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Interactive comment

Interactive comment on "Influence of shearing rate on the residual strength characteristic of three landslides soils in loess area" *by* Baoqin Lian et al.

Anonymous Referee #1

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Residual strength of soils is important for the evaluation of the reactivation potential of ancient landslides. Determination of residual strength of soils is challenging in geotechnical engineering, because, as well known, the residual strength is related to many factors, such as soil type, clay contents, plastic limit, moisture, slaking property, dynamic loading and rate of shear. This study performs ring shear tests on sliding surface soils collected from three landslides in loess area. Two rates of shear are considered to

iscussion paper

investigate the influence of rate of shear on the residual strength. This study matches the scope of the journal. The following comments should be carefully addressed and revision is required.

We thank for your constructive comments. The manuscript has been significantly improved by incorporating your suggestions. The following are our point-to-point responses to your comments.

1) To the best of my knowledge, the influence of rate of shear on the soil residual strength has been widely reported in previous. My question is: what is the difference between the findings revealed in this study and those reported in previous? Where is the innovation of this study?

Reply: With regards to the difference between the findings revealed in this study and those reported in previous: Due to the influence of the shearing rate, the difference

ϕ_r (1) - ϕ_r (0.1) in the Djg, Ydg and Dbz samples, were -0.913°, -1.176° and -0.529° , respectively. Wang (2014) and Fan et al. (2017) asserted that the residual shear strength of remolded loess hardly affected by shearing rate below 5 mm/min. However, the results in this study shown that ϕ_r (1) - ϕ_r (0.1) under all normal stress levels were negative for slip zone loess. Moreover, the maximum value of the difference ϕ_r (1)- ϕ_r (0.1) even reached about 1.176°. see details on lines 401-407 of the revised manuscript.

With regards to the innovation of this study: On general, the effect of the shearing rate on the residual strength of the soil has not been sufficiently studied in high and slow shearing rate range. Many studies above have been conducted on the residual shear strength of soils, and some inconsistent or even opposite results have been reported in the literature, which implied that there is still a lack of experimental data on this topic. Furthermore, research on the impact of the shearing rate on the residual strength of loess soil in relatively lower shearing rate range from 0.1 mm/min to 1 mm/min is scarce. See details on lines 96-102.

2) In Line 128, distilled water is added to the soil until the desired water content is achieved. but in Line 166, distilled water is added to soil until the saturated moisture is obtained. Which one is correct? Please check.

Reply: In our study, all ring shear tests were conducted on saturated specimens. We have checked these two sentences and we have replaced "desired water content" with "saturated water content" in the revised manuscript, see line 183 of revised manuscript.

3) In Section 3.1, two rates of shear are selected to investigate the influence of the rate. Why are the two rates preferred? Please explain it.

Reply: Following the previous study conducted by Tika et al. (1996), shearing rate higher than 10 mm/min is defined as high shearing rate, whereas, shearing rate lower than 10 mm/min is defined as low shearing rate. See detail on lines 65-66 of revised manuscript.

In slow shear rate range, Yokota et al. (1995) showed that residual strength is not affected by shearing rate lower than 1.01 mm/min in ring-shear tests. However, Suzuki et al. (2001) has reported the shearing rate ranging from 0.02 to 2.0 mm/ min significantly affected the residual strength of kaolin clay and mud stone. Furthermore, research on the impact of the shearing rate on the residual strength of loess soil in relatively lower shearing rate is scare, thus, we chosen two shearing rates 0.1 mm/min and 1 mm/min in slow shearing rate range to investigate the shearing rate influence on the loess under the naturally drained condition.

4) As is known, shear behavior of soils is closely related to moisture. But in Section 3.3, samples only with saturated moisture are used. Please explain it.

Reply: Yes, shear behavior of soils is closely related to moisture content of soils. Since loess is sensitive to changing in moisture content, its strength would dramatically reduce with increasing of moisture content. Therefore, in this study, we only focus on the saturated specimen corresponding to the lowest strength of loess.

5) Previous literature has revealed the shear stress fluctuates as shear displacement increases, making it difficult to determine exact value of residual shear strength. In this study, how to determine this value?

Reply: Actually, previous literature has revealed the shear stress fluctuates as shear displacements increases especially at high shear rates (Li ,2013). Following the research conducted by Bromhead (1992), the residual stage is attained if a constant shear stress is measured for more than half an hour in this study.

6) In Section 4.3, the Coulomb law is adopted to determine the residual frictions. This study states that, the law assumes that residual cohesion is zero. However, most previous works seem not require the assumption.

Reply: Based on previous research (Bishop, 1971; Kimura et al., 2014; Skepmton, 1964), we assume the residual cohesion is zero.

7) Errors are found in writing.

7a) The “a series” in Line 20 should be “a series of ”.

Reply: Implemented. We have replaced “a series” with “a series of ”.

7b) The “0.2”in Line 57 should be “0.2 mm/s”.

Reply: Implemented. We have replaced “0.2” with “12 mm/min” in order to keep shear rates unit consistent in this manuscript.

7c) The “0.05” in Line 59 should be “0.05mm/min”.

Reply: Implemented. We have replaced “0.05” with “0.05 mm/min”.

7d) The “a 5%”in Line 59 should be “5%”.

Reply: Implemented. We have replaced “a 5%” with “5%”.

7e) The “ring-shear tests” in Line 63 should be “ring shear tests”.

Reply: Implemented. We have replaced “ring-shear tests” with “ring shear tests”.

7f) The “0.02” in Line 65 should be “0.02 mm/min”.

Reply: Implemented. We have replaced “0.02” with “0.02 mm/min”.

7g) The “mud stone” in Line 66 should be “mudstone”.

Reply: Implemented. We have replaced “mud stone” with “mudstone”.

7h) The “range from” in Line 70 should be “ranging from”.

Reply: Implemented. We have replaced “range from” with “ranging from”.

7i) The “4.5” in Line 104 should be “4.5m”.

Reply: Implemented. We have replaced “4.5” with “4.5 m”.

7j) The “0.001” in Line 159 should be “0.001 degree”.

Reply: Implemented. We have replaced “0.001” with “0.001 degree”.

7k) The “drain” in Line 177 should be “drained”.

Reply: Implemented. We have replaced “drain” with “drained”.

7l) The “Figure 3b, 4b, and 5b” in Line 192 should be “Figures 3b, 4b, and 5b”.

Reply: Implemented. We have replaced “Figure 3b, 4b, and 5b” with “Figures 3b, 4b, and 5b”.

7m) The “asτr/σn (0.1)” and “andτr/σn (1)” in Line 251 should be “as τr/σn (0.1)” and “and τr/σn(1)”.

Reply: Implemented. We have corrected them as the reviewer’s suggestion.

7n) The “ÑDr(1) - Ñˇ Dr(0.1)” throughout the manuscript should be italic.ˇ

Reply: Implemented.

8) Errors are found in figures. In Figures 3, 4 and 5, the unit of normal stress should be “kN/m2”. For example, in the Figure 4a, the unit of σ should be “kN/m2” to keep consistent with the text body.

Reply: Implemented.

9) Apart from rate of shear, additional factors, such as slaking property and dynamic loading, also affect the residual strength of sliding surface of landslides, and in turn governs the stability of colluvial landslides. The following literature may be related to the additional factors and colluvial landsides, and may be cited, if applicable.

Reply: After reading the following references, we cited two references as suggested. It is widely recognized that a reduction in shear strength of soils is closely associated with increasing of moisture content within soils (Shen et al., 2018; Tang et al., 2015; Yan et al., 2018), thus ring shear tests were conducted on saturated moisture content corresponding to the worst condition in engineering in this study. See details on lines 116-120 of revised manuscript.

Li C, Yan J, Wu J, et al. Determination of the embedded length of stabilizing piles in colluvial landslides with upper hard and lower weak bedrock based on the deformation control principle. Bulletin of Engineering Geology and the Environment, 2017: 1-20.

Yan C, Xu X, & Huang L. Identifying the impact factors of the dynamic strength of mudded intercalations during cyclic loading. Advances in Civil Engineering, 2018.

Shen P, Tang H, Huang L, & Wang D. Experimental study of slaking properties of red-bed mudstones from the Three Gorges Reservoir area. Marine Georesources & Geotechnology (in the press).

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