Evaluation of Bearing Capacity from Field and Laboratory Tests

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Abstract

In this work, the comparison between the values of bearing capacity of soil determined by two different methods, the first method is field plate load test and the second method is several laboratory tests. The study find out that the allowable bearing capacity estimated from the first method widely near from its value computed by second method. Also this study confirm the probability of using Plate load test for estimating soil bearing capacity for small jobs and shallow layer depth to avoid using comprehensive soil investigation and economizing both cost and time. Empirical relation ship for bearing capacity estimation achieved from the results of the two methods by using stiff brown silty clay soil at Erbil governorate - north of Iraq.

Keywords: Bearing capacity, Plate load test, Modulus of subgrade reaction, Unconfined compression test, Soil settlement.

أحتساب قيمة قابلية التحمل للتربة من الفحوص الموقعية و المختبرية

الخلاصة

في هذا البحث، تمت المقارنة بين قيمتي قابلية التحمل للتربة والتي تم الحصول عليها من أجـــراء نوعين من الفحوص,النوع الاول(موقعي) وهو فحص تحمل الصفيحة والثاني(مختبري) بواسطة اجراء عدد من الفحوص المختبرية حيث وجد بأن قابلية تحمل التربة المسموحة المحسوبة بالطريقـــة الاولـــى تقترب بشكل واسع من قيمتها عند حسابها بالطريقة المختبرية .وتم التوصل من خلال هـــذه الدراســـة أيضا الى أثبات أمكانية استخدام فحص تحمل الصفيحة لتخمين قابلية تحمل التربة للأعمـــال الـــصغيرة والطبقات القليلة العمق والاستغناء عن استخدام تحريات كاملة للتربة تقليلا للكلفة والوقت مـــن خـــلال التوصل الى علاقة رياضية تربط بين قيمة تحمل التربة المحسوبه بكلتا الطـــريقتين مـــستخدمين بـــذلك نموذج لتربة طينية صلبة من محافظة اربيل في شمال العراق.

Introduction

To avoid comprehensive geotechnical exploration and investigation which take more time and cost in small jobs with light load structures.

Foundation engineer can be use of Plate Load Test to obtain quick results and data concerning bearing capacity.

Comparison of bearing capacity obtained from complete geotechnical investigation using data of three boreholes with (10m) depth drilled according to (ASTM D-5783), and another data obtained by carrying out three Plate Load Test at the same site according to(ASTM D-1194) adopted in this study.

Obviously the most reliable method of obtaining the ultimate bearing capacity at a site is to perform a load test. This

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would directly give the bearing capacity if the load test is on a full-size footing; however, this is not usually done since an enormous load would have to be applied (Bowles 1997).

Plate Load Test Procedure

The standard method for a field load test is given by the American Society for Testing and Materials (ASTM) under Designation D-1194 (ASTM, 1997). Circular steel bearing plates 152 to 760 mm (6 to 30 in.) in diameter and 305 mm x 305 mm (1ft x 1 ft) square plates are used for this type of test.

To conduct the test, one must have a pit of depth D_f excavated. The width of the test pit should be at least four times the width of the bearing plate to be used for the test. The bearing plate is placed on the soil at the bottom of the pit, and an incremental load on the bearing plate is applied. After the application of an incremental load, enough time is allowed for settlement to occur. When the settlement of the bearing plate becomes negligible, another incremental load is applied. In this manner, a load-settlement plot can be obtained, as shown in the test results.

The method of performing plate load test is outlined in the below sketch fig. (1).

Plate Load apparatus

1- Bearing Plate

Circular steel bearing plate, not less than 25 mm thickness, and 1000 cm^2 area is used.

2- Hydraulic Jack

Hydraulic Jack with sufficient capacity to provide & maintain the maximum load of 15 ton .

3- Settlement Recording Device

Dial gauge, capable of measuring settlement of the test plate to an accuracy of at least. 0.01 mm.

4- Proving Ring

Proving ring with capacity of more than 12 tons .

5- Miscellaneous Apparatus

Includes loading columns, steel stands & other construction tools required for preparation of the test pits & loading apparatus .

Field Work

The plate load tests for (3) locations at the specified site within Erbil governorate north of Iraq. Were carried out on Jan., 2007.

The tests were conducted at depth of (2.5m) for a circular plate of 1000 cm^2 area & maximum applied pressure of 4kg/cm^2 ,see fig.(3).

Laboratory Work

Unconfined Compression Test is conducted according to :(ASTM D-2166) ,on the test samples obtained from undisturbed soil samples taken by Shelby tube according to(ASTM D-1587) at depth (2.5-3.0m) below the N.G.L.

Description of Subsoil Strata

The subsurface profile of the area explored by drilling (3) boreholes of (10) m depth from the NGL, are seemed to be consist from a major Strata; stiff to very stiff silty Clay, with white spots of lime and/or carbonate compound and some black traces of organic matter.

From the values of specific gravity and consistency indices and according to the unified soil classification system, the majority of the subsoil strata is classified as CI to CH.

The water table was not encountered, as observed at the time of investigation, below the existing ground level (NGL) down to the drilled depth.

Results of Tests

The laboratory test results are conducted in Andrea Engineering Tests Laboratory and deals with pertinent physical, mechanical and chemical properties of the soil .The summary of the laboratory test results are shown in table (1).

The allowable bearing capacity (qall.) of the silty clay evaluated from the several laboratory test results were as shown in table (2), using Terzaghi equation with modification suggested by Meyerhof.

In addition, the plot of pressure versus settlement obtained from Plate Load Tests used for evaluating the modulus of subgrade reaction (Ks)and in turn (qall.) correlated from Ks, and the values were as shown in table(2).

The allowable bearing capacity can be estimated by means of modulus of subgrade reaction (Ks) from the relation ship reported in (Bowles 1997):

Ks = 40 (SF) qa ….. (1a)
Ks = Δ Load /Δ Settlement …..(1 b)

Where (qa) is allowable bearing capacity furnished in (KN/m^3) and (SF) is the safety factor taken as(3)

The equation above based on ΔH=25 mm, for ΔH=6, 12, 20mm the factor (40) can be adjusted to 160, 83, 50 respectively.

The plot of pressures versus settlements and the modulus of subgrade reaction values are enclosed herewith in fig. (4).

Discussion of Results

A discussion of the results which were derived from both field and laboratory testing carried out on soil is as follows:-

Soil mechanics is the basis of foundation design. Application of soil mechanics to foundation design is necessary to study the stress distribution, and engineering properties of subsoil material.

The net ultimate bearing capacity is defined as the pressure that can be supported at the base of the footing in excess of that at the same level due to the surrounding surcharge.

Although plate load tests may seem to be a reasonable approach, experience has proven otherwise. This is primarily because the plate is so much smaller than the foundation, and we cannot always extrapolate the data accurately, as in fig. (2).

So to verify the validity and safe application of the load test results, it is therefore necessary to explore the sub-soil strata, minimum up to (Df+1.5B) below the natural ground level.

As general, it can be noticed from the values of bearing capacity obtained by two methods, direct soil loading (Plate load test) and by laboratory tests that the bearing capacity of soil stratum estimated by plate load test widely near from that value estimated from laboratory test as shown in fig.(5)and fig.(6).

Also, the relationship between the bearing capacities obtained by two methods from fitting points in fig. (7) can be Wright as:

qall. (Field)=0.31115qall. (Lab.) +220.063 ….. (2)

These results can be attributed firstly to the stresses distribution of soil layer in case of plate load test confirms with the stress distribution in second case of laboratory test. Secondly to the bearing capacity of obtained from plate load test depended originally on the settlement value of the soil layer therefore the lower settlement value means the higher bearing capacity estimated by two methods because the soil layer is very stiff.

These results of bearing capacity checked and fitting with three another sites results for the same soil properties investigated by Andrea engineering Laboratory in Erbil government .

Conclusions

1. Bearing capacity estimated by field plate load test confirm with the bearing capacity obtained form laboratory test.
2. Plate bearing test can be use to predict bearing capacity of soil layer for shallow layer depth to avoid using comprehensive soil investigation and economizing both cost and time.
3. Plate bearing test could be used as alternative methods when the full investigations unavailable.
4. For saturated undrained Clayey soil cohesion parameter (C) can be estimated by adopting the allowable bearing capacity computed from plate load test.
5. The value of bearing capacity shows an approximate confirmation with that mention by Bowles 1997.

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Table (1) The Summary of the Laboratory Test Results.

BH	Depth (m)	Atterberge Limits			Wc %	γd (gm/cm3)	Gs	Fines No.200 %	Compression Properties			
		L.L %	P.L %	P.I %					eo	Cc	Cr	Pc kPa
1	2-2.5	54	24	30	19.5	15.2	2.70	97.5	0.763	0.21	0.032	120
2	2.5-3	53	23	30	18.0	15.6	2.70	92.7	0.721	0.13	0.029	135
3	3-3.5	51	22	29	16.5	16.9	2.71	98.4	0.657	0.10	0.022	170

Table (2) Bearing Capacity Values by Field and Laboratory Tests.

BH	Field Plate Load Test		Laboratory Tests q all.(kPa)
	Ks (kPa/m)	q all.(kPa)	
1	145283	302.6	276
2	152323	317.3	320
3	163443	340.5	401

Where: Ks = 160 × 3× q all. (Field) for max. ΔH= 6 mm (According equation 1)

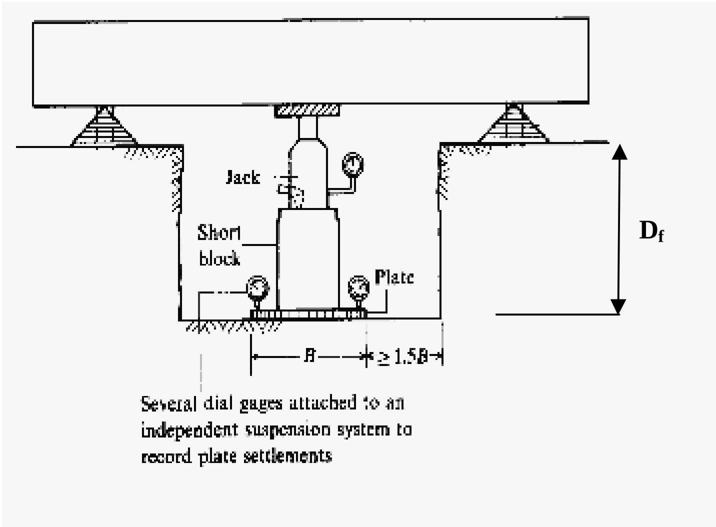


Figure (1) Plate Load Test Device.

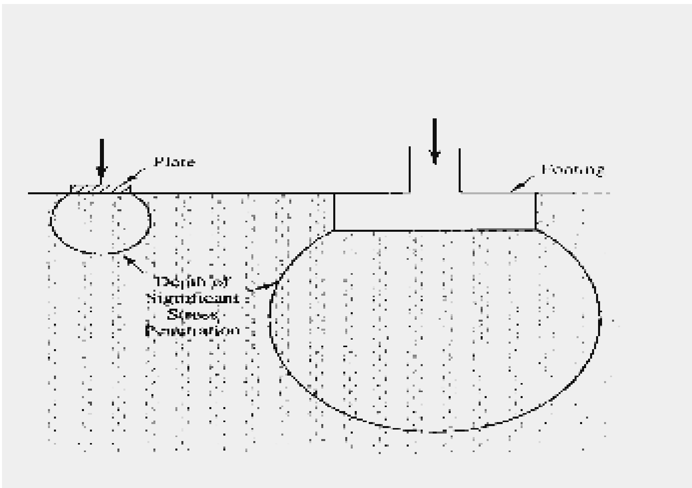


Figure (2) The stresses induced by a plate load test do not penetrate very deep into the soil, so its load-settlement behavior is not the same as that of a full-sized footing.

a. General Site View

b. Closed view of Plate Load Test

c. Load Applied by Heavy Truck

Figure (3) Plate Load Test carried out in Erbil Gas Power Station on 21st Jan,2007,Erbil Governorate ,Iraq.

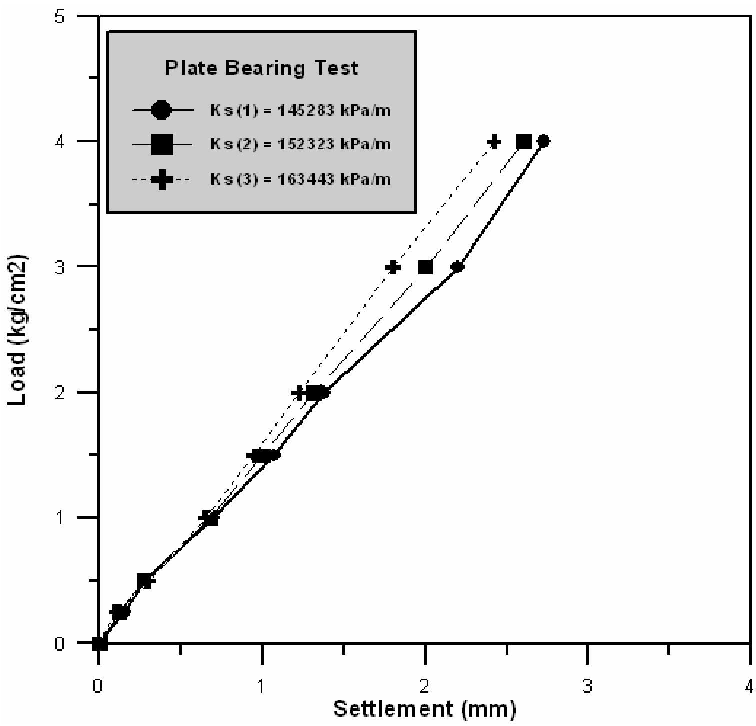
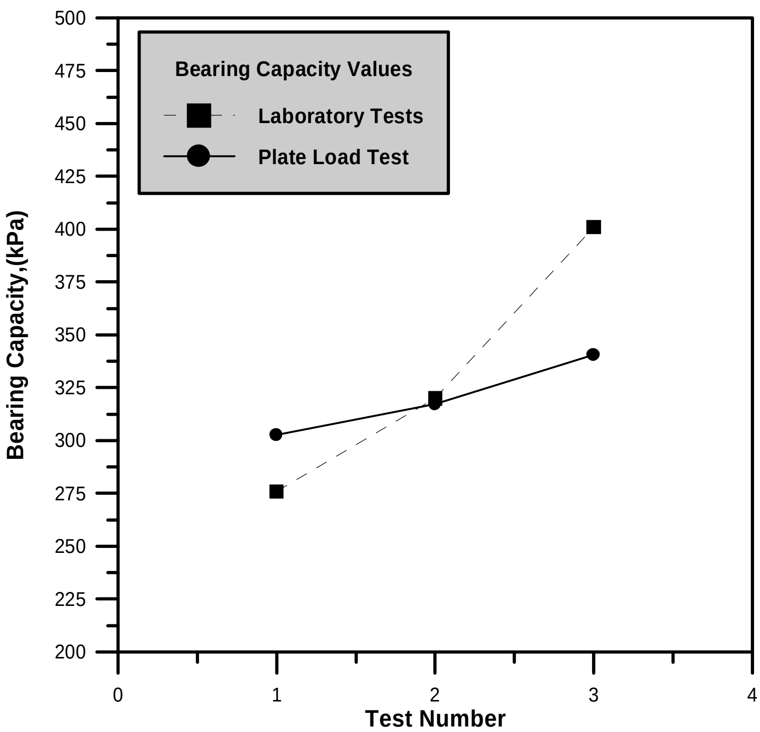
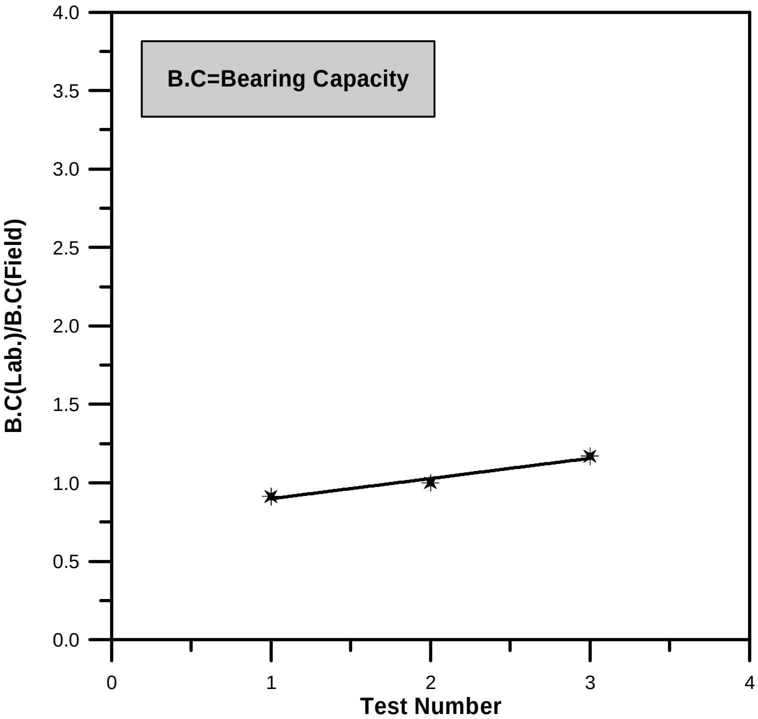


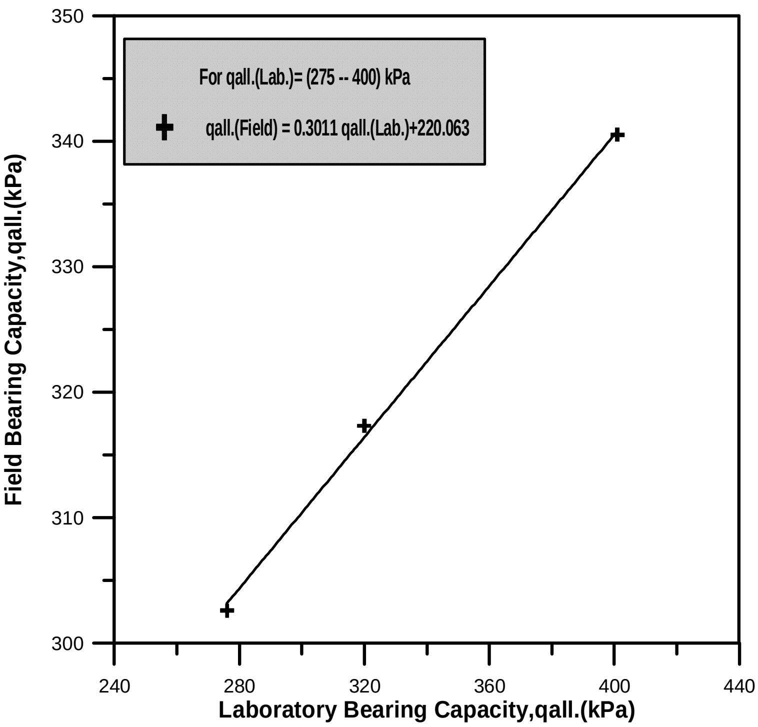
Figure (4) Plot of Load Versus Settlement of Plate Load Test.



Figure(5) Values of bearing capacity obtained by two methods.



Figure(6) Confirm values of Bearing capacity estimated by two methods.



Figure(7)Field and Laboratory Bearing Fitting Curve.