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Use of Plate Load Tests for Bearing Capacity Evaluation in Silts

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Introduction

Alluvial deposits are encountered extensively in the northern and central regions of India. These deposits consist primarily of silts having varying amounts of sand and clay. In some areas, these deposits also contain gravel sized calcareous concretions/nodules colloquially known as "kankar".

When the clay fraction is low or absent in such deposits, they exhibit low plasticity or may be non-plastic as is the case for sandy silts. On the other hand presence of clay may cause such deposits to exhibit medium to high plasticity.

The soil in and around Delhi, consists primarily of silt (53 to 77%) which has a low clay content (3 to 7%) with varying amounts of sand (10 to 25%) and kankar (10 to 15%). It is tan in colour and exhibits low plasticity. On the ground surface, and at shallow depths, the silt has low moisture content and exhibits high unconfined compressive strength.

The bearing capacity of shallow foundations on silts has not been a subject of much detailed study. Raju et al. (1971), Singh et al. (1971), Roy et al. (1971), Gupta (1986), Aziz (1987) and Kaniraj et al. (1987) have reported results of field plate load tests and laboratory model tests on silt deposits and their findings can be summarised as follows :

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(a) Silts exhibit high bearing capacity in the dry state;

(b) This high bearing capacity reduces markedly upon ingress of water;

(c) Silt behaves in the field, like a soil which exhibits both a cohesion intercept, c, and an angle of shearing resistance, ϕ;

(d) Laboratory determination of c and ϕ through triaxial tests is difficult because the presence of gravel sized kankar hampers preparation of undisturbed samples of 38 mm diameter for triaxial testing and

(e) Laboratory determined shear parameters, c and ϕ, do not always represent the c and ϕ operative in the field; and

In the absence of any standardised procedures for determining the bearing capacity of shallow foundations on silts, the existing practice consists of assuming that silt will behave either as a coarse grained soil ($c = 0$) or as a fine grained soil ($\phi = 0$) and then applying the procedures used for determining the bearing capacity of shallow foundations on sand or clay, as the case may be.

This approach is clearly approximate because silt behaves like a c - ϕ material in the field. Both c and ϕ are dependent on the percentage of clay, sand and kankar present in the soil as well as on the insitu density, insitu water content and the drainage condition. A realistic method for determining the bearing capacity of shallow foundation on silts should incorporate a technique which can identify the c and ϕ values operative in the field.

This paper describes one such technique, in which c and ϕ values are evaluated using results from field plate load tests and laboratory unconfined compression tests.

Existing Practice

The existing practice for evaluating the bearing capacity of shallow foundations on silt requires a decision as to whether the silt will behave similar to a coarse grained soil or to a fine grained soil. Once this decision is made, the evaluation of the bearing capacity is relatively straight forward as discussed below.

Treating Silts as Coarse Grained Soil

The bearing capacity of coarse grained soils is evaluated on the basis of Standard Penetration Test (SPT) results and/or State Cone Penetration Test (SCPT) results.

Two methods based on SPT results are commonly used, namely (a)

Teng's method (1965) based on an empirical correlation between N-values and the ultimate bearing capacity, and (b) Bureau of India Standard method (IS: 6403-1981) based on Vesic's (1973), bearing capacity theory.

In Teng's method, the observed N-values from SPT tests are corrected for overburden and dilatancy and the ultimate bearing capacity, q_{ult}, determined from :

$$q_{ult} = \left\{N^2 B R'_w + 3\left(100 + N^2\right)\right\} D R_w / 31 \tag{1}$$

where R_w, R'_w = water table correction factors
B = width of foundation in metres
D = depth of foundation in metres

The method of the Bureau of India Standards (IS : 6403 - 1981) uses the N-values to estimate the angle of shearing resistance ϕ on the basis of the correlation given by Peck et al. (1967). The ϕ value, so determined, is used to determine q_{ult} from the following equation for general shear failure :

$$q_{ult} = 0.5 B_\gamma N_\gamma s_\gamma d_\gamma i_\gamma W' + \gamma D N_q s_q d_q i_q \tag{2}$$

Where N_γ. N_q = bearing capacity factors as per Vesic (1973)
s.d.i = shape, depth and inclination factors
W' = water table correction factor
γ = unit weight of soil

Treating Silt as Fine Grained Soil

The bearing capacity of fine grained soils is evaluated on the basis of $\phi = 0$ analysis using $c = (\text{unconfined compressive strength})/2$. The following bearing capacity equation is used as per the Bureau of India Standards (IS : 6403 - 1981) :

$$q_{ult} = c N_c s_c d_c i_c + \gamma D N_q s_q d_q i_q \tag{3}$$

where N_c, N_q = bearing capacity factors as per Vesic (1973); for $\phi = 0$, $N_c = 5.14$ and $N_q = 1.0$.

Aim and Scope of Study

A field study was undertaken on Delhi silt comprising of plate load tests, standard penetration tests and unconfined compression tests, with an aim to evaluate the accuracy of the existing methods for determining q_{ult} of shallow foundations on silt deposits, and if found lacking to seek a new, better method.

A site having uniform soil conditions down to 5 m depth below the ground surface and water table at 20 m depth was identified. Plate load tests were conducted at a depth of 0.75 m. SPT tests were also conducted at the same depth. Large diameter undisturbed samples were collected and the unconfined compressive strength determined in the laboratory. q_{ult} was determined from N-values and from unconfined compressive strength and compared with the actual values obtained from the plate load tests. This was done for two soil conditions – the in-situ dry condition and soaked condition obtained by flooding the site for a specific period of time. The tests on soaked silt were considered necessary since behaviour has been observed to change dramatically on ingress of water (Kaniraj et al., 1987).

Results of plate load tests and unconfined compression tests were used to develop a new method for evaluating c and ϕ. These values of c and ϕ determined from tests on 30 cm × 30 cm plates were used to estimate the q_{ult} of 45 cm × 45 cm plates. The estimated values were compared with the actual values obtained in the field to validate the new method. A new procedure for evaluating the bearing capacity of foundations on the basis of this new method is suggested.

The scope of the work reported herein is limited to determining q_{ult} and does not include settlement considerations.

Testing Programme

Table 1 gives a summary of the testing programme. Eight plate load tests were conducted in eight pits of size 2.25 m × 2.25 m × 0.75 m (depth). Two sizes of square plates were used, namely, 30 cm × 30 cm and 45 cm × 45 cm. The soil condition was either dry or soaked. For each test condition two tests were performed to check for reproducibility.

Adjacent to the test pits at a distance of 0.5 m, SPT tests were conducted at a depth of 0.75 m (Fig. 1). In addition, upon the completion of each plate load test, four undisturbed samples were taken from the pit as shown in Fig. 1. The salient features of the field and laboratory tests are described below.

Plate Load Tests

Tests were conducted in accordance with IS : 1888 (1982). Load was applied using a hydraulic jack taking reaction against a truss anchored by spikes to provide 15 T reaction. A 20 T proving ring with a least count of 12 kg was placed between the jack and the bottom flange of the truss (Fig. 2) to measure the applied load accurately. A ball and socket joint was provided at the top to ensure axial loading.

Steel plates having a thickness of 20 mm with a chequered bottom were used. During each test, the settlement of the 4 corners of the plate was measured by 4 dial gauges, having a least count of 0.01 mm and a travel of 50 mm, clamped to independent datum bars placed across the pit.

Load increments applied were (a) 1000 kg for 45 cm plate, dry soil

TABLE 1 : Testing Programme

Test No.	Square Plate Size (cm)	Moisture Condition	Standard Penetration Tests (Nos.)		Undisturbed Samples (Nos.)	Laboratory Tests
			Dry	Soaked		
PL1	30	Dry/Natural	1	–	4	GSD*, UCS**, Density, Water Content
PL2	30	Dry/Natural	1	–	4	GSD*, UCS**, Density, Water Content
PL3	45	Dry/Natural	1	-	4	GSD*, UCS**, Density, Water Content
PL4	45	Dry/Natural	1		4	GSD*, UCS**, Density, Water Content
PL5	30	Soaked	1	1	4	GSD*, UCS**, Density, Water Content
PL6	30	Soaked	1	1	4	GSD*, UCS**, Density, Water Content
PL7	45	Soaked	1	1	4	GSD*, UCS**, Density, Water Content
PL8	45	Soaked	1	1	4	GSD*, UCS**, Density, Water Content

* GSD = Grain Size Distribution,

** UCS = Unconfined Compressive Strength

Note : Liquid Limit and Plastic Limit were determined on mixed representative sample

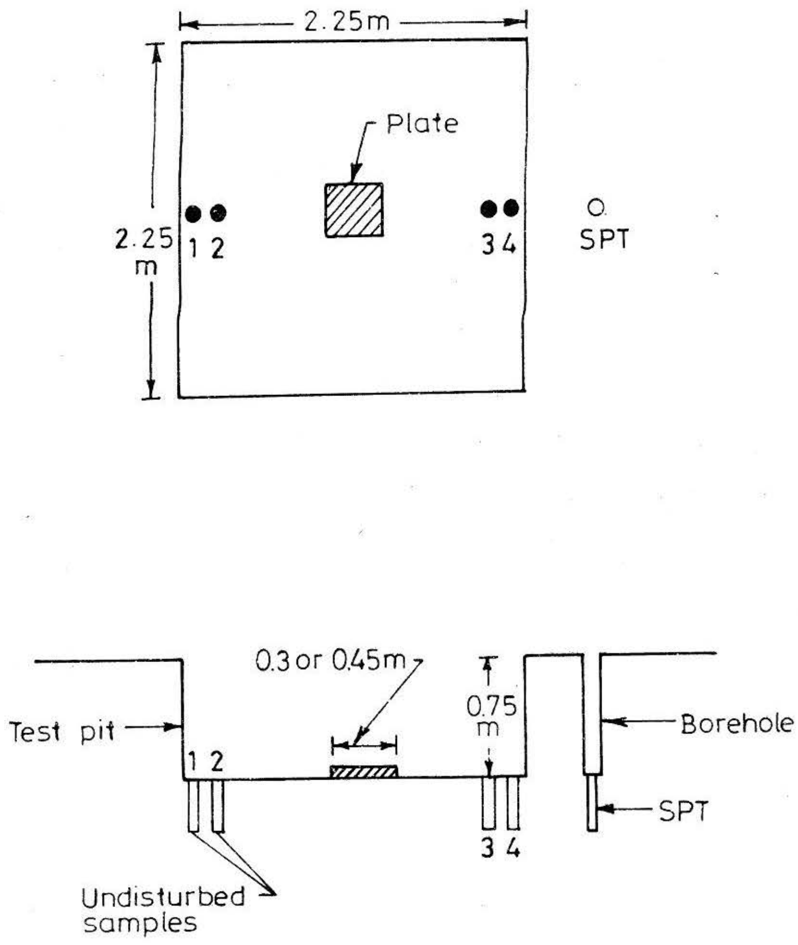

FIGURE 1 : Test Pit Locations of Undisturbed Samples and SPT Test

(b) 500 kg for 30 cm plate, dry soil, (c) 250 kg for 45 cm plate, soaked soil and (d) 125 kg for 30 cm plate, soaked soil. After application of each increment, the load was maintained at a constant level by manual pumping of the jack and the settlement of the plate was recorded at regular intervals until the rate fell below 0.02 mm/min.

Dry and Soaked Soil Conditions

Plate load tests were conducted on two soil conditions – natural/dry condition and soaked condition. For tests under natural/dry condition, the pit was initially dug upto 70 cm. The truss was placed and anchored over the pit. The last 5 cm of the soil was removed just prior to starting the test to

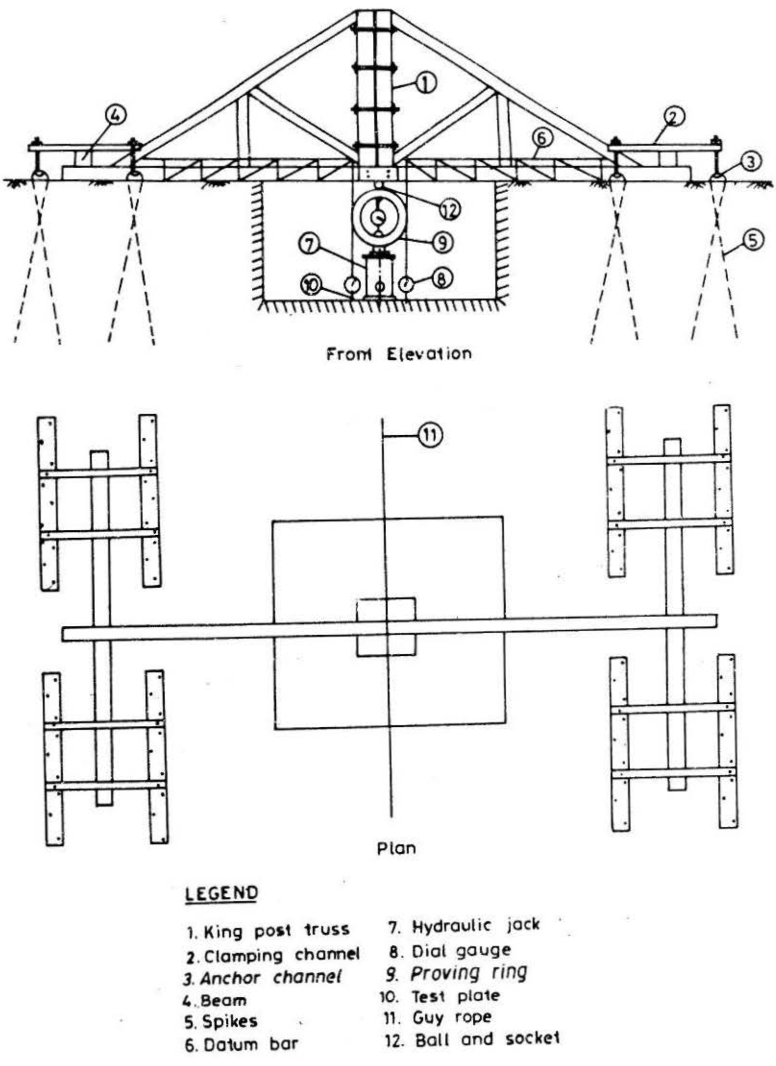

FIGURE 2 : Test Setup for Plate Load Test

ensure that no uneven drying of soil took place due to different amounts of exposure of the soil after digging of pits.

For tests under soaked condition, each pit was flooded with water upto a height of 40 cm for 2 days and the water allowed to soak into the base of the pit. The plate load test was conducted on the third day. The water was observed to soak into the pit completely and no water was standing in the pit when the test was conducted.

Uniformity of moisture conditions below the plate was ascertained for both types of soil conditions by measuring water content of samples at depths of 15, 30, 45 and 60 cm below the plate after each plate load test. The results indicated uniform moisture conditions with depth.

Standard Penetration Tests

One SPT was performed in a borehole adjacent to each pit soon after the completion of each plate load test. Boreholes were drilled using spiral auger and the *SPT conducted as per IS : 2131 (1981). For soaked soil* conditions, two SPTs were conducted. One in a dry borehole and another in a soaked borehole flooded for 2 days in a manner identical to that used in the pits. Water content samples were taken from each SPT sample to check that the moisture condition in the borehole and the pit were similar, both for natural/dry and soaked conditions.

Collection of Undisturbed Samples

Undisturbed samples were collected from each pit at the end of the plate load tests to determine the insitu density, insitu water content and unconfined compressive strength of the soil. Thin walled shelby tubes, 7.25 cm in diameter and 30 cm long, were pushed into the soil with the help of a hydraulic jack taking reaction against the bottom flange of the anchored truss to yield high quality undisturbed samples.

Laboratory Tests

Grain size distribution of the soil was determined by a combination of wet sieve analysis and hydrometer analysis. The Atterberg's limits were determined for the portion of the soil passing 425 micron sieve.

Unconfined compressive strength was determined by performing tests on samples of length 14.5 cm and diameter 7.25 cm (H/D = 2.0) immediately upon extrusion of the samples from the sampling tube. The samples could not be trimmed to a smaller diameter because of the presence of gravel sized kankar in the soil. Care was taken to ensure minimum time lapse between sampling and laboratory testing to preclude the possibility of moisture loss in the samples.

Results

Grain Size Distribution and Atterberg's Limits

Table 2 shows the results of grain size distribution analysis and Atterberg's limits. The soil consists mainly of silt (54 to 62%), with some

TABLE 2 : Grain Size Distribution and Atterberg's Limits

Test No.	Grain Size Distribution				Atterberg's Limits
	% Clay	% Silt	% Sand	% Gravel (Kankar)	
PL1	6.0	56.0	27.0	11.0	
PL2	7.0	61.5	15.7	15.8	Liquid limit 28
PL3	7.0	60.5	18.3	14.2	Plastic limit 20
PL4	6.0	60.5	19.9	14.6	Platicity Index = 8
PL5	7.0	60.1	22.4	10.5	(Results of mixed representative
PL6	6.0	57.8	19.8	16.4	sample passing 425 micron sieve)
PL7	7.0	60.6	21.9	10.5	
PL8	6.0	54.8	24.8	14.4	

sand (15 to 27%) and a small amount of clay sized material (6 to 7%). Kankar is also present in the soil in the gravel sized range in small quantities (10 to 16%). The soil exhibits low plasticity, with a liquid limit of 28, plastic limit of 20 and plasticity index of 8.

Uniformity of Moisture and Density

Table 3 indicates the water content values observed at the end of the plate load tests from three locations – (a) beneath the plate, (b) from undistributed samples and (c) from SPT samples. One notes from the table that the moisture conditions are fairly uniform for both the natural/dry state as well as the soaked state of the soil. Table 4 indicates the average degree of saturation of the soil as well as the average unit weight. It is observed that the unit weight is fairly uniform. Soaking causes the degree of saturation to increase from about 20% to about 80% and the unit weight to increase from about 1.69 gm/cc to about 1.98 gm/cc.

Unconfined Compressive Strength and N-Values

Table 5 gives the results of unconfined compression tests as well as standard penetration tests. One notes from this table that the soil shows high undrained strength and N-values in the dry state, which drop drastically upon soaking.

TABLE 3 : Moisture Condition in Field Tests

Test No.	Moisture Condition	Water Content Beneath Plate at Depths (%)				Water Content in Undisturbed Samples (%)				Water Content in SPT Sample (%)
		15cm	30cm	45cm	60cm	No.1	No.2	No.3	No.4	
PL1	Dry	5.7	5.1	5.8	6.0	-	5.2	5.4	-	5.9
PL2	Dry	6.0	6.0	6.1	6.4	6.1	-	5.6	-	6.3
PL3	Dry	5.8	5.9	6.1	-	-	5.8	6.0	-	5.8
PL4	Dry	5.9	5.8	6.1	6.0	6.2	6.5	-	-	6.0
PL5	Soaked	20.0	20.2	19.8	20.7	18.0	18.1	17.1	18.9	19.4
PL6	Soaked	18.6	19.8	19.2	19.3	17.5	18.0	18.7	17.5	18.9
PL7	Soaked	18.5	17.9	19.9	19.9	18.0	18.0	17.8	17.4	-
PL8	Soaked	19.4	18.9	19.2	19.6	17.6	17.7	-	17.3	18.3

TABLE 4 : Unit Weight and Degree of Saturation

Test No.	Average Water Content (%)	Average Degree of Saturation (%)	Average Unit Weight (gm/cc)
PL1	5.74	21.52	1.67
PL2	6.20	24.08	1.695
PL3	5.72	22.73	1.70
PL4	5.90	22.03	1.675
PL5	18.00	78.13	1.965
PL6	17.63	82.21	2.01
PL7	17.79	77.10	1.96
PL8	17.58	79.20	1.985

TABLE 5 : N-Values and Unconfied Compressive Strength

Test No.	Moisture Condition	Unconfined Compressive Strength (kpa) (kPa)					N-Values	
		Sample 1	Sample 2	Sample 3	Sample 4	Average	Dry Soil	Soaked Soil
PL1	Dry	–	246	214	–	230	26	–
PL2	Dry	223	–	230	–	227	26	–
PL3	Dry	183	141	161	–	172	25	–
PL4	Dry	172	133	–	–	152	27	–
PL5	Soaked	22.5	20	26.5	21.5	23	28	6
PL6	Soaked	27.8	30	22	30.2	27	28	4
PL7	Soaked	26.2	23.4	29.9	25.1	26	29	6
PL8	Soaked	26.4	27.6		22.7	26	29	6

The high unconfined compressive strength values highlight that in spite of its low plasticity, the silt matrix of the soil exhibits high cohesion in the dry state. This cohesion registers a large fall on ingress of water. Significant scatter is observed in the strength values of samples from the same pit. This appears to be an account of the presence of kankar in the soil which influences the quality of undisturbed samples as well as causes disturbance during the trimming of the length of each sample.

The N-values show lower scatter and greater consistency.

Plates Load Test Results

Figures 3 and 4 show the load-settlement curves from the plate loads tests for the dry and soaked soil conditions respectively. In each figure the result of 30 cm and 45 cm square plates are plotted. One notes that in both these figures the curves for the 30 cm and 45 cm plates lie very near each other indicating that an increase in plate size does not significantly increase the bearing capacity. This behaviour is more akin to that of a fine grained soil than that of a coarse grained soil in which an increased in the plate size would have resulted in a shift in the load-settlement curve with an increase in bearing capacity.

The influence of soaking of the soil on bearing capacity is evident from Fig. 5 which depicts the results of plate load tests conducted on dry and soaked soils plotted on the same scale. A drastic reduction in the bearing capacity takes place due to soaking. This figure also supports the observation that the soil behaves more like a fine grained soil. The load-settlement behaviour of a coarse grained soil would have been only marginally affected by soaking of the soil.

An attempt was made to evaluate the ultimate bearing capacity, q_{ult}, from the load-settlement curves using two methods, namely the log-log method and the double tangent method. The log-log method did not show any discernible kink in the plotted results, hence the double tangent method was used. Figure 6 shows how the q_{ult} values were obtained by this method. The q_{ult} values so obtained are listed in column 4 of Table 6.

The two plate load tests in which 45 cm plates were used on dry soil could not be stressed to failure on account of limitations of the total reactions which could be provided by the anchored truss. Nevertheless it is fairly evident from Fig. 3 that these two tests would show a q_{ult} similar to that obtained from tests on 30 cm plates i.e. of the order of about 1000 kPa.

One notes from Table 6 (column 4) that soaking causes to decrease ten-fold from about 1000 kPa in the dry state to 100 kPa in the soaked state.

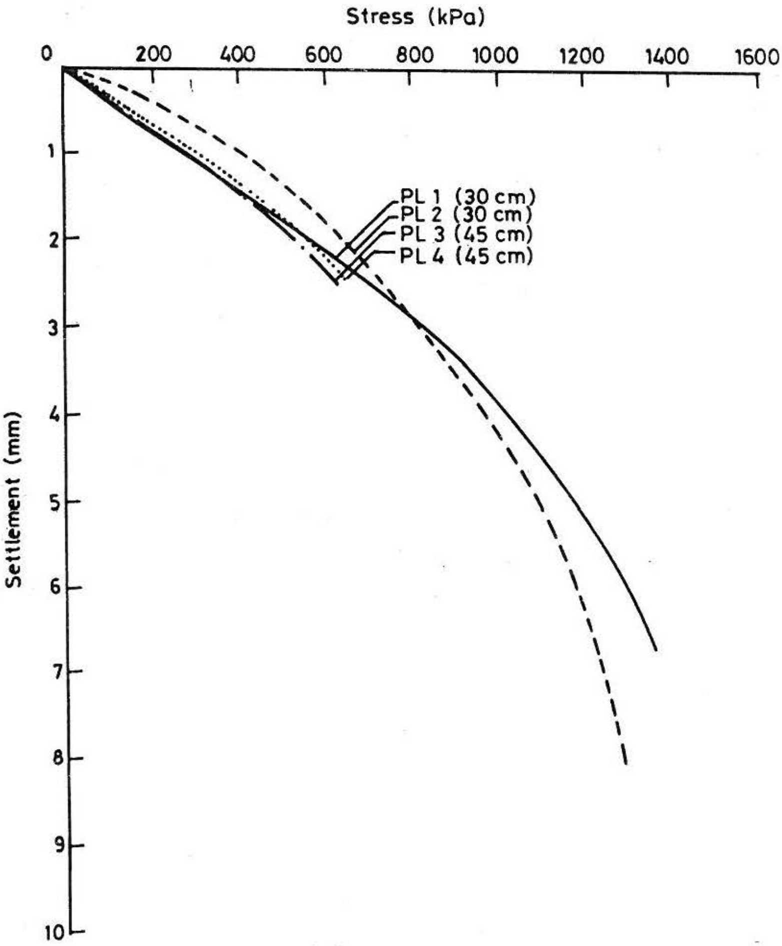

FIGURE 3 : **Load Settlement Curves of 30 cm and 45 cm Plate Load Tests on Dry Soil**

Evaluation of Existing Practice

As per the existing design practice, q_{ult} for 30 cm and 45 cm square plates was estimated by treating silt, both as a coarse grained soil and as a fine grained soil. The results are listed in columns 5, 6 and 7 in Table 6 from which one can compare the estimated values with the observed values (column 4).

It is evident from the table that estimation of on the basis of N-values, both as per Teng's method (1965) or the Bureau of Indian Standards method (IS : 6403 - 1981) results in very low values in comparison to the observed

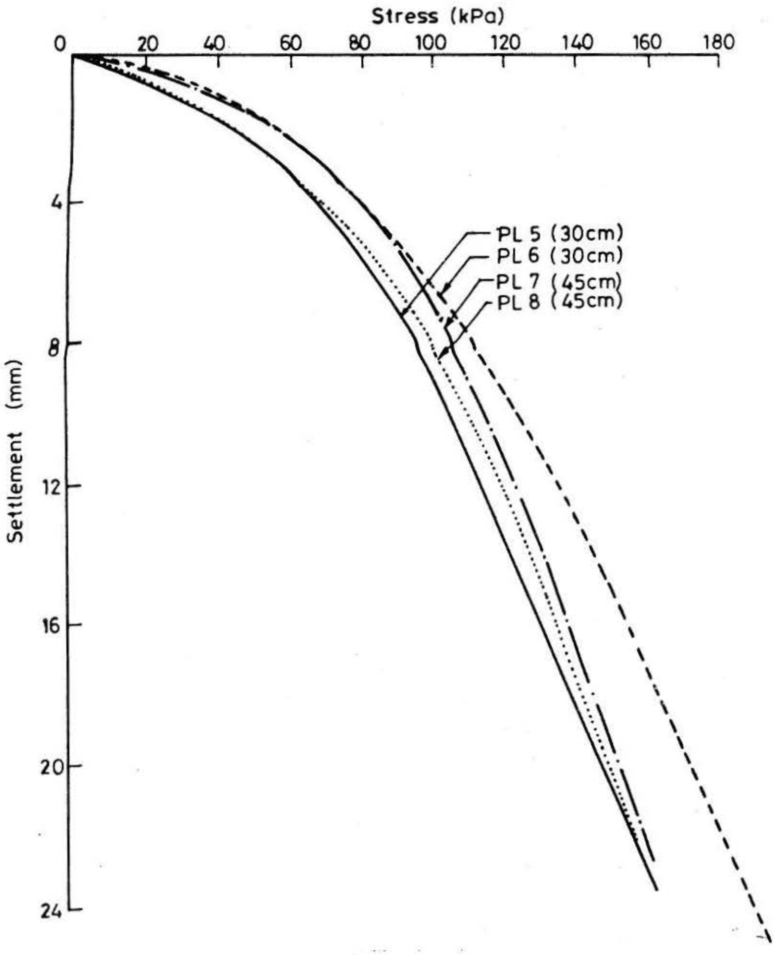

FIGURE 4 : Load Settlement Curves of 30 cm and 45 cm Plate Load Tests on Soaked Soil

values. This is so because in both these methods, q_{ult} is proportional to the foundation width B, whereas the actual test results show no such dependence on B. In such a situation not only would these methods underestimate q_{ult} for small values of B, as for plates of plate load tests, but they would overestimate q_{ult} for footings with large B.

The q_{ult} values obtained on the basis of fine grained soil behaviour show a much better agreement with the observed q_{ult} values from actual tests. Nevertheless the estimated values are lower than the observed values by about 25% for the dry soil and by about 10 to 20 % for the soaked soil state. This indicates that though the soil behaves predominantly like a fine grained soil, there is some contribution of the angle of shearing resistance,

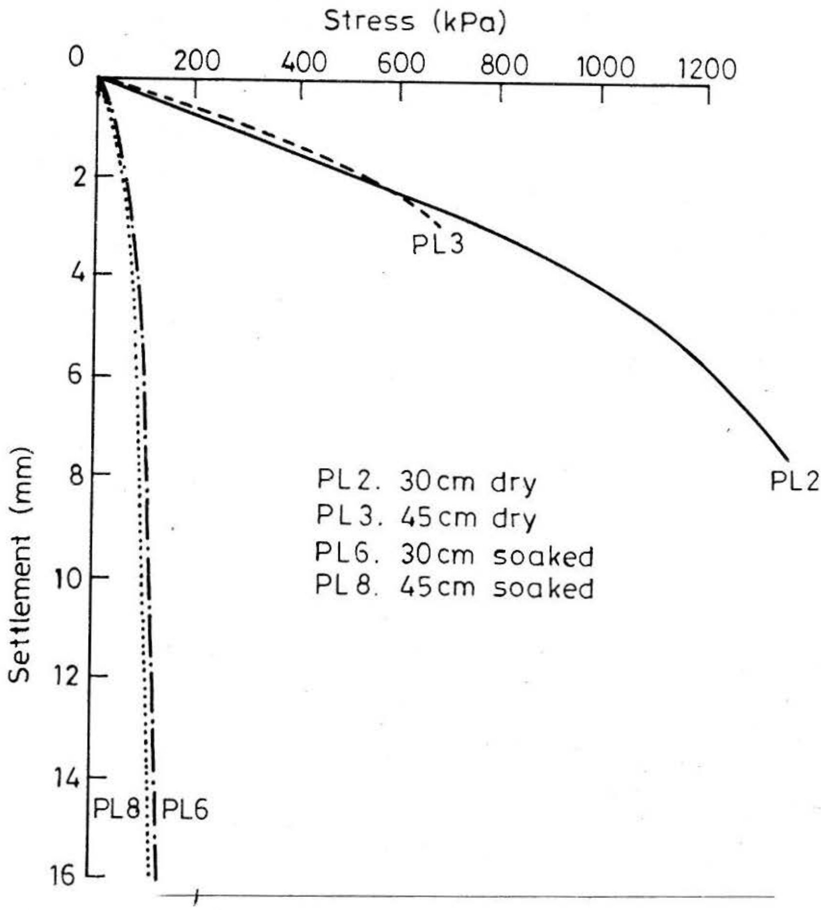

FIGURE 5 : Effect of Moisture on Load-Settiement Curves

ϕ, to q_{ult} over and above that of the cohesion intercept, c.

The results listed in Table 6 clearly demonstrates that the simplified practice of treating silt as a coarse grained material or a fine grained material can lead to large errors in the estimation of the ultimate bearing capacity. It is necessary to evolve a method which will not assume c or ϕ to be zero but which will clearly delineate the c and ϕ values of the soil operative in the field. Such a method is described in the following section.

A Method for Evaluating c and ϕ

The q_{ult} determined from plate load tests can be equated to c and ϕ using the bearing capacity equation.

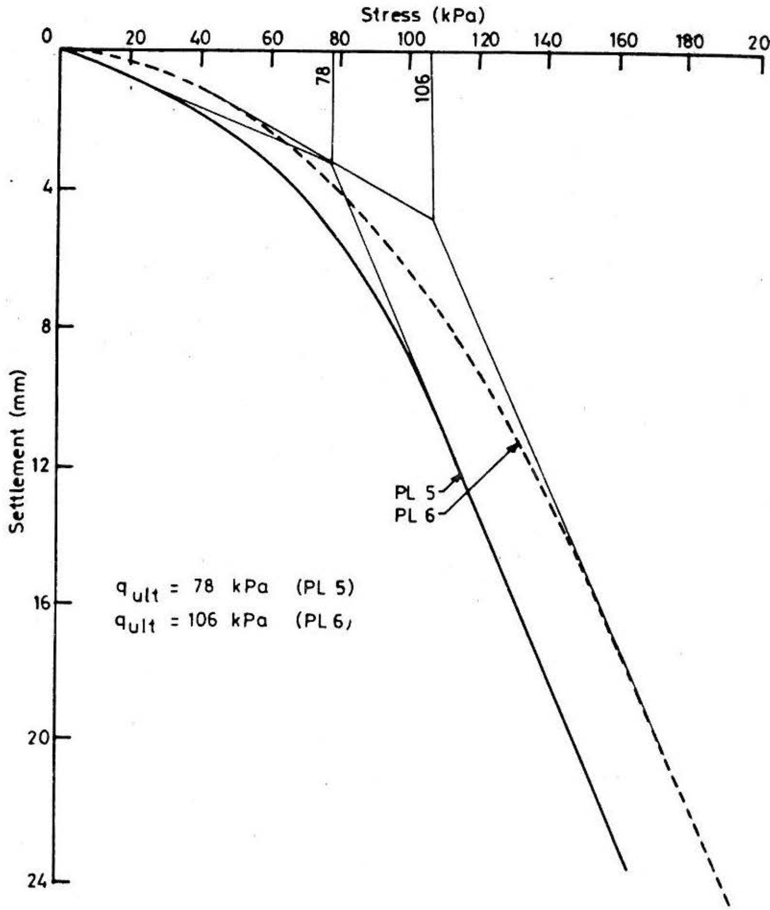

FIGURE 6 : Load Settlement Curves of 30 cm Plate Load Tests on Soaked Soil

$$q_{ult} = c\,N_c\,s_c\,d_c\,i_c + \gamma\,D\,N_q\,s_q\,d_q\,i_q + 0.5\,B\gamma\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W' \tag{4}$$

For plate load tests, conducted at the soil surface and under vertical load, $D = 0$, $d_c = d_q = d_\gamma = 1$ and $i_c = i_q = i_\gamma = 1$. The above equation reduces to

$$\begin{aligned} q_{ult} &= c\,N_c\,s_c + 0.5\,B_\gamma\,N_\gamma\,s_\gamma \\ &= 1.3\,c\,N_c + 0.4\,B_\gamma\,N_\gamma \qquad \text{(for square plates)} \end{aligned} \tag{5}$$

Since N_c and N_γ are functions of ϕ, the above equation has essentially two unknowns, c and ϕ.

TABLE 6 : Plate Load Test Results

Test No.	Square Plate Size	Moisture Condition	Observed q_{ult} (kPa)	Estimated q_{ult} on the basis of (kPa)			
				C.G.S.†		F.G.S.†	New Method
				Teng	IS:6403	IS:6403	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PL1	30	Dry	1060	292.7	194.7	768	-
PL2	30	Dry	970	292.7	197.6	758	-
PL3	45	Dry	(About 1000)‡	407.8	259.7	541	1021
PL4	45	Dry	(About 1000)‡	471.6	329.8	524	1021
PL5	30	Soaked	78	13.9	52.8	77	-
PL6	30	Soaked	106	9.2	42.9	90	-
PL7	45	Soaked	104	20.9	78.8	87	92
PL8	45	Soaked	103	20.9	79.9	87	92

† C.G.S. = Coarse Grained Soil F.G.S. = Fine Grained Soil

‡ Tests could not be stressed to failure. Load-settlement curves follow results of PL1 and PL2 very closely. q_{ult} would be appromimately of the order of 1000 kPa.

The unconfined compressive strength, q_u, can also be equated to c and ϕ by the relation

$$q_u = 2c\cos\phi/(1-\sin\phi) \qquad (6)$$

Using the values of q_{ult} and q_u determined from plate load tests and unconfined compression tests respectively it is possible to solve Eqns. (5) and (6) to find the values of c and ϕ by trial and error. The procedure is relatively simple. By assuming different values of ϕ, starting from 0 and going upto a maximum of 35°, Eqns. (5) and (6) are solved to give the values of c. The value of ϕ which yields identical values of c from both the equations gives the unique solution.

TABLE 7 : c and ϕ Values

Test No.	Moisture Condition	Observed qult (kPa)	c (kPa)	ϕ (kPa)
PL1	Dry	1060	96	10.3
PL2	Dry	978	98	8.2
PL3	Dry	–	–	–
PL4	Dry	–	–	–
PL5	Soaked	78	11	1.1
PL6	Soaked	106	13	4.7
PL7	Soaked	104	12	5.4
PL8	Soaked	103	12	5.6

The c and ϕ values determined by this method are listed in Table 7. One notes from this table that for a given soil condition, dry or soaked, the c and ϕ values obtained from different tests are similar in magnitude, irrespective of the size of the plate.

Further, it is also evident from this table that Delhi silt, in the dry state, exhibits a high c and low ϕ. Upon soaking, both c and ϕ values decrease; the decrease in c is much more substantial than that in ϕ.

Because of the significant scatter observed in the unconfined compressive strength results as well as the possible variations in determining q_{ult} by the double tangent method, it was felt necessary to see if errors in the observed q_{ult} and q_u would significantly influence c and ϕ determined by using Eqns. (5) and (6). Dadu and Kaushik (1990) conducted a detailed error-analysis study to establish the influence of variation in q_{ult} and q_u on the calculated values of c and ϕ. This study showed that errors of upto $\pm$ 10% in q_{ult} and q_u do not influence the calculated values of c and ϕ significantly.

The fact that plate load tests using different plate sizes yield similar values of c and ϕ indicates that these values can be used to estimate the ultimate bearing capacity of footings of larger size using the bearing capacity Eqn. (4).

To validate the new method, q_{ult} was estimated for 45 cm × 45 cm plates on the basis of c and ϕ determined from 30 cm × 30 cm plates. The estimated and the observed values of q_{ult} are listed in columns 8 and 4 respectively of Table 6 which clearly establish that the new method gives more accurate results than those obtained by the existing methods.

Suggested Procedure

For determining the ultimate bearing capacity of shallow foundations on silt deposits, the following procedure is suggested.

(a) At least 3 plate load tests should be conducted at the depth at which the foundation is to be placed. The tests should be conducted under the worst anticipated moisture condition. q_{ult} should be determined from the load settlement curves using the double tangent method.

(b) Four undisturbed samples should be collected from the site of each plate load test and the average unconfined compressive strength determined. If gravel sized kankar is present, large diameter samples (50 to 75 mm diameter) having height to diameter ratio of 2.0 should be tested.

(c) For each plate load test, values of c and ϕ should be evaluated using the observed values of q_{ult} and average q_u and substituting them in Eqns. (5) and (6).

(d) An average of all the values of c and ϕ determined from all plates load tests should be used for computing the ultimate bearing capacity of foundations using the bearing capacity Eqn. (4).

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