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# Testing Procedures on the Assessment of the Effects Temperature on Residual Shear Strength of Soils

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Drained residual shear strength is the parameter used in the back analysis of the reactivated landslides and slip surface test [1,2]. The effects of temperature on residual shear strength were not extensively studied, and the method used to assess such effect across the literatures shows some discrepancies. Any internal or external factor impacting the applied stresses and the mobilized residual shear strength may lead to reactivating landslides. Therefore, considering the aggrevating climate change, it is essential to study the impact of temperature on residual shear strength and establish the best method for measuring this effect. The study by [3] concluded that for smectite-bearing soils, the residual shear strength decreases as temperature decreases. In the thermal ring shear tests conducted by [3], the specimen was first consolidated under the desired normal stress, and sheared in room temperature. Furthermore, the temperature was lowered while shearing and residual shear strength was measured as the specimen continued to be sheared. Changing the temperature during shearing without removing the loading arms from the top cap prohibits the specimen to experience the full thermally-induced volume changes and potentially disrupts the results . On the other hand, the study by [4] concluded that there is no significant effect of temperature on residual shear strength of soil. In [4], the specimen was cooled to 5°C at the beginning of the consolidation stage and was sheared after reaching desired normal effective stress. The main difference between these two described procedures is that [3] changed the temperature as the specimen was sheared, while [4] changed the temperature of the specimen prior to the consolidation stage.

The observed disrepencies within the literature may originate in the method of testing. Therefore, this study aims to investigate whether the instant in which the temperature changes in the testing procedure to determine the residual shear strength impacts the results. The tests are conducted in accordance with ASTM 6467 on two clays: EPK clay (99.3% Kaolinite and 0.7% Zeolite) and Rhassoul clay (70.5% montmorillonite, 29.4% Illite and 0.1% Kaolinite). Three ring shear experiments are performed on each of the selected clays. All the experiments starts with preparing the specimen at the liquid limit and place it in the container to form a specimen. In the first set of experiments, the specimen is consolidated under the first effective stress of 7kPa. Once the primary consolidation under this first load is complete, the temperature of the specimen is changed to the target value of 50°C. After the temperature and the volumetric strains stabilize, the consolidation stages proceed to a maximum vertical stress of about 300kPa and then unloaded back to the first load to initiate the preshearing stage. Preshearing is the step to develop a failure surface by shearing the sample for at least the displacement of one full revolution. After one full rotation, the reloading and subsequent shearing stages are performed and residual shear strength is recorded. The other two sets of experiments are conducted in similar fashion, with the difference in the time of the temperature change; in the second set of experiments the temperature is altered before the preshearing stage and in the third set the temperature is changed after the preshearing stage. It should be noted that during the temperature change the loading arms of the ring shear apparatus are not in contact with the top cap. These individual tests are then compared to assess whether the timing of temperature change can influence the residual shear strength of soils. It should also be noticed that the same procedure was followed without a sample in the ring shear apparatus to calibrate the impact of temperature on the system. The results, however, were not significant and thus, neglected in after the test data processing.


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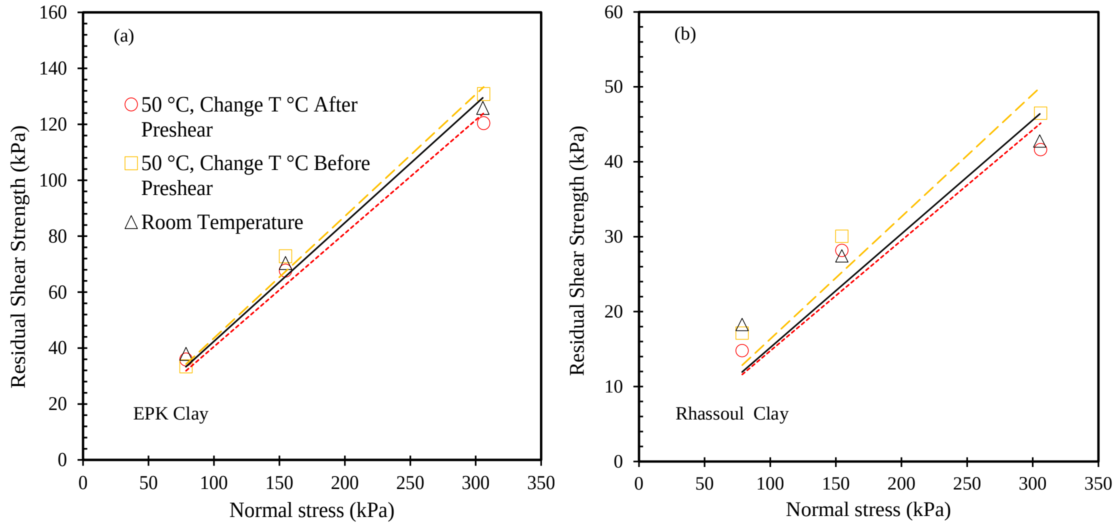


**Figure 1: Residual Shear Strength of a) EPK Clay, and b) Rhassoul clay.**

Figure 1 presents the obtained residual shear strength friction angles for EPK and Rhassoul Clay at room temperature and at 50°C. The preliminary results of EPK Clay shown in Figure 1 (a) suggest, although minimal, the residual friction angle of the EPK decreases as the temperature increases to 50°C after preshearing. On the other hand, the results obtained from Rhassoul Clay ring shear tests reveal that the alteration of the friction angle is more significant when changing the temperature before preshearing, see Figure 1 (b). These results suggest that the instance at which the temperature changes in a thermal ring shear test can impact the drawn conclusion. Therefore, in the absence of a global standard, it is more reasonable to choose the test method by considering real-life situations, precisely the actual temperature and its variation during the compaction or consolidation of the soil in situ. Furthermore, since clays' thermo-mechanical behavior depends on mineralogy [5], the observed trend between the residual shear strength and temperature is also consequently mineralogy dependent. Therefore, this study will be expanded further by considering various mineralogy of clays and a wide range of temperatures to provide a better understanding of both the impact of the thermal ring shear test method and the impact of temperature on residual shear strength.

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