Effect of Plate Sizes on Clay Soil for determining Bearing Pressure and Settlement Using Model Plate Load Test

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Abstract- This study is a semi-laboratory plate load test conducted on a pit outside the laboratory on undisturbed clay soil from the site. The soil has liquid limit of 35 % and plasticity index of 21 % with 54 percent passing sieve 200 µm the soil is classified as A-6 soil. The model plate load test and plaxis model plate load test for the three square plate's shows an increase in allowable bearing capacity from 130 x 130 mm square plate size of 27 kN/m^2 to 37 kN/m^2 for square plate of 160 x 160 mm and 40 kN/m^2 for 200 x 200 mm square plate size. While settlement decreases from 25 mm for 130 x 130 mm square plate size to 15 mm settlement for square plate of 160 x160 mm and 5 mm for plate size of 200 mm x 200 mm. plaxjs model plate load follow the same pattern as that of Model plate load test with allowable bearing capacity of 333 kN/m^2 for 130 x 130 mm square plate to 400 kN/m^2 for 160 x 160 mm square plate and 417 kN/m^2 for 200 x 200 mm square plate. The settlement was 10 mm for square plate of 130 x 130 mm to 7.5 mm for square plate of 160 x 160 mm and 4.5 mm for square plate of 200 x 200 mm. The settlement yielded a good correlation coefficient.

Indexed Terms- Bearing Capacity, Model Plate load test, Plaxis Model Plate Load Test, Square Plate Size, Settlement.

I. INTRODUCTION

Plate load test are used to determine bearing capacity and settlement of foundation soil with the aid of square or circular plates. The plate load tests are categories into field in-situ plate load test, laboratory plate load test and semi-laboratory plate load tests. The in-situ test is carry out on site directly using automatic hydraulic jack [1-5]. The test can either be a gravity plate load test or a reaction truss plate load test. The test is to determine the deformation of soil and subsequently the corresponding bearing capacity of the in-situ soil simultaneously as against the laboratory of the settlement and bearing pressure of the soil. The laboratory plate load test is carry out on either disturbed or undisturbed samples from the site [6-10]. The test allows for collection of either the in situ soil or the disturbed soil sample from the site and transporting it to the laboratory for the plate load test. The semi-laboratory plate is conducted on a pit dug outside the laboratory or in a fabricated container of various shape and sizes [11]. The apparatus are set up to facilitate the conduct of the test [12-14]. However, [15] designed a modified plate load test similar to the conventional one were undisturbed soil sample can be tested using reaction frame method. The reaction frame was design for loading of about 300, 150 and 50kN using lever arm arrangement.

[6] conducted a plate load test on clay soil using hydraulic jack but find out that at the application of 400 kN/m^2 pressure on the soil for long time the pressure failed to 250 kN/m^2 indicating that hydraulic jack cannot sustained long duration loading and as such concluded that hydraulic jack test cannot gives a reliable results and end up using laboratory plate load reaction frame test equipment having a tank for conducting plate load test on the clay.

The aim of the research was to determine the effect of plate sizes on settlements and bearing capacity of lever arm gravity loading test on clay soil using semi-laboratory method outside the laboratory.

II. METHODOLOGY

A. Laboratory test procedures

The soil samples used for the research were collected from a site in Federal University of Technology, Gidan Kwano Campus, Minna north central part of Nigeria.

The sample was classified as clay with low plasticity (CL) according to American Association State Highway and Transport Officials (AASHTO) and A-6 for Unified Soil Classification System (USCS) [16, 17, 18, 19] respectively. The physical properties of the soil is shown in table 1 and figure 1 is sieve analysis of the soil.

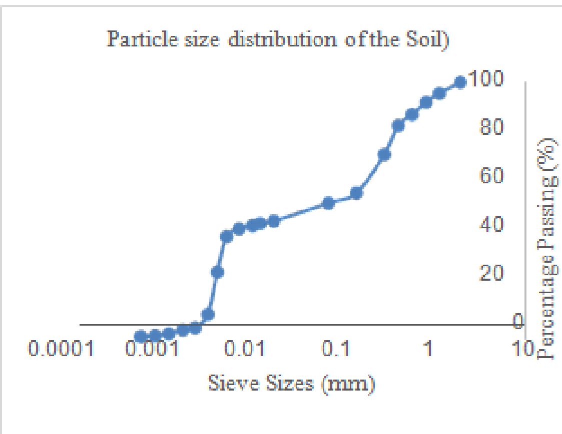

Figure 1: Particle size distribution of the soil.

Table 1: Geotechnical properties of Soil,

Particulars	Value
Specific Gravity	2.52
Liquid Limit. LL (%)	35
Plasticity PI	21
Percentage Passing Sieve 75µm	59
Soil Classification (USCS)	CL
Cohesion (kN/m^2)	40
Angle of Internal Friction (°)	6

B. Model Plate Load Testing Apparatus and Experimental Procedures

A three (3) square model test box of 650 mm by 650 mm, 800 mm by 800 mm and 1,000 mm by 1,000 mm with equal height and thickness of 70 mm and 4 mm respectively, are made of steel with a smooth inside wall surface to reduce frictions with the soil. The frame of field model plate load test equipment consist of a lever arm of 670 mm long and 5 mm thickness having a depth of 60 mm and tapered to the end at 30 mm. An equal angle of 40 mm by 40 mm and 5 mm thickness was used to construct the frame which comprising the legs, crossing beam and support beam which was all assemble using bolt and nut of 10 mm diameter. A square plate base of 130 mm by 130 mm with 4 mm thickness. A brass iron of 15 mm diameter was used as a bushing with a pin fixed in side with a diameter 10 mm together. A 40 mm width and 3 mm thick iron steel transfer column attached with a dial gauge that has 0.01 mm accuracy and 20 mm revolution. Five (5 mm) diameter solid steel rod was used as loading hanger.

The undisturbed soil sample was collected from 0.7 mm at foundation depth with the use of the rectangular model box drive into the soil and the box was remove with the undisturbed soil sample in it. The sample was put into the dug pit outside civil engineering laboratory federal university of technology, Minna. The model plate load test equipment was instated on the pit the plate of 130 mm by 130 mm, 160 mm by 160 mm and 200 mm by 200 mm were placed on top of the trimmed soil sample [6, 15]. Also, [20] specifies that after the application of each load increment, the cumulative load be maintained for a selected time interval of 30 min (i.e 1, 2, 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 minutes). The load was applied incrementally of 6 kN/m^2 12 kN/m^2, 24 kN/m^2, 47 kN/m^2, 93 kN/m^2, 186 kN/m^2 and 372 kN/m^2 [12] at time interval of 30 minutes or when the settlement was less than 0,002 mm per minute. The deformation of the plate was recorded at each time interval.

C. Numerical Plate Load Test Using Plaxis Software

Plaxis 3-D is a finite element software package used for geotechnical engineering; it provides with a 3-D model capability that can be applied for various geotechnical engineering analyses. The model uses Shear strength parameters angle of internal friction φ and cohesion c, unity weight of the soil, passion ratio and modulus of elastic of the soil E obtained from modulus volume change M_V [21].

III. RESULTS AND DISCUSSION

A. *Model Plate Load Test*

The variation in the test results for the same depth of clay soil is due to the variation of the different plate sizes. Since the pressure was not same throughout the plate load test programme. The results from the graph of model plate loads test (MPLT) figure 2, shows that plate size of (130 mm by 130 mm) has a settlement value of 25 mm follow by plate size of (160 mm by 160 mm) with settlement of 15 mm and plate size of (200 mm by 200 mm) with the settlement value of 5 mm. The corresponding allowable bearing capacity indicating that plate size 130 mm by 130 mm) has allowable bearing capacity value of 27 kN/m^2, plate size of (160 mm by 160 mm) which has allowable bearing capacity of 37 kN/m^2 and lastly plate size of (200 mm by 200 mm) with the allowable bearing capacity of 40 kN/m^2 as presented in table 3.

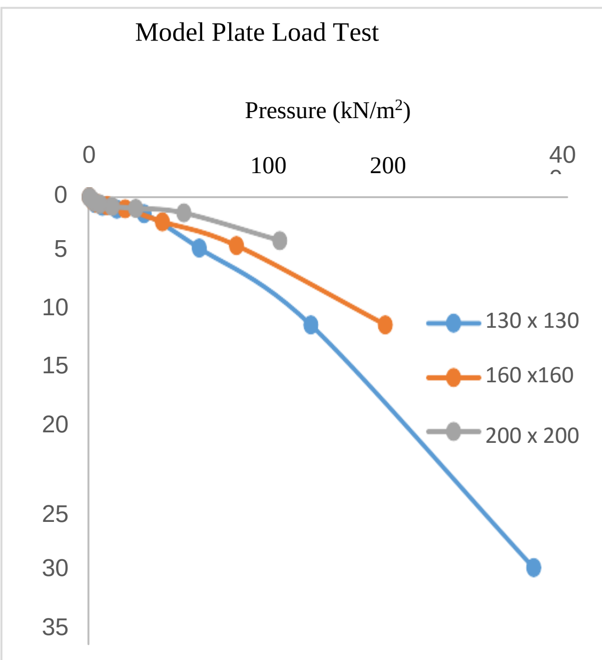

Figure 2: Load –Settlement Curve of Model Plate Load Test

The settlement of the three plate sizes was plotted in figure 3. The result shows a decrease of settlement as the plate size is increased. Plate size of 130 x130 mm has a settlement of 25 mm, plate size 160 x 160 mm has settlement of 15 mm and plate size of 200 x 200 mm has settlement of 5 mm figure 6, this results is in agreement of those obtained by [22]

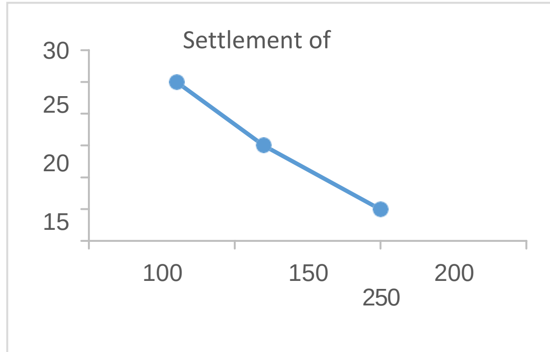

Figure 3: Settlements Observe by three Plate Sizes of Model Plate Load Test

The allowable bearing capacity obtain from the model plate indicate gradual increase of plate size and an increase in Allowable bearing capacity from 27 kN/m^2 for plate size 130 x 130 mm to 37 kN/m^2 for Plate size 160 x 160 mm and allowable bearing capacity of 40 kN/m^2 for plate size 200 x 200 mm as shown in figure 4.

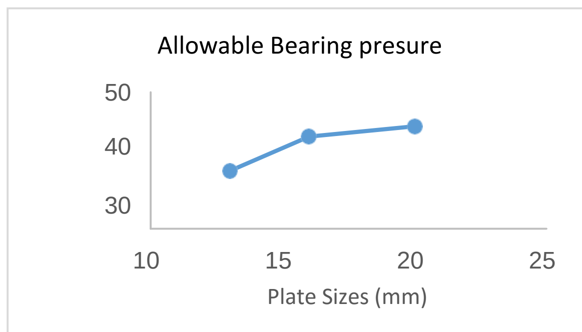

Figure 4: Allowable Bearing Capacity from Three Plate sizes of Model Plate Load Test.

B. *Plaxis Model Plate Load Test*

The allowable bearing capacities of the soil from plate size (130 mm by 130 mm) using Plaxis model was 417 kN/m^2 and the corresponding settlement of 4.5 mm. The graph is shown in figure 5 [23]. The settlement is in agreement with [24] of 25 mm minimum as recommended for building structures.

Also, plate size 160 mm by 160 mm) gives an allowable bearing capacity of 400 kN/m^2 and the corresponding settlement 7.5 mm. The graph is presented in figure 5, the findings is in agreement with [25] and [26]. The settlement is below 25 mm minimum as recommended for building structures in [24]

However, Allowable bearing capacity and settlement for square plate of 200 mm by 200 mm using plaxis model was 333 kN/m^2 and 4.5 mm respectively. The graph is presented in figure 6 is in line with the findings of [27] and [28].

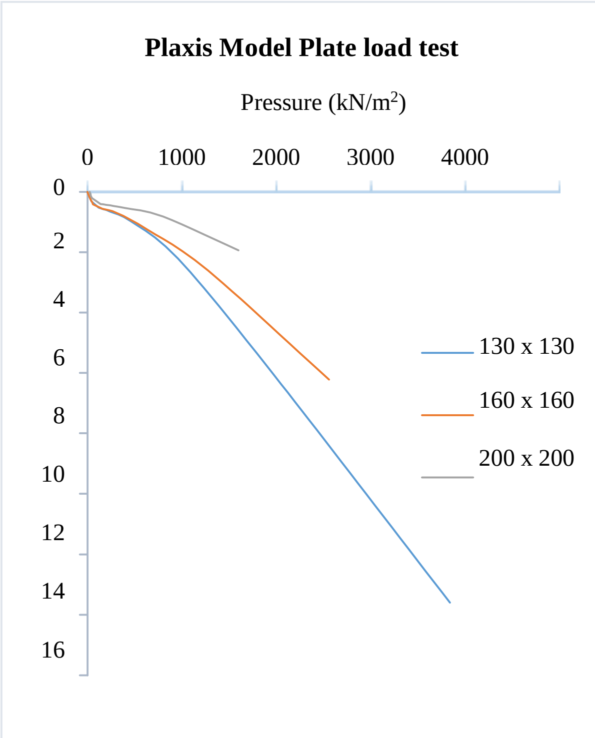

Figure 5: Load –Settlement Curve of Plaxis Model Plate Load Test

As observe from model plate load test the settlement follow the same pattern of decreasing order as the size of plate is increase there is a corresponding decrease in settlement as observe by [29,30] as shown in figure 6.

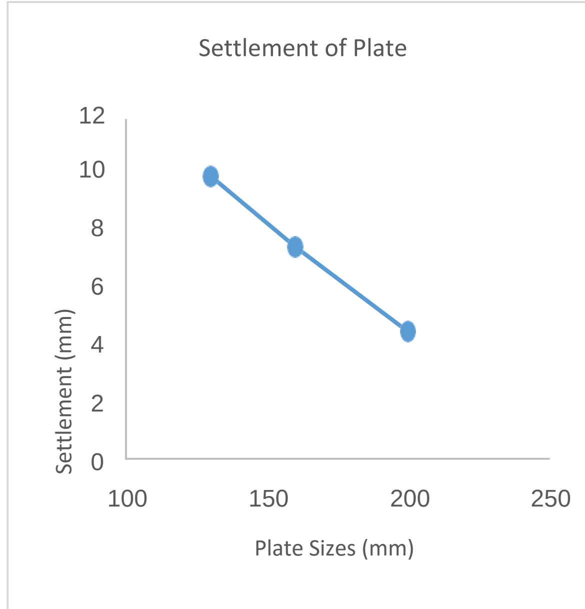

Figure 6: Settlements Observe by three Plate Sizes of Plaxis Model Plate Load Test

Allowable bearing Capacity of the plaxis model shows that when the plate size is increased the allowable bearing capacity equally increases which signifies that as plate sizes are increase there is geometry increase in the on the allowable bearing capacity of the foundation soil as presented in figure 7.

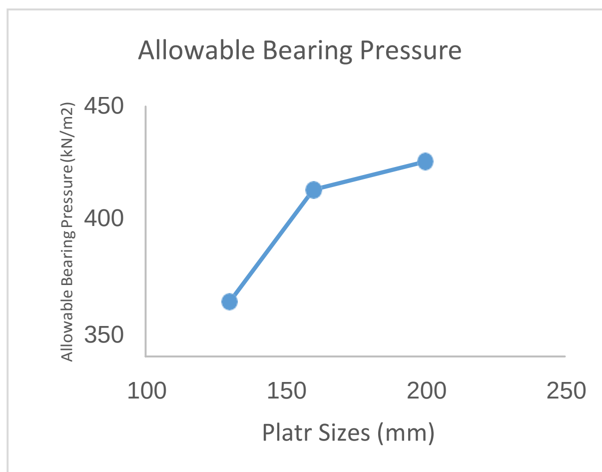

Figure 7: Allowable Bearing Capacity from Three Plate sizes of Plaxis Model Plate Load Test

CONCLUSION

Prediction of settlement and bearing capacity for foundations using Model plate load test and Plaxis model plate load test for three different plate sizes have been investigated. The tests reported the new facets of plate load test that is in agreement with those reported in literature. The results of the measured plaxis model plate test and model plate load test shows decrease on settlement when plate size is increase there is an increase in allowable bearing capacity when plate size is increased. The tests performed shows the settlement predictions by plaxis model plate load and model plate load test were differently affected by the plate size adopted.

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