The Discussers are correct that the duration of the laboratory healing periods, e.g., 300 days, is insignificant compared to field/geologic healing periods, which is noted in the paper. As a result, the field healing may be different than observed in the laboratory.

9. It is interesting that the Discussers' experience indicates a strength gain on the order of 20 to 50%. The Writers are interested in learning more about this experience and strength gain in the Appalachian Plateau and hopefully this will be an area of future collaboration.

10. The Writers also appreciate that the Discussers' "observations in the Appalachian Plateau indicate that this phenomenon certainly exists, at least for some colluvial landslide masses in the region". Some reviewers of this paper were skeptical of the measured strength gains so the Writers are appreciate this comment and are interested in learning more about these observations. These observations also appear to support the test results of D'Appolonia et al. (1967) that show a peak strength greater than the laboratory drained residual strength for a landslide in West Virginia.

11. The Writers are preparing another paper on the direct shear test results and their comparison to the ring shear test results. The Writers will forward this paper to the Discussers in as soon as it is available.

12. Finally, the writers agree that the best estimate of residual shear strength, e.g., from ring shear testing, should be used in all assessments of future stability of existing landslide masses, whether they are actively moving, creeping, or apparently quasi-stable. This is stated in conclusion No. 5 of the paper which states: "Therefore, the suggestion of Skempton (1964, 1985) of using the drained residual shear strength for remediation of reactivated landslides and for comparison with back-calculated shear strength parameters should still be followed."

APPENDIX I.- References

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