

DISCUSSIONS

Liquid limits and fall cones: Discussion¹

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The authors have compared the liquid limit values obtained by the percussion method and the fall cone method and also compared the values obtained by the methods and standards followed in different countries. In this connection, the discussers would like to comment on certain issues.

The details pertaining to the Indian cone given in Table 1 of the note do not tally with the method that is currently being adopted in India. The Indian code of practice for the determination of liquid and plastic limits when first published in 1965 contained only the percussion method. In the first revision in 1970, the cone method of determining the liquid limit was introduced, which contained the details given in Table 1 of the note. The second revision of the code was done in 1985, and currently, the same revised version is being adopted (IS: 2720—Part 5 (Bureau of Indian Standards 1985)). According to this, the cone has an apex angle of $30 \pm 1/2^\circ$, a length of 35 mm, and a mass of 80 ± 0.5 g. The liquid limit is the moisture content corresponding to a 20 mm penetration of the cone. The Indian code also identifies a one-point method of determining the liquid limit using the cone and gives two equations:

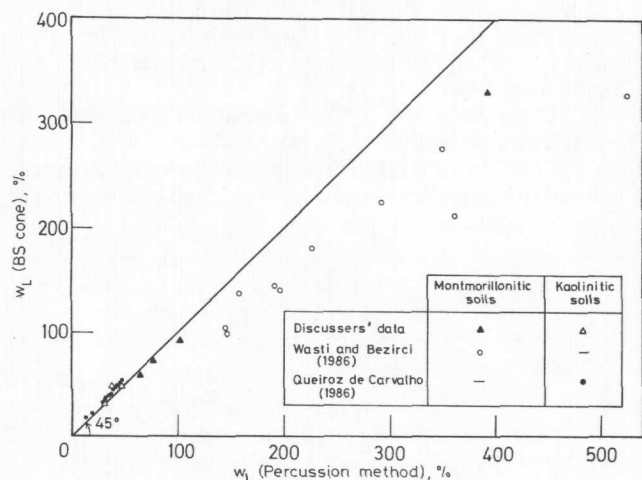
$$[D1] \quad w_L = \frac{w_N}{0.77 \log D}$$

$$[D2] \quad w_L = \frac{w_N}{0.65 + 0.0175D}$$

where w_N is the water content corresponding to a penetration of D mm ($16 \text{ mm} < D < 26 \text{ mm}$).

Many investigators have tried to compare the liquid limits obtained by the percussion method as per BS-ASTM (British standard adopts a soft based and ASTM standard specifies a hard base) with those obtained by the cone method (Sherwood and Ryley 1970; Skopek and Ter-Stepanian 1975; Littleton and Farmilo 1977; Budhu 1985; Moon and White 1985; Queiroz de Carvalho 1985; Sivapullaiyah and Sridharan 1985; Wasti and Bezirci 1986; and Rao 1987, to name a few). It has been observed by many, including the discussers, that the liquid limit obtained by the percussion method can be as low as about 26% less than and as high as about 71% more than the liquid limit obtained by the cone method. However, no attempt has been made in the past to recognize the cause for this difference, except for Budhu (1985) who has attributed the observed dif-

Fig. D1. Comparison between the liquid limits obtained from the percussion method and the cone method.



ference in the results by the two methods to the clay content of the soil.

The first discussor has been involved in many research works in the past concerned with the mechanisms governing the liquid limit of soils (Sridharan and Venkatappa; Rao 1975; Sridharan et al. 1986; Sridharan et al. 1988; Sridharan 1991). These works have indicated that the mechanisms controlling the liquid limit of the kaolinitic soils and montmorillonitic soils are different. While the mode of particle arrangement as governed by the interparticle forces controls the liquid limit of kaolinitic soils, the thickness of the diffuse double layer controls the liquid limit of montmorillonitic soils.

Figure D1 shows a typical comparison of the liquid limits obtained by the British Standard cone method with those obtained by the percussion method. The data presented include only those soils in which the dominant clay mineral type present is known. The data of Queiroz de Carvalho (1986) correspond to lateritic soils from Brazil, which contain kaolinite as the only clay mineral. For those soils, the cone method gave higher values than the percussion method. The soils tested by Wasti and Bezirci (1986) are montmorillonite-rich soils (i.e., mixture of bentonite and natural soils from Turkey). For all the soil mixtures tested, the percussion method gave much higher values than the cone method. The discussers' data in Fig. D1 correspond to natural soils. They have observed that the cone method gives a higher liquid limit than the percussion method for kaolinitic soils and that the percussion method results always give higher liquid limits than the cone method for montmorillonitic soils.

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In the light of the above discussion, the discussers are of the opinion that the dominant clay mineral type and its proportion in the clay content are responsible for the deviations between the results obtained from the percussion and cone methods, rather than the clay content alone as proposed by Budhu (1985).

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Liquid limits and fall cones: Reply¹

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The Authors are grateful for the interest that the Discussers have shown in this paper.

The Discussers present a comparison of liquid limits obtained by the percussion method with those obtained by the fall cone method. Typically, the percussion method gives higher liquid limit values than the fall cone method for liquid limits higher than about 60%, and lower values when the liquid limit is lower than about 60%. They indicate that the difference depends on the dominant clay mineral type. This is certainly an important factor, but probably not the only one, since the Authors found a similar behaviour (Figs. 3 and 5) with clayey soils from eastern Canada having essentially the same dominant clay minerals.

The Discussers also give details concerning the fall cone method currently used in India. It may be of interest to mention that a recent paper by Farrell et al. (1997) confirms the Authors' observation (Fig. 1) that the liquid limit determined with the 60° – 60 g fall cone at a depth of penetration of 10 mm is practically equal to that determined with the 30° – 80 g fall cone at a depth of penetration of 20 mm.

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