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Discussion of "Determination of liquid limit by the fall cone method"*

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Discussion

The readers appreciate the comparative study that the authors have made on the liquid limit (LL) test results obtained by both the Swedish Standard (SS) fall-cone (LL_{FC}) and the Brazilian standard percussion (LL_{cup}) methods presented for soil samples collected from different geological formations in Brazil. The LL obtained by current standard methods are not definitive values but indicators of soil when its conditions reach the limit state (Manafi, 2019). The two LL methods measure different physical quantities (Haigh, 2012). Compared with the percussion (or Casagrande) method, the fall-cone method is less error-prone (Claveau-Mallet et al., 2012).

The most common LL fall-cone devices are the Swedish cone (60º-60g fall-cone) and the British/French cones (30º-80g fall-cone) (Leroueil & Le Bihan, 1996). LL measured by fall-cone test is not standardized in Brazil, and the readers would like to include some additional comments on a comparison of LL_{cup} with LL_{FC} values obtained by the Standard BS 1377 (BSI, 1990) fall-cone method considering different soils having $LL_{cup} < 100\%$. The investigated data come from different operators and laboratories, and it may be expected that some uncontrolled factors during the LL measurements have played a role in the observed differences between the LL_{cup} and LL_{FC} values.

Figure 1 illustrates a comparison of LL data obtained by the SS (Clemente et al., 2020) and BS (Bicalho et al., 2014) fall-cone methods with those obtained by the Brazilian standard percussion method (hard rubber base cup). The solid square symbols are the data reported by the authors (SS fall-cone). The open square symbols are the data from BS fall-cone reported by the Bicalho et al. (2014). The LL for different natural inorganic low plasticity clays from different locations in Brazil were compiled by Bicalho et al. (2014) and included data by Pinto & Castro (1971) and Silveira (2001) with LL_{cup} ranging from 14 to 98% and LL_{FC} from 18 to 98% (BS fall-cone method). The clays are essentially kaolinites and illites. A fitted empirical relationship ($LL_{FC} = LL_{cup} + 2.7$, $R^2 = 0.98$) shows that LL_{cup} values are generally 2.7% lower than LL_{FC} for the data, Figure 1. The linear empirical LL_{FC} - LL_{cup} correlation proposed by Queiroz de Carvalho (1986) for 27 samples of lateritic soils from Brazil (LL_{cup} ranging from 13 to 48%) in which kaolinite is the only clay mineral is also presented in Figure 1. The comparison of data from different sources shows variations in the LL results based on Casagrande and fall-cone methods (Figure 1). It can be observed from Figure 1 that most data fall within $LL_{FC} = 0.8LL_{cup}$ and $LL_{FC} = 1.2LL_{cup}$ lines. The data consistently indicate higher LL being obtained for the fall-cone devices compared to the Casagrande cup for $LL_{cup} < 40\%$, while the difference in LL_{FC} and LL_{cup} is more spread out for $LL_{cup} > 40\%$ for the investigated fine-grained soils. Also, the LL_{FC}/LL_{cup} ratio may range to values even greater than 1.2 at low LL_{cup} values (i.e., $LL_{cup} < 40\%$). It is therefore worthwhile to examine the differences in the LL_{cup} and LL_{FC} (SS and BS fall-cone) of fine-grained soils when applying LL values obtained by different standards in soil classification systems and empirical correlations in geotechnical engineering, even for $LL_{cup} < 100\%$ where the LL values obtained with the fall-cone and Casagrande methods are often considered approximately equal (Wasti & Bezirci, 1986; Spagnoli, 2012).

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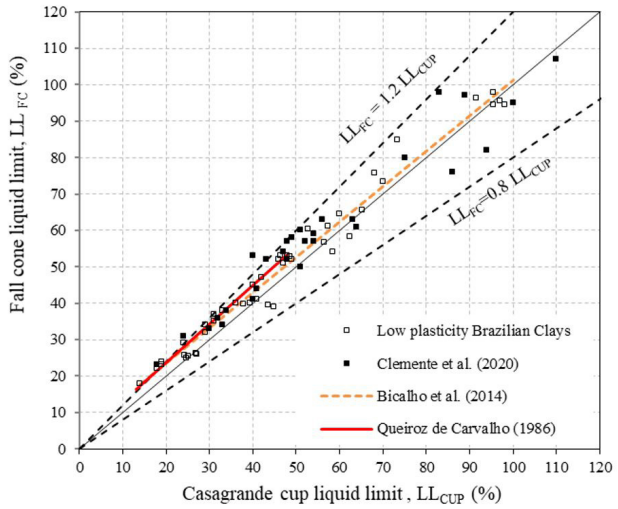

Figure 1. Comparison of LL test results obtained by the SS and BS fall-cone methods with those obtained by the Brazilian standard percussion method for LL data between 14% and 110%.

Declaration of interest

We wish to confirm that there are no known conflicts of interest associated with this publication.

Author's contributions

Kátia Vanessa Bicalho: conceptualization, supervision, review and approval. Janaina Silva Hastenreiter Küster: discussion, writing – reviewing and editing; Lucas Broseghini Totola: discussion, writing – reviewing and editing. Letícia Garcia Crevelin Cristello: discussion.

List of symbols

LL	Liquid limit
LL_{FC}	Liquid limit obtained by the fall-cone method
LL_{cup}	Liquid limit obtained by the standard percussion method
SS	Swedish Standard
BS	British Standard
R^2	Coefficient of determination in linear regression

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