Activity of Soils

Activité des Sols

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SYNOPSIS The definition of activity of soils, Skempton 1953, considering the relationship between the plasticity index and the percentage of clay to yield to a straight line passing through the origin, implies that the activity of a clayey soil depends only on the clay minerals However, it has been noted that for some soils, this line might not pass through the origin, which emphasizes the necessity to study the influence of the coarse grained fraction on activity. In this investigation, five different coarse grained soils were used, each one was mixed at different percentages with the same type of clay. An activity line was traced corresponding to each type of coarse grained soil. This implies that the properties of coarse grained fraction of soil influence the activity. A new definition of activity is recommended to express the activity of soil, incorporating the influence of coarse grained fraction.

INTRODUCTION

The activity of clay as was first presented by Skempton 1953, has been widely used to express the type of clay minerals in a clayey soil. The activity was denoted by A and was defined as the ratio of the plasticity index PI to the percentage by weight of the clay fraction C (particles finer than 2 um).

$$A = \frac{PI}{C} \qquad (1)$$

For many clays the plot of the plasticity index versus the clay content yields to a straight line passing through the origin , which implies that the activity of a clayey soil depends only on the type of clay and is not affected by the amount of clay or the coarse grained fraction of soil (particles coarser than 2 um). However, deviation from these observations, were noted by different investigators. Some of them attributed the deviation to the difference of liquid limit devices used (Seed et al, 1962) Fig.1 , others considered it to be due to the presence of coarse particles (Grim 1962 and White 1955). Or due to low clay percent (Grim et al 1959 and Seed et al a, b), and the non linear relationship between plasticity index and percentage of clay (Norman 1958 and Youssef et al 1965). Effect of coarse grained fraction of soil on activity can also be deduced from previous works e.g. Novais-Ferreira 1969, Ranganatham and Satyanarayana 1965, and Rabba 1975. The work described in this paper is an attempt to investigate the influence of coarse grained fraction of soil on the activity.

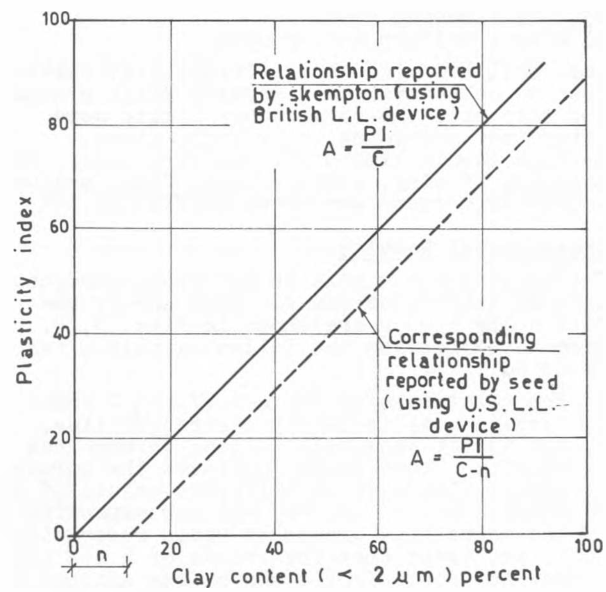

Fig.1 Effect Of Liquid Limit Device Type On Activity (After Seed et al., 1962).

EXPERIMENTAL WORK

Tested Soils

Clay fractions < 2 μm separated by hydrometer analysis were mixed with five different coarse grained soils > 2 μm to consist five groups of soils as follows :

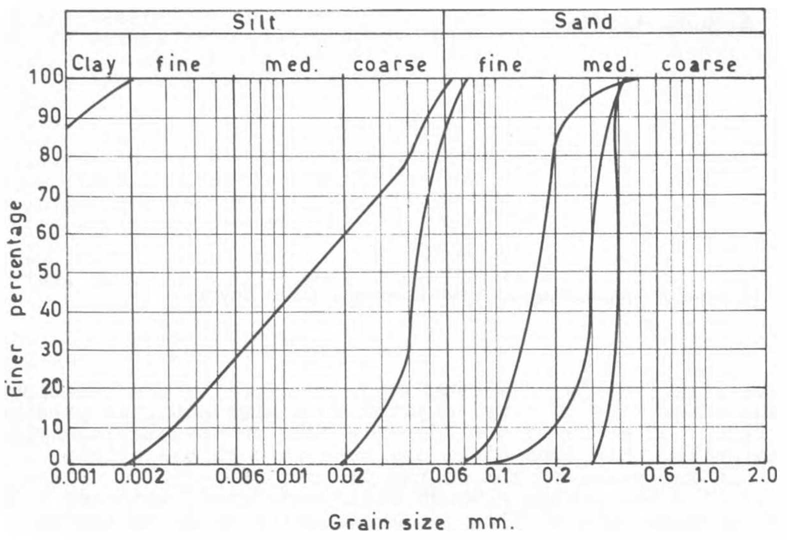

Fig.2 Grain Size Distribution of Tested Soils

a) Clay + silt (separated by hydrometer analysis).
b) Clay + ground sand (passed from sieve No. 200).
c) Clay + fine sand.
d) Clay + medium sand.
e) Clay + uniform medium sand.

Each soil was mixed by different clay percentages to make different prepared soils groups. For each soil the consistency limits were determined according to specifications. British liquid limits devices were used. The gradings of clay, silt, ground, fine, medium and uniform sands are shown in Fig.2.

Experimental Results

The consistency limits at different percentages of clay fractions for each one of the five soils groups are shown in Figs. 3, 4. From these results the following points can be noted :

a) The relationships between PI and C for a certain soil is nearly a straight line, but is not generally passing through the origin. These lines intersect the percentage of clay axis at different values of n equals -34, -3, 0, +8, +16 corresponding to the above five groups of soils respectively. It was noted that the values of n are bigger for coarse soils and become smaller as the soils get finer until it reaches -34 for silt-clay soils.

b) Soils having the same type and amount of clay minerals may have different plasticity indices if their grading are different.

c) Soils composed of pure silt particles 2 um has some plasticity.

DISCUSSION OF TEST RESULTS

a) It is known that the liquid and plastic limits and consequently the plasticity indices are related to the amount of the absorbed water that is attracted to the surfaces of the soil particles. No doubt, that silty soils have surface area bigger than that of sandy soils and consequently it is necessary for such soils to have higher plasticity indices, similar results were obtained by Novais Ferreira for fine and coarse sands mixed with the same clay.

b) It may be expected that soils of fine particles as silt needs smaller amount of clay, in order to develop plasticity, than the corresponding soils with coarse particles as sands. Consequently, fine sand will need smaller quantity of clay to develop plasticity than coarse sand. It follows that the lines representing the relationships between PI and C will not generally pass through the origin. Furthermore it will be expected that coarse sands for example need smaller amount of bentonite, to have some plasticity than that of kaolinite. Thus it becomes clear that the value of n depends on two factors.

(i) Grading of particles as in the present study.

(ii) Type of clay mineral. (Seed et al 1962, and Zacharias & Ranganatham 1972).

c) In order to determine the activity of soils such as those under our study, the effect of intersept n must be taken into consideration. Seed's formula will displace each line parallel to its original direction. Consequently, the different soils contain the same clay will remain to have different activities.

From the above, it is evident that an expression of activity is required.

RECOMMENDED FORMULA

From this investigation and previous works the relationships between the plasticity indices and corresponding clay percentages

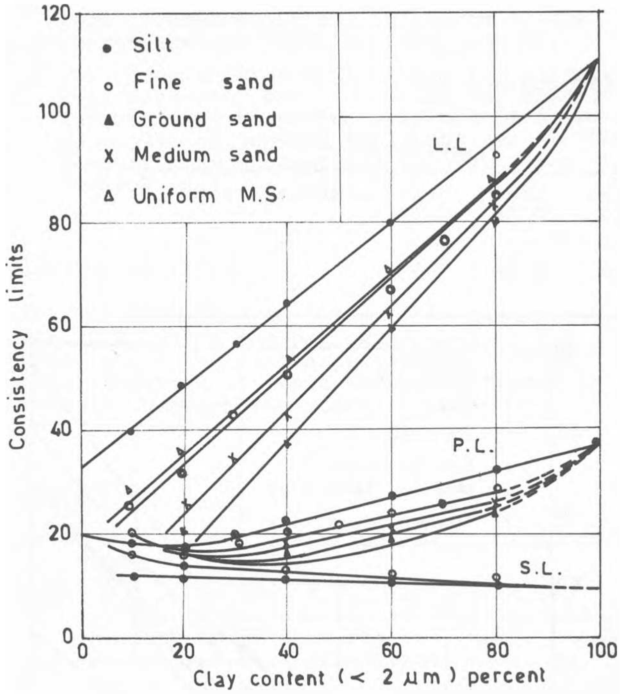

Fig. 3 Effect of Grading of Soils on Consistency Limits

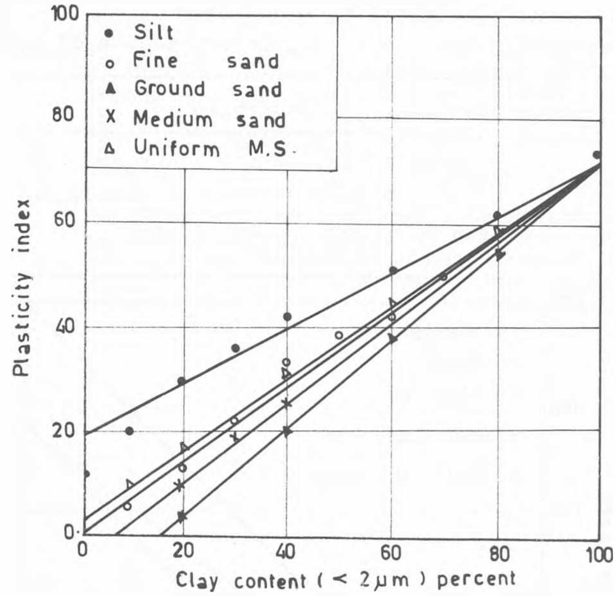

Fig. 4 Effect of Grading of Soils on Plasticity Index

yield to a straight line, but not generally passing through the origin. The line intersects the percentage of clay axis at a value $\pm$ n .

Consequently, the activity of a soil can be represented by the following formula :

$$A = \frac{PI}{C \mp n_1} \qquad \text{(see Fig. 5)}$$

where $n_1 = n \dfrac{100 - C}{100 \mp n}$

then $A = \dfrac{PI}{C \mp n \quad \dfrac{100 - C}{100 \mp n}}$

$$= \frac{PI\ (100 \mp n)}{100\ (C \mp n)} = \frac{PI}{C_E} \qquad (2)$$

where $C_E = \dfrac{100\ (C \mp n)}{(100 \mp n)}$ = modified clay percentage

The value of A is the normal skempton coefficient for the activity of clay. While the value of n depends mainly on the coarse grained fraction of the soil particles and the interaction between the clay fraction and the coarse grained fraction in the soil.

In order to determine the activity of the clayey soil, it is preferable to perform two tests, one for the clay fraction alone to find the actual value for A and the other for the total soil. From these two tests activity line can be traced and the intercept of the percentage of clay axis n can be determined.

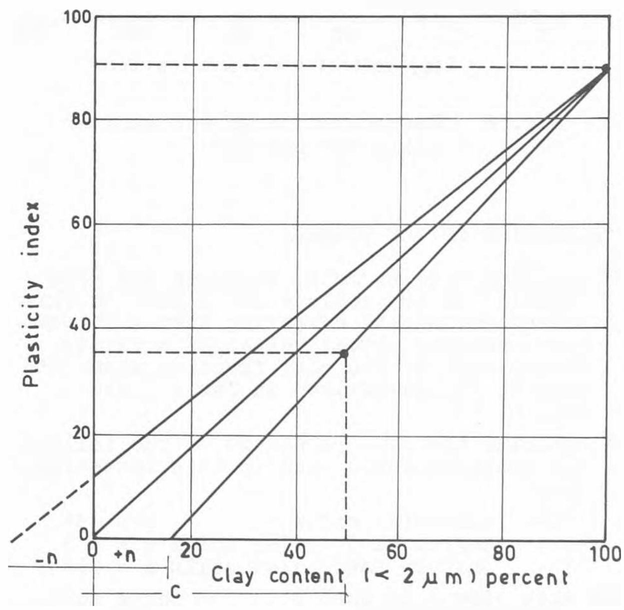

Fig. 5 Determination of Activity by The Proposed Formula

TABLE I

Determination of Activity for Soils A and B

	Properties			Activity			
	C	PI	n	Skempton	Seed	New F	Actual value
Soil A	51	60	-34	0.85	0.55	0.73	
	100	73					0.73
Soil B	47	48	+24	0.98	1.96	1.49	
	100	152					1.52

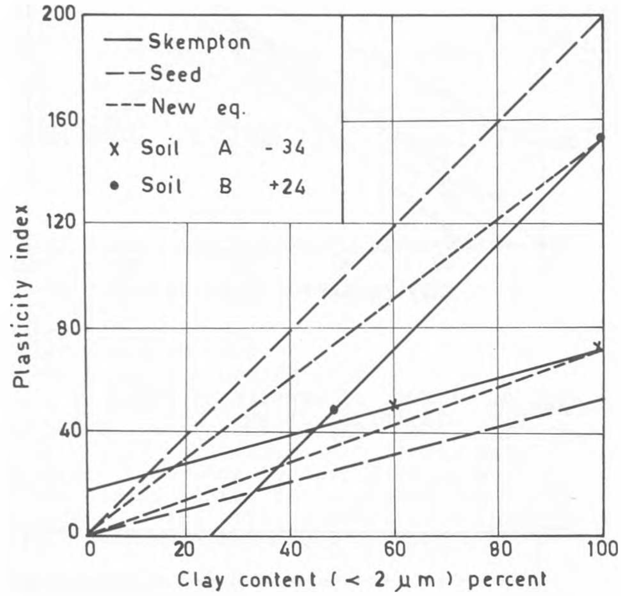

Fig. 6 Determination of Activity of Soils "A" and "B"

APPLICATION OF THE FORMULA

a) Applying this formula, Skempton and Seed formula, to two soils A and B used in this investigation and comparing them with the corresponding actual values of activity determined for the clay fraction alone the results are summarized in Table I and Fig. 6.

b) Applying the same procedure to the following prepared soils used in this investigation

i- Silt-clay soils n = -34
ii- Medium sand - clay soils n = + 8
iii- Uniform sand- clay soils n = +16

The same clay A is used with the three soils groups. The activity of this clay is 0.73 . The results are summarized in Fig. 7, which illustrates that the new formula gives values for activity very close to the actual value as determined for the clay fraction alone. Whereas seeds formula may give values of activity greater or smaller than the actual activity. The obtained different lines

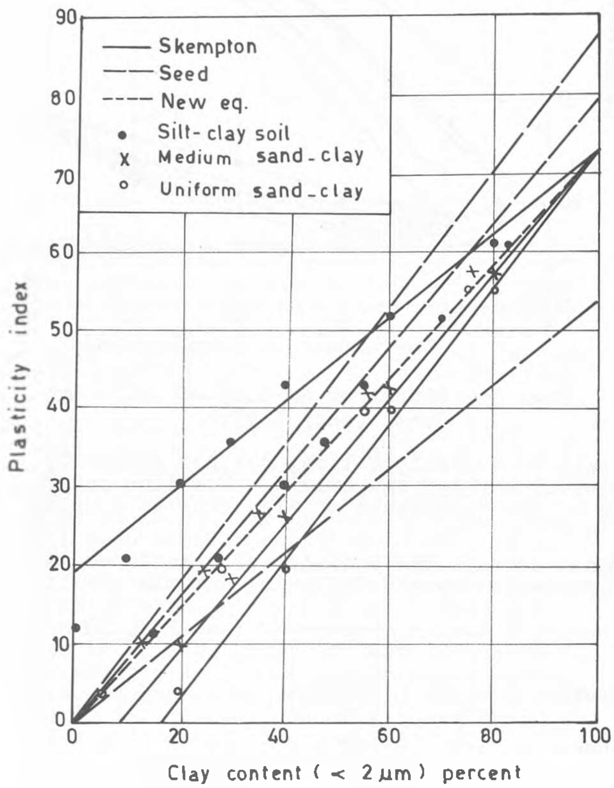

Fig. 7 Determination of Activity by Using Skempton, Seed and New Equation.

representing the relationships between PI and C became one line using the new formula , whose slope represents the activity.

c) Applying the same analysis to works carried out by other investigators (e.g. Zacharias and Ranganatham) confirmed the above mentioned conclusion.

CONCLUSIONS

a) The line representing the activity of soil is not generally passing through the origin but it may intersect the clay content percent axis at either a positive or negative value, depending on the type of the coarse grained fraction of the soil.

b) Activity of soil can be expressed in a form incorporating the influence of the coarse grained fraction (equation 2).

c) The determination of activity for clayey soil from only one test using the previous formulas can be misleading, and it is recommended to perform two tests one at 100 percent clay content and the other for the natural soil.

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