Title of Article:

O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. *Geotechnical and Geological Engineering*, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6

Author: **Brendan C. O'Kelly**

PhD, FTCD, CEng, CEnv, MICE
Associate Professor,
Department of Civil, Structural and Environmental Engineering,
Trinity College Dublin,
Dublin, D02 PN40, Ireland
Email: bokelly@tcd.ie ORCID: 0000-0002-1343-4428

1 Introduction

As stated by the author, the paper under discussion (Zidan, 2020) '*attempts to relate the undrained shear strength of remolded fine-grained soils stabilized by Portland cement to the consistency index*'. In this regard, the author used an indirect strength measurement approach — reverse extrusion (RE) — employing Eq. 2, after Whyte (1982), reported in the paper under discussion to estimate the undrained shear strength (c_u) over the plastic range for three different Upper Egypt fine-grained soils, which were reported to have very different plasticity characteristics, as quantified by standard consistency limit tests. The undrained shear strengths of the cement-stabilized soils were also estimated using the same RE approach for different cement contents and curing periods of between one and four weeks. In employing Eq. 2 for these strength calculations, the author implicitly assumes that, for his extrusion apparatus R value of 40, the ratio of steady-state extrusion pressure to undrained shear strength (P/c_u) has a constant magnitude of 17.5 for the three investigated Upper Egypt fine-grained soils, considering both their remolded and cement-stabilized conditions. However, as described below, the P/c_u magnitude for a given R value is not the same constant value for different fine-grained soils but can vary significantly between them. Additionally, it will be shown that for a given fine-grained soil, higher overall P/c_u values are expected for undisturbed and cured RE specimens compared to remolded RE specimens.

Cite this article:
O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. Geotechnical and Geological Engineering, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6

2 Non-uniqueness of the P/c_u ratio

The author computes undrained shear strengths employing Eq. 2 reported in the paper under discussion. This equation was deduced by Whyte (1982) from RE tests performed on a single remolded low-plasticity clay (LL = 32.5%, PL = 16.5%) from the UK, and he cautioned that '*these results are to be considered only as an indication of the stress ratio [P/c_u = 17.5 for R = 40] since the equipment used was relatively crude*' (Whyte, 1982: p. 22). In fact, Medhat and Whyte (1986) reported an entirely different P/c_u – R correlation, reported as Eq. 3 in the paper under discussion, which was deduced from RE tests performed on remolded Flixton clay, also from the UK, that produced a P/c_u value of 21.5, with R = 40, for this soil material.

It is also worth elaborating on the process by which Whyte (1982) deduced his P/c_u value of 17.5 for the single remolded low plasticity clay investigated. In deducing this value, Whyte (1982) determined the P/c_u magnitude that produced a close match with his 'strength based' liquidity index against remolded c_u plots prepared from data of undrained shear strength in triaxial compression against water content reported for four soils investigated earlier by Skempton and Northey (1952). Whyte's 'strength based' liquidity index is explained as follows. For the four soils investigated by Skempton and Northey (1952), they determined the LL water content values using the British Standard 'soft' base Casagrande-cup apparatus for which Whyte (1982) assigned a remolded undrained shear strength (i.e., c_{uLL}) value of 1.6 kPa. Their PL water content values were determine using standard thread-rolling for which Whyte (1982) assigned a remolded undrained shear strength (i.e., c_{uPL}) value of 110 kPa — and in doing so, Whyte (1982) defined a fixed strength gain factor, R_{MW} (= c_{uPL}/c_{uLL}), of approx. 70 for reducing water content from the LL to the PL states. Whyte himself acknowledged that '*values of shear strength at the plastic limit cover a large range from 20–320 kN/m^2 which at first sight appears to invalidate a strength criterion as a basis for the* [plastic] *limit*' (Whyte, 1982: p. 17). In the Introduction section of his paper, the author does not mention pertinent research published in the last 10 or so years that definitively shows a very wide variation in c_{uPL} values (and hence R_{MW}) occurs between different fine-grained soils (Nagaraj et al., 2012; Haigh et al., 2013; O'Kelly, 2013; Sivakumar et al., 2016; O'Kelly et al., 2018), such that in practice their liquidity index against remolded c_u plots are not identical and often are significantly different (Vardanega and Haigh, 2014). In other words, the process by which Whyte (1982) deduced (calibrated) the P/c_u value of 17.5 (R = 40) for the low plasticity clay investigated is now generally understood as being defective.

3 Non-uniqueness of P/c_u ratio for remolded soils

For a given remolded fine-grained soil, previous researchers have assumed that its P/c_u value remains the same over its full plastic range, including at the water contents corresponding to the soil's consistency limits. In the paper by O'Kelly (2017), the discusser investigated the ratio of deduced P to measured c_u values for the PL water content — that is, the ratio P_{PL}/c_{uPL} — reported for 60 remolded fine-grained soils in the paper by Kayabali and Ozdemir (2013). Specifically they reported values of P, deduced using the RE approach with R = 40, and measured c_u from unconfined compression testing for each of the 60 soils investigated. As evident from Figure 1 presented in this discussion, the values of the P_{PL}/c_{uPL} ratio for these remolded soils varies widely, in the range of approx. 9.5 to 20 (ignoring

Cite this article:
O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. Geotechnical and Geological Engineering, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6

extreme values), with a mean P_{PL}/c_{uPL} value of 13.9 and standard deviation of 3.2 (O'Kelly, 2017). As evident from the regression lines fitted to the Kayabali and Ozdemir (2013) data in this figure, the P_{PL}/c_{uPL} ratio seems to exhibit an overall reducing trend with increasing plasticity index (PI), more so for the clay soils than the silt soils investigated, with various reasons for this behavior explored in the paper by O'Kelly (2017). Included in Figure 1 is the experimental data point of P/c_u = 17.5 for PI = 16%, after Whyte (1982), which tallies with the general overall trend for the Kayabali and Ozdemir (2013) data.

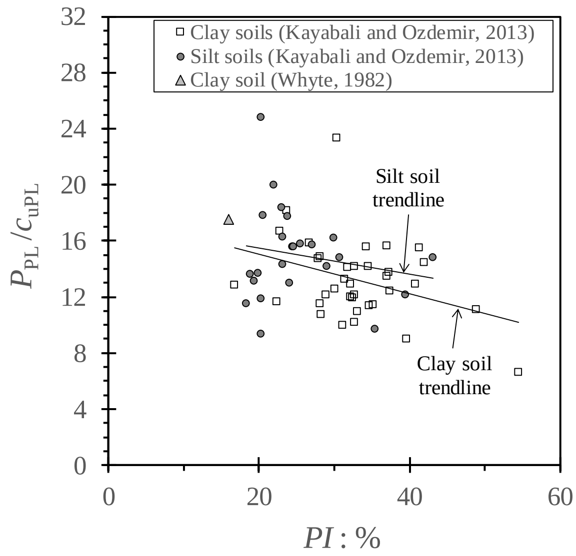

Figure 1. Ratio of RE pressure to remolded undrained shear strength values at the PL water content plotted against plasticity index for various silt and clay soils, considering an extrusion ratio of 40 (adopted from O'Kelly (2017)).

4 Non-uniqueness of *P/c_u* ratio for undisturbed soils

O'Kelly (2017) also investigated the P/c_u ratio values (for R = 40) reported in the paper by Kayabali and Ozdemir (2013) for 75 undisturbed natural clay soils occurring at various natural water content (w_n) values. As evident from Figure 2, the values of the P/c_u ratio for these undisturbed clay soils varied significantly, in the range of approx. 10.3 to 22.8 (ignoring extreme values), with a mean P/c_u value of 14.9 and standard deviation of 4.7 (O'Kelly, 2017), compared to 13.9 and 3.2, respectively, for the 60 remolded soils.

Cite this article:
O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. Geotechnical and Geological Engineering, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6

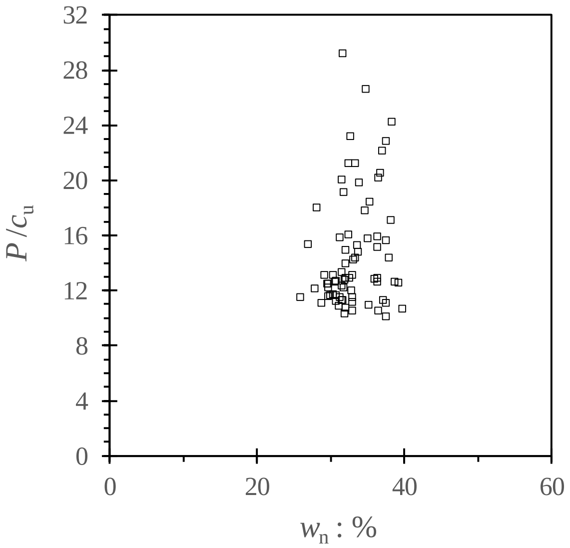

Figure 2. Ratio of RE pressure to undrained shear strength values plotted against natural water content for 75 undisturbed clay soils, considering an extrusion ratio of 40 (adopted from O'Kelly (2017)).

5 Summary and conclusions

The experimental evidence presented above was obtained from a range of different sources and indicates the wide scatter in the P/c_u magnitude between different fine-grained soils, even for those soils with the same PI value. The P/c_u value of 17.5 given by Eq. 2 for $R = 40$ was deduced by Whyte (1982) from RE testing of a single remolded low plasticity clay (PI = 16%) from the UK using an analysis/interpretation process that is now generally understood as being defective. Considering the PI values in the paper under discussion ranged between 10% and 57%, the author's assumption of a constant P/c_u magnitude of 17.5 used in computing undrained shear strengths for the three remolded Upper Egypt fine-grained soils seems unconvincing — any agreement between the RE-deduced and actual strength values would likely be purely coincidental.

Further, from inspection of the P and corresponding c_u values reported in Figures 8 and 9 of the paper under discussion, it appears that the author employed the same P/c_u magnitude of 17.5 in computing the undisturbed undrained shear strengths of these soils amended with 5–20 wt% cement and for between 7 and 28 day curing. Since the various cement-stabilized soils are completely different materials in terms of their physico-chemical and mechanical behavior/properties compared to the remolded unamended Upper Egypt fine-grained soils investigated, it is very inappropriate to assume that they both have the same P/c_u magnitude of 17.5.

Cite this article:
O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. Geotechnical and Geological Engineering, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6

References

Haigh SK, Vardanega PJ, Bolton MD (2013) The plastic limit of clays. Géotechnique 63(6): 435–440, https://doi.org/10.1680/geot.11.P.123.

Kayabali K, Ozdemir A (2013) Use of reverse extrusion method to determine undrained shear strength. Geotechnical and Geological Engineering 31(2): 719–727, https://doi.org/10.1007/s10706-013-9621-y.

Medhat F, Whyte IL (1986) An appraisal of soil index tests. In: Site investigation practice: assessing BS 5930. Edited by AB Hawkins. Geological Society, London, UK, vol. 2, pp. 317–323.

Nagaraj HB, Sridharan A, Mallikarjuna HM (2012) Re-examination of undrained strength at Atterberg limits water contents. Geotechnical and Geological Engineering 30(4): 727–736, https://doi.org/10.1007/s10706-011-9489-7.

O'Kelly BC (2013) Atterberg limits and remolded shear strength – water content relationships. Geotechnical Testing Journal 36(6): 939–947, https://doi.org/10.1520/GTJ20130012.

O'Kelly BC, Vardanega PJ, Haigh SK (2018) Use of fall cones to determine Atterberg limits: a review. Géotechnique 68(10): 843–856, https://doi.org/10.1680/jgeot.17.R.039.

O'Kelly BC (2019) Reappraisal of soil extrusion for geomechanical characterisation. Geotechnical Research 6(4): 265–287, https://doi.org/10.1680/jgere.19.00006.

Sivakumar V, O'Kelly BC, Henderson L, Moorhead C, Chow SH, Barnes GE (2016) Discussion: Measuring the plastic limit of fine soils: an experimental study. Proceedings of the Institution of Civil Engineers – Geotechnical Engineering 169(1): 83–85, https://doi.org/10.1680/jgeen.15.00068.

Skempton AW, Northey RD (1952) The sensitivity of clays. Géotechnique 3(1): 30–53, https://doi.org/10.1680/geot.1952.3.1.30.

Vardanega PJ, Haigh SK (2014) The undrained strength – liquidity index relationship. Canadian Geotechnical Journal 51(9): 1073–1086, https://doi.org/10.1139/cgj-2013-0169.

Whyte IL (1982) Soil plasticity and strength – a new approach using extrusion. Ground Engineering 15(1): 16–24.

Zidan AF (2020) Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index. Geotechnical and Geological Engineering 38(5): 5341–5353, https://doi.org/10.1007/s10706-020-01367-6.

Cite this article:

O'Kelly, B. C. (2021) Discussion of "Strength and consolidation characteristics for cement stabilized cohesive soil considering consistency index" by Ahmed F. Zidan, published in Geotechnical and Geological Engineering, https://doi.org/10.1007/s10706-020-01367-6. Geotechnical and Geological Engineering, vol. 39, issue 6, pages 4659-4662, https://doi.org/10.1007/s10706-021-01763-6