Bull. Min. Res. Exp. (2025) 176: 154-157

Bulletin of the Mineral Research and Exploration

http://bulletin.mta.gov.tr

Reply to: "Discussion: Determination of Atterberg Limits Using the Vane Shear Test Method [Bull. Min. Res. Exp. (2024) 174: 1–10]"

Kamil KAYABALI[a*], H. B. NAGARAJ[b], Deniz YILMAZ[c] and Muhammet BEYHAN[d]

[a] *Ankara University, Geological Engineering Department, Ankara, Türkiye*
[b] *B.M.S College of Engineering, Bangalore, India*
[c] *Fugro Sial Yerbilimleri, Ankara, Türkiye*
[d] *Öksüt (Centerragold) Mining, Ankara*

Reply

The main focus of the criticisms raised by O'Kelly and Soltani (2025) (hereafter referred to as discussers) to the authors' article in Bulletin of Mineral Research and Exploration (174, 1-10) is to examine the veracity of the strength-based equations presented by Kayabalı et al. (2024). The discussers applied the predictive equations proposed by the authors to dissimilar soils in the two articles (Kayabalı et al., 2015*a*; Kayabalı et al., 2015*b*) published earlier by the lead author with his research group. The discussers showed that the predictive equations 6 and 7 given by Kayabalı et al. (2024) yield extremely high values of liquid limit (LL) and plastic limit (PL) when applied to dissimilar soils. Further, discussers argued that the approach proposed by Kayabalı et al. (2024) led to erroneous results in determining soil classes.

First of all, authors need to emphasize that 500 sets of tests were conducted for the 100 soils examined in the article under discussion. It should be appreciated that such a voluminous data set cannot be presented in full detail in an article that is expected to be of a reasonable length. Therefore, the experimental results were presented as only a and b coefficients of vane shear tests (VST) for space-saving considerations. The same approach was adopted by Kayabalı et al. (2015*a*) and Kayabalı et al. (2015*b*), where only a and b coefficients of VST were preferred for presenting test data in place of lengthy details. Among the predictive equations in article under discussion, authors' priority of use is surely the first two ones (i.e. equations 4 and 5), since they estimate the two important Atterberg limits (namely LL and PL) with only one set of data comprising only water content and undrained shear strength from VST. Obtaining the a and b coefficients for equations 6 and 7 requires at least a few- to several sets of data for any fine-grained soil. Since the authors could not present the experimental data in full detail in the article under discussion, the discussers naturally had to use prediction equations 6 and 7 presented in the paper.

The detailed data sets produced by the lead author's research group in the past and published in Kayabalı et al. (2015*a*) and Kayabalı et al. (2015*b*) were retrieved from the archive and the predictive performance of especially the equations 4 and 5 presented in Kayabalı et al. (2024) were re-evaluated using those

Citation Info: Kayabalı, K., Nagaraj, H. B., Yılmaz, D., Beyhan, M., 2025. Reply to: "Discussion: Determination of Atterberg Limits Using the Vane Shear Test Method [Bull. Min. Res. Exp. (2024) 174: 1–10]".Bulletin of the Mineral Research and Exploration 176, 154-157. https://doi.org/10.19111/bulletinofmre.1647260

**Corresponding author: Kamil KAYABALI, kayabali@ankara.edu.tr; H. B. NAGARAJ, drhbn.civ@bmsce.ac.in; Deniz YILMAZ, deniz_yilmazz@hotmail.com; Muhammet BEYHAN, mmbeyhan@gmail.com*

dissimilar soils. The data in Kayabalı et al. (2015*a*) originally belonged to 60 soils. Approximately 300 sets of test data were produced by performing 3-7 sets of experiments for each soil comprising LL, PL, water content, and undrained shear strengths. The authors applied Equation 4 in Kayabalı et al. (2024) to the data sets in Kayabalı et al. (2015*a*). In this way, the LLs obtained for each soil by employing the predictive equation, varying in number between 3 and 7, were compared with the LLs of that soil determined through the falling cone method (Figure 1). This figure comprises only 60 pairs of LLs instead of some 300+ pairs of LLs for the sake of simplicity. That is to say, the mean value of the LLs for the 3-7 pairs of water content and undrained shear strength predicted by the strength-based equation of 4 was compared with the LL value determined by the fall-cone test. According to this figure, the prediction performance of our strength-based equation yields quite reasonable comparisons up to about LL = 60%. Liquid limits calculated by predictive equations are generally 15% higher than the experimentally found LLs. Similar steps were employed using equation 5 to PL as shown in Figure 2. A quick glimpse shows that while equation 5 in Kayabalı et al. (2024) gave reasonable values when the plastic limits were low, it overpredicted PL for higher plastic limits. Plastic limits calculated by the prediction equation are generally 18% higher than those determined experimentally.

After retrieving some 600+ sets of experimental data employed by Kayabalı et al. (2016*b*) from the archive for 120 dissimilar soils, the LLs again were predicted by Equation 4 by Kayabalı et al. (2024) as shown in Figure 3. It is observed from Figure 3 that the proposed predictive equation 4 performs better for this data set. According to Figure 3, the prediction equation in our 2024 article overpredicted the liquid limit by 9% in 103 of 120 soils and underpredicted it by 4% in 17 of them. When looking at the performance of the prediction equations in predicting the plastic limit for the last data set (Figure 4), it is seen that the plastic limit is generally overpredicted by about 33%.

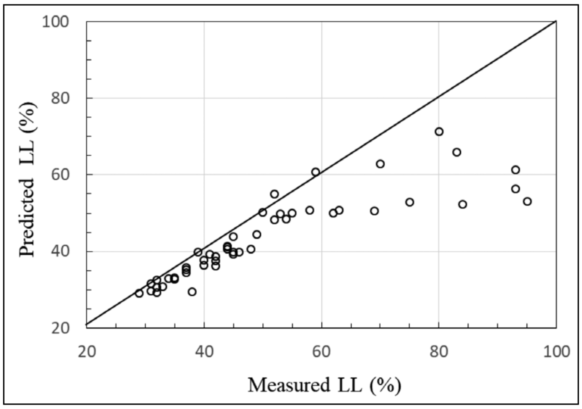

Figure 1- Comparison between the mean values of predicted LLs and experimental LLs for each soil by employing Kayabalı et al. (2015*a*) data.

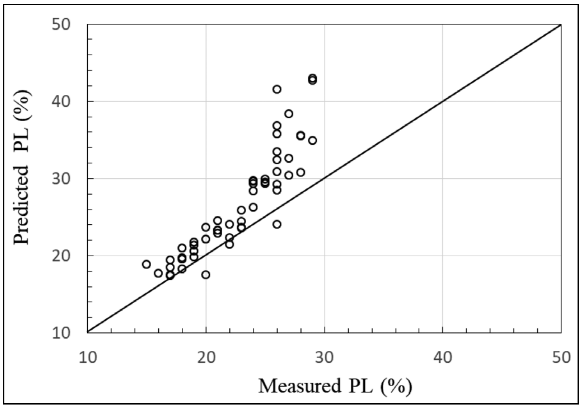

Figure 2- Comparison between the mean values of predicted PLs and experimental PLs for each soil by employing Kayabalı et al. (2015*a*) data.

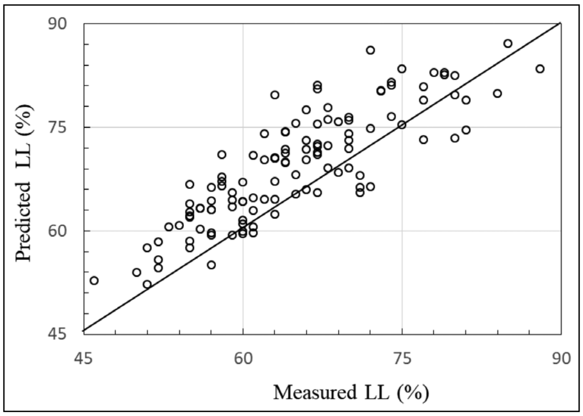

Figure 3- Comparison between the mean values of predicted LLs and experimental LLs for each soil by employing Kayabalı et al. (2015*b*) data.

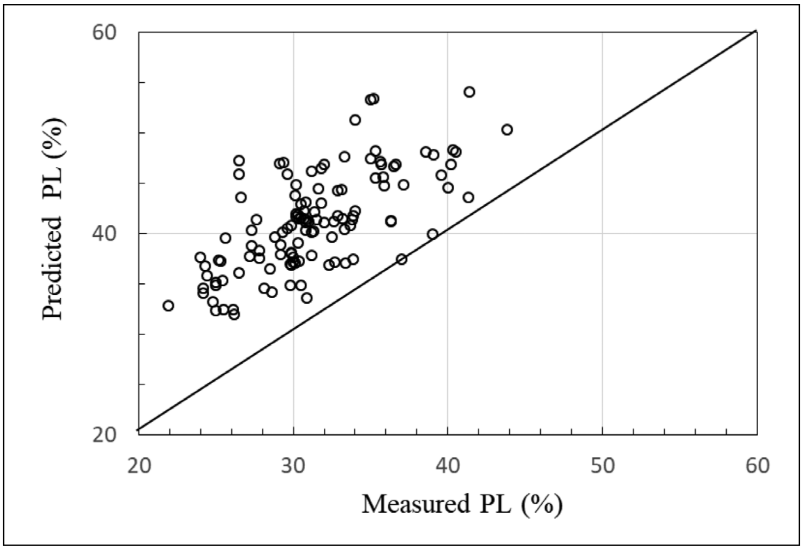

Figure 4- Comparison between the mean values of predicted PLs and experimental PLs for each soil by employing Kayabalı et al. (2015*b*) data.

The authors ackonwledge that there is a typo in Equation 2 as pointed out by the discussers. It should have been given as follows:

$$K = \frac{\pi D^2 H}{2x10^6}\left[1 + \frac{D}{3H}\right] \quad (1)$$

This equation presented in the paper under discussion is given only as background information. It was not used directly in the computations. The software of the VST apparatus directly gave the undrained shear strength values.

The evaluations of the proposed predictive equations rendered within the context of this reply show that the predictive equations 4 and 5 yielded reasonably acceptable results for dissimilar soils of our research group's previous studies. It can be seen that the discrepancy in the scatter of predicted LLs and PLs in this reply gets significantly narrower compared to the scatter of the results obtained by the discussers. An important point the authors need to mention here is that the undrained shear strengths obtained by our research group in both 2015 investigations were carried out using the VST mechanism shown in Figure 5. In this device, calibrated springs are used to determine the undrained shear strength. The VST mechanism used in current article under discussion is servo-controlled and provides much more precise results. Therefore the authors are of the opinion that the scatter obtained in the previous set of data that tested with our predictive equations mainly may be due to the mechanism involved in apparatus set being used. Other minor effects may be the use of unusual soils such as bentonite mixtures in experimental


Figure 5- The old-fashioned vane shear test apparatus used in the earlier investigations of the lead author and his research group.

studies and the fact that the operators performing the experiments are different for each of the study.

It was emphasized in a great number of earlier studies that the hand-rolling or the plate-rolling method used in determining the plastic limit is somehow irrational for being not quantitative. Because it is akin to the liquid limit, several research was performed in the past on determining the PL together with the LL by using the fall-cone method. The authors believe that research will continue for a longer time to establish the plastic limit on a more rational basis. Despite everything, the authors are of the opinion that the method used in the paper under discussion has a significant premise in determining both the liquid limit and plastic limit of fine-grained soils. So, the authors recommend prospective researchers employ a VST apparatus giving more precise undrained shear strength values and avoid the use of a spring-type VST machine for further investigations of Atterberg limits.

References

Kayabalı, K., Aktürk, Ö., Fener, M., Üstün, A., B., Dikmen, O., Harputlugil, F., H. 2015*a*. Evaluation of undrained shear strength of fine-grained soils in consideration of soil plasticity. Yerbilimleri – Bulletin of the Earth Sciences Application and Research Centre of Hacettepe University 36(3): 121–136.

Kayabalı, K., Aktürk, Ö., Fener, M., Dikmen, O., Harputlugil, F., H. 2015*b*. Revisiting the Bjerrum's correction factor: Use of the liquidity index for assessing the effect of soil plasticity on undrained shear strength. Journal of Rock Mechanics and Geotechnical Engineering 7(6): 716–721.

Kayabalı, K., Nagaraj, H. B., Yilmaz, D., Beyhan, M. 2024. Determination of Atterberg Limits using the vane shear test method. Bulletin of the Mineral Research and Exploration 174(174): 1–10.

O'Kelly, B. C., Soltani, A. 2025. Discussion: Determination of Atterberg Limits Using the Vane Shear Test Method [Bulletin of the Mineral Research and Exploration (2024) 174: 1–10].