Accepted manuscript doi:
10.1680/jgeot.21.00268

Accepted manuscript doi:
10.1680/jgeot.21.00268

Manuscript title: Discussion: Use of fall-cone flow index for soil classification: a new plasticity chart

Authors: Paul J. Vardanega*, Stuart K. Haigh[†], Brendan C. O'Kelly[‡], Xianwei Zhang[§], Xinyu Liu[§‖], Cheng Chen[§], Gang Wang[§‖]

Affiliations: *Department of Civil Engineering, University of Bristol, Bristol, UK; [†]Department of Engineering, University of Cambridge, Cambridge, UK; [‡]Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin, Ireland; [§]State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, China and [‖]University of Chinese Academy of Sciences, Beijing, China.

Corresponding author: Xinyu Liu, State Key Laboratory of Geomechanics and Geotechnical Engineering, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Xiaohongshan, Wuchang, Wuhan 430071, P. R. China.

E-mail: liuxinyu17@mails.ucas.ac.cn

Accepted manuscript doi: 10.1680/jgeot.21.00268

Contribution by Xianwei Zhang, Xinyu Liu, Cheng Chen, Gang Wang

Vardanega *et al*. (2021) proposed a new plasticity chart for soil classification using flow index and fall-cone liquid limit as measured from fall-cone tests. The new plasticity chart is of important significance as it allows soil classification to be performed without thread-rolling tests which may well introduce the operator's influence. The discussers examined the applicability of this new plasticity chart to several soils containing diatom with unique particles morphology and porous structure. The classification results based on the classic Casagrande plasticity chart and the new plasticity chart are compared and discussed herein.

Material description and test method

The soils tested herein include natural diatomaceous earth (DE) and artificial kaolin-diatomite mixtures (KDM) with varying diatomite contents. The kaolin-diatomite mixtures were included to investigate how diatomite content affects soil consistency limits. The particle compositions of studied soils determined following ASTM standard were given in Table 2. Natural DE was collected at the depth of 4.0 m from the lacustrine deposits of Shengzhou, Zhejiang Province, China. KDM was prepared by adding diatomite to kaolin clay (RP-2, Active Minerals International), with the content of diatomite being 0%, 20%, 40%, 60%, 80%, 100%. All the diatomite contents in this paper are based on the dry mass ratio. For convenience, the mixtures are labeled in the form of "diatomite content: kaolin content". For example, 40D:60K stands for the mixture with 40% diatomite and 60% kaolin clay. The mixture 100D:0K in fact is pure crushed diatomaceous earth consisting of whole and broken frustules (Fig. 7) from Changbai Prefecture, Jilin Province in China.

Accepted manuscript doi: 10.1680/jgeot.21.00268

The consistency limits of studied soil were determined through thread-rolling and fall-cone tests following ASTM (2017) and BSI (1990). All samples were soaked in deionized water for 7 days before the test to allow full infiltration of water into the intra-skeletal pores of the frustules. Values of FI_c were calculated from fall-cone test data was calculated using equation (3).

Testing results and discussion

Table 2 presented the consistency limits as well as the soil classifications according to the classic Casagrande plasticity chart and the new plasticity chart. Also given in this table are the corresponding results for DKM soils from the literature. It is revealed that the classifications of both natural DE and DKM according to the new plasticity chart are identical to those following the Casagrande plasticity chart. This confirms the effectiveness of the new plasticity chart which allows soil classification to be conducted based on FI_c from the fall-cone test as an alternative for plasticity limit from the thread-rolling test. This has important practical implications, especially when considering the non-plastic nature of pure diatomite (100D:0K).

Figure 8 indicates that the natural DE is positioned above A-line and corr. A-line, with its I_p and w_L varying considerably. Besides, the natural DE was classified as clay (CE) according to the new plasticity chart. However, the particle size analysis reveals the dominant silt-sized particles, and the soil was classified as silt accordingly. Such inconsistency between the soil classification according to plasticity chart and particle composition is possibly due to the high content of diatom with extremely high water-holding capacity. Due to the non-plastic nature of pure diatomite (100D:0K), existing methods fail to measure its consistency limits. Although some successful cases have been reported (Kim, 2012; Wiemer *et al*. 2017), they cannot be applied to the current study due to the different diatom types and its fragment levels. It is found from the plasticity chart in

Accepted manuscript doi: 10.1680/jgeot.21.00268

Fig. 8 that the increasing content of non-plastic diatomite leads to a dramatic increase in w_L and w_p but only a slight reduction of I_p, with the data of Wiemer *et al.* (2017) being the only exception. This conclusion is different from the previous study (Shiwakoti *et al*. 2002) in which sand particles were added to kaolin clay. Although the adding of both non-plastic diatomite and sand ultimately lead to the non-plastic nature of the mixture, the sand affected the w_L and w_p of the mixture differently from the diatomite. The natural DE and DKM are featured by the extremely high liquid limit that increases with diatom contents. However, such an increase is the result of high fluid holding capacity due to intra-skeletal porosity of diatom instead of plasticity (e.g., Shiwakoti *et al*. 2002; Bandini & Al Shatnawi. 2017), as proved by very limited I_p value changes of DKM mixtures (Table 2). Note that although the studied soil can be classified as clay with an extremely high liquid limit according to the new plasticity chart, a large amount of water is in the intra-skeletal pore spaces thus it barely interacts with soil particles (Bandini & Al Shatnawi. 2017). Consequently, current results show that the consistency limits of diatomaceous soil do not provide information on soil property as they are conventionally expected to do. Cautious should be taken when classifying diatomaceous soil according to the Casagrande plasticity chart and the new plasticity chart, as well as deriving the fundamental soil parameters from w_L, w_p, and I_p.

In addition to diatomaceous earth, the new plasticity chart appears to be inapplicable also to peat with a porous and compressible nature due to the open cellular structure of the organic solids. Previous studies have confirmed the inappropriateness of Atterberg limits to peat (O'Kelly *et al.* 2015; 2018) and the adoption of them could be misleading. The ΔI_p–ΔI_{pc} plots in Fig. 4 quantify the deviations of data points from the A-line. Interestingly, the discussers found that the data points with the most significant deviations from the A-line are

Accepted manuscript doi: 10.1680/jgeot.21.00268

those representing peat from the South-west of England [TCD database and literature' data by Vardanega et al. (2019) in Table 1]. Consequently, it is reasonable to expect a minor modification of equation (5) with the data of peat excluded will lead to more accurate predictions, considering the notional nature of Atterberg limits for peat.

The discussers kindly welcome ongoing comments and discussions from the authors.

Authors' reply

The authors welcome the discussion on our paper proposing a new classification chart for plastic soils. The authors appreciate the opportunity in this reply to respond to and clarify some of the points raised by the discussers.

Use and evolution of soil classification frameworks

The need to update the Casagrande plasticity chart due to the preference in various codes employing the cone-penetrometer device over the Casagrande-cup device for liquid limit (w_L) determination (as suggested in Dragoni et al. 2008); or to change the function of the A-line (e.g., Reznik, 2017); or to develop new soil classification methods (e.g., Polidori, 2003, 2004, 2007; Jang & Santamarina, 2016; Moreno-Maroto and Alonso-Azcárate, 2018) have been the subject of considerable research efforts. The original paper (Vardanega et al. 2021) sought to do two things: (i) remove the need for the thread-rolling test for the plastic limit (w_P) from the classification system by using the fall-cone flow index (FI_c) from Sridharan et al. (1999), and (ii) adjust the A-line and U-line equations (Eqs. (1) and (2)) (based on the work of Casagrande (1947), as given in Howard (1984)) using the equations linking the fall-cone liquid limit with the Casagrande-cup liquid limit, developed in O'Kelly et al. (2018), and Eq. (5). The authors acknowledge that any deficiencies in the original Casagrande classification methodology will not be overcome by achievement of aims (i) and (ii).

Accepted manuscript doi: 10.1680/jgeot.21.00268

The discussers introduce the idea that both the traditional Casagrande approach for soil classification, incorporating the thread-rolling test for plastic limit, and the updated version based on flow index do not correctly classify two soil types: diatomaceous earth (DE) and peat soils. As demonstrated by the discussers for DE soils (but also for peat soils, cf. Skempton & Petley (1970)), consistency limits can be determined in the laboratory for these soils, but the Casagrande classification system (traditional or revised) alone does not give sufficient insight into the behaviour of these materials in the field (O'Kelly, 2015, 2016). While noting this, the authors would also contend that the Casagrande system for classification has this drawback to some extent for all natural materials, as it is based on remoulded soil parameters (w_L and w_P), testing only the fraction of the disaggregated material that passes the 425-μm sieve size. It is acknowledged this drawback is considerably more marked for the DE and peat soil types referred to in the discussion. In the case of peats, more useful tests for soil classification purposes may be organic content, fibre content, natural water content, and degree of humification (decomposition), as elaborated in the papers by Edil & Wang (2000) and O'Kelly (2015, 2016). Users of any soil classification framework should be aware of its inherent limitations and potential drawbacks in indicating relevant soil field behaviour. The authors' response to the discussers specific comments is given in the following sections.

Diatomaceous earth (DE soils)

The discussers note that for diatomaceous earth (DE) soils, a group of soils that were not included in the original database, the soil classifications derived using both the Casagrande plasticity chart and that described by Vardanega et al. (2021) are identical in all cases. It is pleasing to see that the new classification scheme agrees with the Casagrande chart. The discussers further note, however, that the natural DE soils they investigated are misclassified by both charts, with these soils (comprised of majority silt-sized particles) plotting above the A-line and hence being classified as clays. It should be remembered that there is no theoretical basis for the original formula for the A-line given in Casagrande (1947). As more recent experience has shown that, in general, this line divides clays and silts well, such that the

Accepted manuscript doi:
10.1680/jgeot.21.00268

position of soils on the Casagrande chart has become the de-facto classification tool for fine-grained soils, with their classification by measurement of particle-size composition rarely carried out. The fact that both charts misclassify the natural DE soils is hence interesting but not necessarily surprising. As already pointed out, as the proposed new classification chart is derived from the Casagrande chart, any misclassification will naturally persist with use of the new chart.

The discussers also rightly point out that for some DE soils, such as pure crushed DE consisting of whole and broken frustules (i.e., DKM, 100D:0K), which are clearly identified as non-plastic, the new plasticity chart (and the Casagrande chart) would still classify said materials as plastic silts. While both classification charts should only be used having established the plasticity credentials of the fine-grained test materials, we accept that this should be clarified for the new chart, as with the lack of need for a thread-rolling test, this point may be missed. It should, however, be pointed out that the plasticity, or otherwise, of fine-grained soil can generally be judged by touch rather than requiring a plastic limit test. Also pointed out in the original paper (Vardanega et al. 2021), for fine-grained soil identified as being non-plastic, Eq. (5) in said paper should not be applied to compute a 'plasticity index' (plastic range), or therefrom a 'plastic limit'.

Peat soils

The discussers also suggest that the framework should exclude peat soils. The authors note that organic soils were included in the soils studied by Casagrande when developing the original soil classification framework (Casagrande 1947), so it was deemed valid to include such material types in the determination of Eqs. (5) and (6) in the original paper, as the test data is experimentally valid for the database of fine-grained materials studied (notwithstanding the earlier comments about the link or lack thereof to field performance of the obtained data). The authors would also like to clarify (as stated in the original paper) that the peat soil data from Vardanega et al. (2019) was determined for soil samples with the peat fibres removed. The authors do agree that the consistency limits are not sufficient for classification of natural peat soils for the reasons already mentioned in this reply.

However, as suggested by the discussers, the authors have re-run the correlation analysis presented in the original paper (Vardanega et al. 2021), excluding the peat and high-content organic soil data from the TCD database (see Table 3) and the peat soil data from Vardanega et al. (2019) (see Table 1 for the full listing of the source publications for the original analysis). This reduces the number of data-points for the correlation from 235 to 208, i.e. the 27 removed datapoints comprise approximately 11.5% of the data-points. Figure 9 shows the updated correlations for the reduced database, which are given as Eqs. (12) and (13) in this reply:

$$I_{Pc}(\%) = 0.693\left(FI_c(\%)\right) \qquad [R^2 = 0.983;\ n = 208] \qquad (12)$$

$$I_{Pc}(\%) = 0.622\left(FI_c(\%)\right)^{1.023} \qquad [R^2 = 0.974;\ n = 208] \qquad (13)$$

Interestingly, the simple linear form of the correlation (Eq. (12)) has a slightly higher coefficient of determination (R^2) than Eq. (13). Therefore, using the procedure outlined in the original paper (Vardanega et al. 2021), Eq. (12) is used to update the A-line and U-line, given as Eqs. (14) and (15) in this reply.

Revised A-line

$$FI_c(\%) = \frac{0.73}{0.693}\left(\left[\frac{w_{L\ FC}}{1.90}\right]^{\left(1/0.85\right)} - 20\right) \approx 0.495\left(w_{L,FC}\right)^{1.176} - 21.07 \qquad (14)$$

Revised U-line

$$FI_c(\%) = \frac{0.9}{0.693}\left(\left[\frac{w_{L\ FC}}{1.90}\right]^{\left(1/0.85\right)} - 8\right) \approx 0.610\left(w_{L,FC}\right)^{1.176} - 10.39 \qquad (15)$$

Table 4 shows a numerical comparison between Eqs. (10) and (14), and Eqs. (11) and (15). For both sets of equations, the difference of FI_c(%) ranges from around –0.5 to 6 over the w_L range of up to 120%, and from around –0.5 to 102 for the extended plasticity chart for w_L up to 600%. The authors consider that this will not result in a significant change to the classification system presented in the original paper (especially as the current BS5930 (BSI, 2018) standard only presents the plasticity chart up to w_L of 100%, with very high plasticity being when w_L > 70%). However, a classification chart could be produced using Eqs. (14) and (15), if the user of the revised framework should wish to do so.

Acknowledgement

This paper is financially supported by the National Natural Science Foundation of China (Nos. 41972285, 41672293, 41972293).

Accepted manuscript doi:
10.1680/jgeot.21.00268

References

ASTM (2017). D4318-17e1: Standard test methods for liquid limit, plastic limit, and plasticity index of soils. West Conshohocken, PA, USA: ASTM International.

ASTM (2021). D7928-21: Standard test method for particle-size distribution (gradation) of fine-grained soils using the sedimentation (hydrometer) analysis. West Conshohocken, PA, USA: ASTM International.

Bandini, P. & Al Shatnawi, H. H. (2017). Discussion of "Fines Classification Based on Sensitivity to Pore-Fluid Chemistry" by Junbong Jang and J. Carlos Santamarina. *J. Geotech. Geoenviron.* **143**, No. 7, 07017011. http://doi.org/10.1061/(ASCE)GT.1943-5606.0001691.

BSI (1990). BS 1377-2: Methods of test for soils for civil engineering purposes (classification tests). London, UK: BSI.

BSI (2018). ISO 14688-2:2017: Geotechnical investigation and testing – Identification and classification of soil. Part 2: Principles for a classification. London, UK: BSI.

Campbell, D.J. (1975). Liquid limit determination of arable topsoil using a drop-cone penetrometer. *Journal of Soil Science,* **26(3):** 234–240, https://doi.org/10.1111/j.1365-2389.1975.tb01946.x

Casagrande, A. (1947). Classification and identification of soils. *Proceedings of the American Society of Civil Engineers,* **73(6):** 783–810.

Accepted manuscript doi: 10.1680/jgeot.21.00268

Díaz-Rodríguez, J. A., & Moreno-Arriaga, A. (2017). Contributions of diatom microfossils to soil compressibility. *Proceedings of the 19th International Conference on Soil Mechanics and Geotechnical Engineering*, W. Lee, J.-S. Lee, H. K. Kim, and D.-S. Kim, eds., Korean Geotechnical Society, Seoul, Korea, pp. 349–352.

Dragoni, W., Prosperini, N. & Vinti, G. (2008). Some observations on the procedures for the determination of the liquid limit: an application on Plio-Pleistocenic clayey soils from Umbria region (Italy). *Italian Journal of Engineering Geology and Environment*, 2008, Special Issue 1, 185–198, https://doi.org/10.4408/IJEGE.2008-01.S-12

Edil, T.B. & Wang, X. (2000). Shear strength and K_0 of peats and organic soils. In *Geotechnics of High Water Content Materials* (Edil, T.B. & Fox, P.J. (eds.)). West Conshohocken, PA, USA: ASTM International, STP 1374, pp. 209–225, https://doi.org/10.1520/STP14369S

Howard, A.K. (1984). The revised ASTM standard on the unified classification system. *Geotechnical Testing Journal*, **7(4):** 216–222, https://doi.org/10.1520/GTJ10505J

Jang, J. & Santamarina, J.C. (2016). Fines classification based on sensitivity to pore-fluid chemistry. *Journal of Geotechnical and Geoenvironmental Engineering*, **142(4):** [06015018]. https://doi.org/10.1061/(ASCE)GT.1943-5606.0001420

Kim, K. S. (2012). Engineering characteristics of diatom modified soil mixture. *J. Korean Geotech. Soc.* **28**, No. 5, 77–84. http://doi.org/10.7843/kgs.2012.28.5.77.

Accepted manuscript doi:
10.1680/jgeot.21.00268

Moreno-Maroto, J.M. & Alonso-Azcárate, J. (2018). What is clay? A new definition of “clay” based on plasticity and its impact on the most widespread soil classification systems. *Applied Clay Science*, **161:** 57–63, https://doi.org/10.1016/j.clay.2018.04.011

O’Kelly, B.C. (2005). Method to compare water content values determined on the basis of different oven-drying temperatures. *Géotechnique*, **55(4):** 329–332, https://doi.org/10.1680/geot.2005.55.4.329

O’Kelly, B.C. (2006). Compression and consolidation anisotropy of some soft soils. *Geotechnical and Geological Engineering*, **24(6):** 1715–1728, https://doi.org/10.1007/s10706-005-5760-0

O’Kelly, B.C. (2008). Geotechnical properties of a municipal water treatment sludge incorporating a coagulant. *Canadian Geotechnical Journal*, **45(5):** 715-725, https://doi.org/10.1139/T07-109

O’Kelly, B.C. (2013). Undrained shear strength–water content relationship for sewage sludge. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering*, **166(6):** 576–588, https://doi.org/10.1680/geng.11.00016

O’Kelly, B.C. (2014a). Characterisation and undrained strength of amorphous clay. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering*, **167(3):** 311–320, https://doi.org/10.1680/geng.11.00025.

O’Kelly, B.C. (2014b). Drying temperature and water content–strength correlations. *Environmental Geotechnics*, **1(2):** 81–95, https://doi.org/10.1680/envgeo.13.00016

O’Kelly, B.C. (2015). Atterberg limits are not appropriate for peat soils. *Geotechnical Research*, **2(3):** 123–134, https://doi.org/10.1680/jgere.15.00007.

O'Kelly, B.C. (2016). Briefing: Atterberg limits and peat. *Environmental Geotechnics* **3(6):** 359–363, https://doi.org/10.1680/envgeo.15.00003

O'Kelly, B.C. & Quille, M.E. (2010). Shear strength properties of water treatment residues. *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering,* **163(1):** 23–35, https://doi.org/10.1680/geng.2010.163.1.23

O'Kelly, B.C. & Sivakumar, V. (2014).Water content determinations for peat and other organic soils using the oven-drying method. *Drying Technology*, **32(6):** 631–643, https://doi.org/10.1080/07373937.2013.849728

O'Kelly, B. C., Vardanega, P. J. & Haigh, S. K. (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 (Corrigendum, **68(10):** 935, https://doi.org/10.1680/jgeot.2018.68.10.935).

Polidori, E. (2003). Proposal for a new plasticity chart. *Géotechnique*, **53(4):** 397–406, https://doi.org/10.1680/geot.2003.53.4.397

Polidori, E. (2004). Discussion: Proposal for a new plasticity chart. *Géotechnique*, **54(8):** 555–560, https://doi.org/10.1680/geot.2004.54.8.555

Polidori, E. (2007). Relationships between the Atterberg limits and clay content. *Soils and Foundations*, **47(5):** 887–896. https://doi.org/10.3208/sandf.47.887

Reznik, Y.M. (2017). A brief note on nonlinear relationship between liquid limits and plasticity indices of soils. *Geotechnical and Geological Engineering*, **35(6):** 3035–3038, https://doi.org/10.1007/s10706-017-0293-x

Sampson, L.R. & Netterberg, F. (1985). The cone penetration index: a simple new soil index test to replace the plasticity index. In *Proceedings of the 11th International Conference on Soil Mechanics and Foundation Engineering* (ed. Publications Committee of XI ICSMFE), vol. 2, pp. 1041–1048. Rotterdam, the Netherlands: Balkema. See: https://www.issmge.org/uploads/publications/1/34/1985_02_0141.pdf (accessed 11/11/2021).

Shiwakoti, D. R., Tanaka, H., Tanaka, M., & Locat, J. (2002). Influences of diatom microfossils on engineering properties of soils. *Soils Found.* **42**, No. 3, 1–17. http://doi.org/10.3208/sandf.42.3_1.

Sivakumar, V., Glynn, D., Cairns, P., & Black, J. (2009). A new method of measuring plastic limit of fine materials. *Géotechnique* **59**, No. 10, 813–823. http://doi.org/10.1680/geot.2009.59.10.813.

Skempton, A.W & Petley, D.J. (1970). Ignition loss and other properties of peats and clays from Avonmouth, King's Lynn and Cranberry Moss. *Géotechnique*, **20(4):** 343–356, https://doi.org/10.1680/geot.1970.20.4.343

Sridharan, A., Nagaraj, H.B. & Prakash, K. (1999). Determination of the plasticity index from flow index. *Geotechnical Testing Journal*, **22(2):** 175–181, https://doi.org/10.1520/GTJ11276J

Tanaka, H., & Locat, J. (1999). A microstructural investigation of Osaka Bay clay: the impact of microfossils on its mechanical behaviour. *Can. Geotech. J.* **36**, No. 3, 493–508. http://doi.org/10.1139/cgj-36-3-493.

Tanaka, M., Watabe, Y., Tomita, R., & Kamei, T. (2012). Effects of Diatom Microfossils Content on Physical Properties of Clays. *Proceedings of the 22nd International Offshore and Polar Engineering Conf*, Rhodes, Greece, ISOPE, vol. 2, pp. 593–597.

Vardanega, P.J. & Haigh, S.K. (2014). The undrained strength–liquidity index relationship. *Canadian Geotechnical Journal*, **51(9):** 1073–1086, https://doi.org/10.1139/cgj-2013-0169

Vardanega, P. J., Hickey, C. L., Lau, K., Sarzier, H. D. L., Couturier, C. M. & Martin, G. (2019). Investigation of the Atterberg limits and undrained fall-cone shear strength variation with water content of some peat soils. *Int. J. Pavement Res. Technol.* **12**, No. 2, 131–138 http://doi.org/10.1007/s42947-019-0017-0.

Vardanega, P. J., Haigh, S. K., & O'Kelly, B. C. (2021). Use of fall-cone flow index for soil classification: a new plasticity chart. *Géotechnique*, 1–8. http://doi.org/10.1680/jgeot.20.P.132.

Wiemer, G., Dziadek, R., & Kopf, A. (2017). The enigmatic consolidation of diatomaceous sediment. *Mar. Geo.* **385**, 173–184. http://doi.org/10.1016/j.margeo.2017.01.006.

Table 2 Soil information*

Data sources	Soil description	Particle composition (%) Sand	Silt	Clay	w_L (%)	I_p (%)	Atterberg limits test methods	Soil classification according to CPC	Soil classification according to NPC†
The authors	Natural DE	2.8–6.6	53–67.3	29.9–40.4	96.6–126	59.58–81	Thread-rolling test and	CE	CE
	DKM, 0D:100K	0	35.1	64.9	42	25	fall-cone test	CI-MI (on A-line)	CI-MI (on corr. A-line)
	DKM, 20D:80K	0.8	39	60.2	49.3	30.77		MI	MI
	DKM, 40D:60K	1.8	43.6	54.6	63	41.9		MH	MH
	DKM, 60D:40K	2.2	46.5	51.3	70	46		MH-MV	MH-MV
	DKM, 80D:20K	3.4	58.3	38.3	128	98		ME	ME
	DKM, 100D:0K	4	70.6	25.4	175	153‡		ME	ME
Tanaka & Locat (1999)	DKM, 0D:100K	–	–	64	69	32.92	Thread-rolling test and	MH	MH
	DKM, 25D:75K	–	–	40	83	35.58	Casagrande's cup	MV	MV
	DKM, 50D:50K	–	–	25	101	36.3		ME	ME
	DKM, 75D:25K	–	–	19	112	25.69		ME	ME
Tanaka *et al.* (2012)	DKM, 10D:90K	0.9	10.9	88.2	65	31	Thread-rolling test and	MH	MH
	DKM, 20D:80K	2.9	16.8	80.3	69	30	Casagrande's cup	MH	MH
	DKM, 30D:70K	3.5	21.0	75.5	73	32		MV	MV
	DKM, 40D:60K	3.2	24.6	72.2	83	28		MV	MV
	DKM, 50D:50K	4.9	28.9	66.2	92	30		ME	ME
	DKM, 75D:25K	6.9	36.6	56.5	NP	94		–	–
Diaz-Rodríguez & Abraham 2011	DKM, 0D:100K	–	–	–	62.4	27.5	Ungiven in the original paper	MH	MH
	DKM, 5D:95K	–	–	–	62.9	27.2		MH	MH
	DKM, 10D:90K	–	–	–	63.2	26		MH	MH
	DKM, 15D:85K	–	–	–	63.7	24.9		MH	MH
	DKM, 20D:80K	–	–	–	64.2	25.2		MH	MH
	DKM, 40D:60K	–	–	–	66.8	21.8		MH	MH
	DKM, 60D:40K	–	–	–	69.9	18.2		MH-MV	MH-MV
Wiemer *et al.* (2017)	DKM, 0D:100K	0.1	71.1	34	56.21	18.31	Swedish fall cone method	MH	MH
	DKM,	2.9	69.8	31.1	93.35	34.25	(Sivakumar *et*	ME	ME

Accepted manuscript doi:
10.1680/jgeot.21.00268

	25D:75K						*al.* 2009)		
	DKM, 50D:50K	5.1	72.9	27.4	153.12	69.52		ME	ME
	DKM, 75D:25K	6.8	75.8	22.9	198.82	37.32		ME	ME
	DKM, 100D:0K	7.8	81.0	19.6	289.69	84.19		ME	ME
Shiwakoti *et al.* (2002)§	DKM, 0D:100K	0.1	19.6	80.3	68.8	33.9	Thread-rolling test and Casagrande's cup	MH	MH
	DKM, 25D:75K	0.2	38	61.8	83.1	35.1		MV	MV
	DKM, 50D:50K	0.5	53.8	45.7	100.5	33		ME	ME
	DKM, 75D:25K	0.6	62.6	36.8	112	23.9		ME	ME
	DKM, 100D:0K	0.9	77.1	22	NP	NP		–	–
Kim (2012)	DKM, 0D:100K	–	–	86.8	53.35	23.95	Ungiven in the original paper	MH	MH
	DKM, 25D:75K	–	–	74.1	59.31	24.76		MH	MH
	DKM, 50D:50K	–	–	61.4	70.08	18.77		MH-MV	MH-MV
	DKM, 75D:25K	–	–	48.6	96.05	21.68		ME	ME
	DKM, 100D:0K	–	–	35.9	117.61	15.35		ME	ME

* Abbreviations: CPC = Casagrande plasticity chart; NPC = new plasticity chart; NP = non-plastic.

† $w_{L\ FC}$ used for classification has been corrected according to equation (9) when liquid limits were determined using Casagrande's cup.

‡ Determined through equation (5) as the thread-rolling test is not appropriate for non-plastic diatomite.

§ Particle size in the original paper: Sand (d > 0.075mm); silt (0.005mm < d < 0.075mm); clay (d < 0.005mm)

Table 3: Listing of peat or very high organic content soils excluded from the database (see Table 1 in the original paper for a complete listing of all the database soils) to generate the new regression shown in Figure 9.

Database	Source Publications	*n*	Data excluded to generate Figure 9
TCD database	O'Kelly (2005)[b]	2	Peats, Ireland
	O'Kelly (2006)[b]	1	Fine fibrous peat, Ireland
	O'Kelly (2008)[b]	1	Residue from Ballymore Eustace water treatment plant (WTP), Ireland
	O'Kelly & Quille (2010)[b]	2	Residue from Leixlip and Clareville WTPs, Ireland
	O'Kelly (2013)[b]	1	Biosolids from Tullamore waste-water treatment plant, Ireland
	O'Kelly (2014a)	1	Residue from Ballymore Eustace WTP, Ireland
	O'Kelly (2014b)[b]	1	Residue from Ballymore Eustace WTP, Ireland
	O'Kelly & Sivakumar (2014)[b]	2	Clara and Derrybrien bog peats, Ireland
Other Publication	Vardanega et al. (2019)	16	Soils derived by removing fibres from peat materials sourced from southwest of England
[b] Fall-cone liquid limit values and other geotechnical properties reported in original papers, but not the raw fall-cone liquid limit test data.			

Table 4: Comparison of computed FI_c(%) values for the revised A-line and U-line formulations given in the original paper (Eqs. 10 and 11) and in this reply (Eqs. 14 and 15).

$w_{L\,FC}$ (%)	**A-Line**			**U-Line**		
	Eq.10	**Eq.14**	ΔFI_c	**Eq.11**	**Eq.15**	ΔFI_c
30	6.4	6.0	–0.4	23.5	23.0	–0.5
50	28.7	28.3	–0.4	50.4	50.5	0.1
80	64.1	64.7	0.6	93.4	95.4	2
120	114	117	3	154	160	6
250	290	307	17	370	394	24
450	586	634	48	732	797	65
600	821	897	76	1020	1122	102

Figure captions

Fig. 7 SEM images of studied soils: (a) 100D:0K DKM (mag = 800×); (b) 100D:0K DKM (mag = 2000×); (c) 60D:40K DKM (mag = 5000×); (d)–(f): natural DE under magnifications of 800×, 2000× and 5000×, respectively.

Fig. 8 Positions of the soils in Table 2 on (a) Casagrande plasticity chart and (b) new soil plasticity chart. Note that I_p of 100D:0K DMK was determined using equation (5) because of the inapplicability of the thread-rolling test to non-plastic diatomite.

Fig. 9 Correlation of the fall-cone flow index of Sridharan et al. (1999) and plasticity index for the database used in the original paper (Vardanega et al. 2021), with the peat materials of the TCD database and Vardanega et al. (2019) dataset removed (see Table 3 for full listing of these materials).

Accepted manuscript doi:
10.1680/jgeot.21.00268

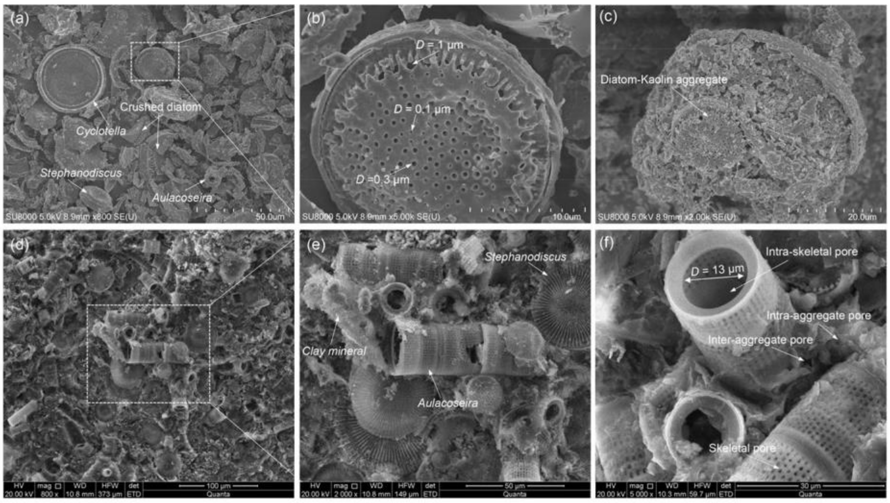

Fig 7

Accepted manuscript doi:
10.1680/jgeot.21.00268

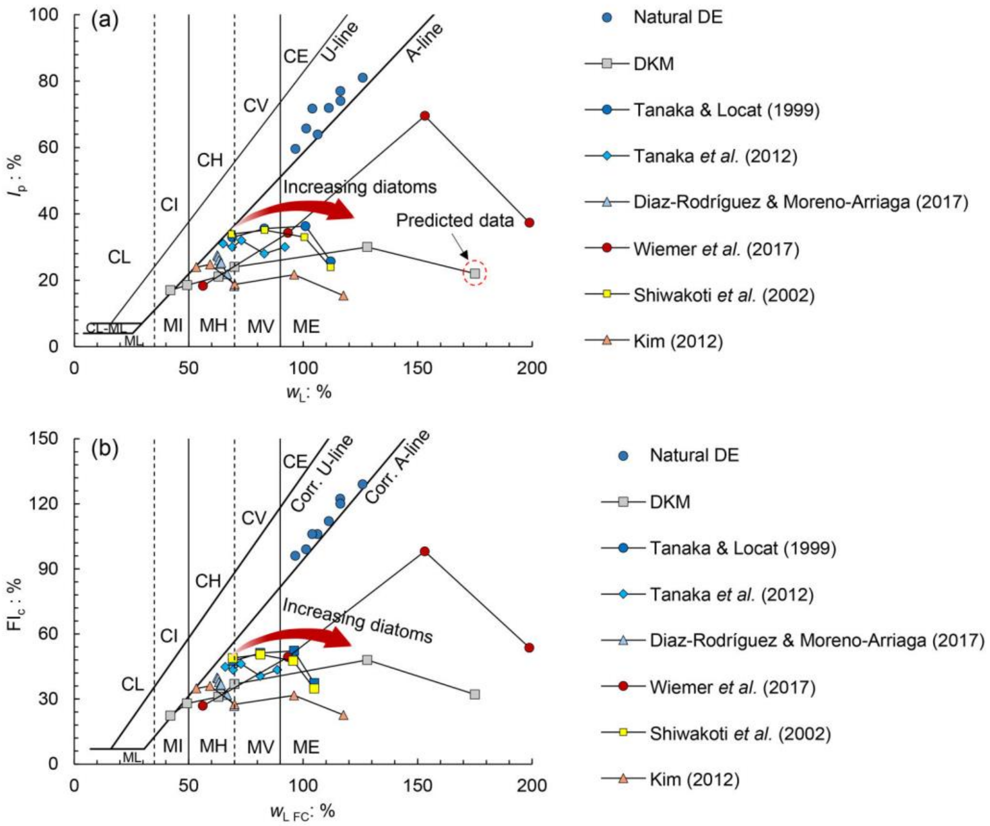

Fig 8

Accepted manuscript doi:
10.1680/jgeot.21.00268

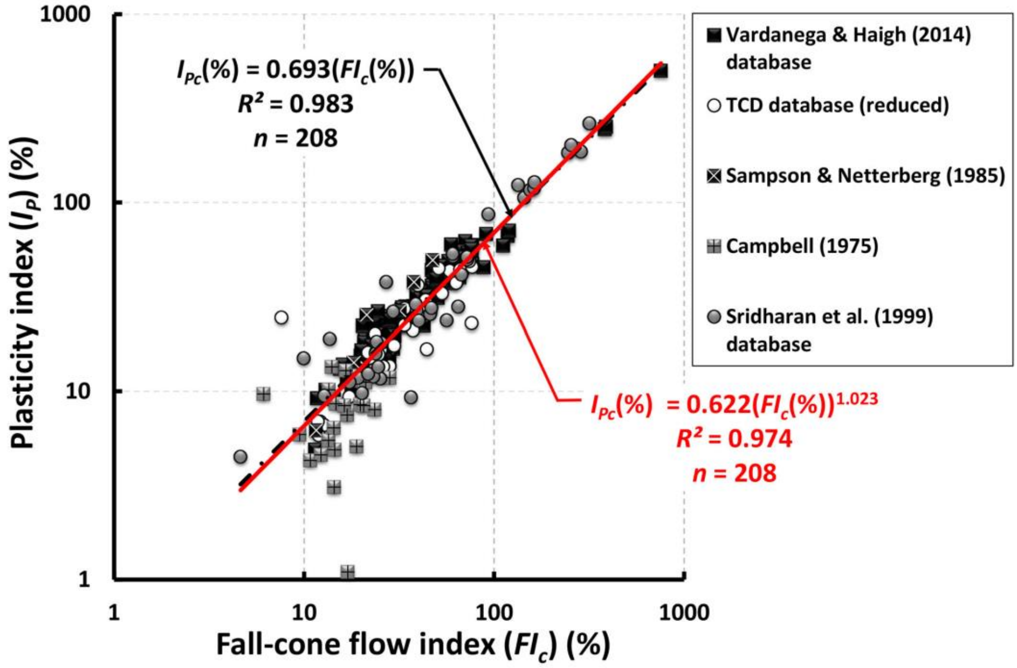

Fig 9