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Pile Load Testing & Determining Bearing Capacity of Cast in Situ Pile: A Case Study

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Abstract- Piles are designed to transfer the load of superstructure to the deeper harder soil strata crossing the upper weaker strata of soil. Cast in situ piles are usually designed by many analyses and using many empirical formulas. But due to a great degree of prevailing uncertainties of subsoil behavior, variation of strata in the same site, diversity in the procedure of construction applied at site, piles are needed to be tested to double or so of design load to verify the conformity with that design load obtained by static design calculation. A case study of load test on a pile of 600mm diameter & length of 35.250m was conducted through ASTM D 1143-81 method. The test load data were collected and converted into graphical forms. The results were interpreted through load-settlement curves applying various methods for determining the allowable load bearing capacity of the pile.

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Abstract- Piles are designed to transfer the load of superstructure to the deeper harder soil strata crossing the upper weaker strata of soil. Cast in situ piles are usually designed by many analyses and using many empirical formulas. But due to a great degree of prevailing uncertainties of subsoil behavior, variation of strata in the same site, diversity in the procedure of construction applied at site, piles are needed to be tested to double or so of design load to verify the conformity with that design load obtained by static design calculation. A case study of load test on a pile of 600mm diameter & length of 35.250m was conducted through ASTM D 1143-81 method. The test load data were collected and converted into graphical forms. The results were interpreted through load-settlement curves applying various methods for determining the allowable load bearing capacity of the pile.

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I. Introduction

A variety of measures involves to determine the load bearing capacity of piles that might be either analytical or empirical in nature. The former requires an evaluation of soil and pile interaction along with several underlying assumptions. On the other hand, the latter is founded on the use of outcomes of in-situ tests and procedures (Medubi et al. 2012). when the soil condition is unpredictable, Pile load test is generally conducted. The test piles are constructed and load will be applied Before constructing the actual load bearing piles of the main structure so that various information's can be gathered. In geotechnical engineering, the bearing capacity determination for piles is a fascinating topic. Due to the complicated nature of the embedment ground of piles and lack of suitable analytical models for foreseeing the pile bearing capacity are the main reasons for the engineer's tendency to peruse further research on this issue. Among different common methods, pile load testing can represent reasonable results, but such tests are expensive, time-consuming, and the costs are often difficult to justify for ordinary or small projects (Thounaojam& Sultana, 2016).

Sometimes it is found that the capacity of the pile is too high comparing the design load, in such cases the actual piles to be constructed can be redesigned. By doing so foundation cost might be reduced. In Bangladesh generally the land owner or the contractors are not that much interested to conduct this test due to its high cost and time consumption. But it will be very helpful for the structure if this test is done. Once the substructure is complete after that any kind of change in sub structure very much costly and difficult. So instead of doing so if pile load test is done then any kind of mistake can be resolved in the initial level of structure.

Pile load test have been carried out to achieve following objectives-

- To determine the settlement under working load
- To confirm the adequacy of design bearing capacity
- As proof of acceptability
- Determine allowable bearing capacity

II. Methodology

This report presents the test results of monotonic static axial pile load tests on cast in situ pile for the site of "A" in Dhaka city. This test was carried out with a view to confirm the carrying capacity of single pile under monotonic static load and to know the settlement behavior of this pile under test. The main purpose of the static pile load test is to demonstrate construction method and to confirm the design assumptions and the bored pile loading capacity. This test also shows the actual safety factor applied for the piles. Static analysis methods estimate shaft and base resistances separately and differently (Thounaojam& Sultana, 2016).However, the use of dynamic formula is highly criticized in some pile-design literatures. Dynamic methods do not take into account the physical characteristics of the soil. This can lead to dangerous miss-interpretation of the results of dynamic formula calculation since they represent conditions at the time of driving. They do not take in to account the soil conditions which affect the long- term carrying capacity, reconsolidation, negative skin friction and group effects.

To observe the design capacity, a test pile is constructed and estimated load is given upon the designed pile. There are three kinds of static pile load testing.

1. Compression pile load test.
2. Tension pile load test.
3. Lateral pile load test.

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In this research project, The Compression pile load testing was conducted and also the test included Anchor method.

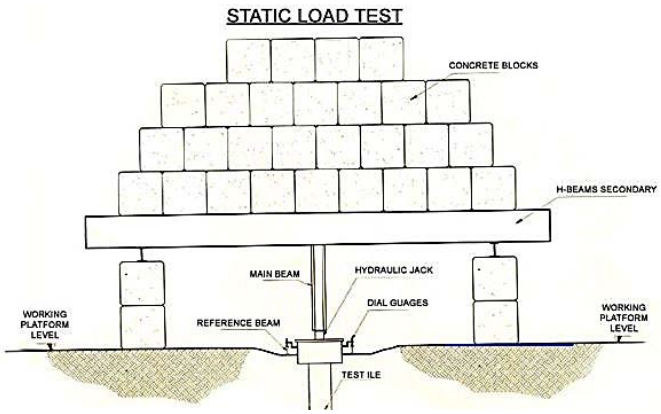

Figure 1: Static load test

The readings are recorded in all the dial gages, the load cell, and the pressure gage for the jack at 1 minute intervals, on the Time-Settlement Data Sheet. The load is given to the pile up to 50%, 100%, 125%, 150%, 175% and 200% and the Gross settlement is checked. Again, with the same procedure stated above, Net settlement is observed. Settlement is checked to a precision of 1/5" (0.5 mm) on the reference points, at a minimum as follows:

1. Immediately before the test,
2. Immediately before rebounding from 100 percent of the design load (all cycles),
3. Immediately before rebounding from 200 percent of the design load (both cycles), and
4. At the end of test, after the final rebound reading

A case study of load test on a pile of 600mm diameter & length of 35.250m was conducted through ASTM D 1143-81 method. The test load data were collected and converted into graphical forms. The results were interpreted through load-settlement curves applying various methods for determining the allowable load bearing capacity of the pile.

Figure 2: Sand Bag used for loading the pile

Figure 3: Hydraulic jack

III. Observation

Physical description of test pile and equipment used are provided in table 1 & table 2 bellow

Table-1: Physical description of test pile

Test pile no	Date of pile casting	Date of testing	Length of pile	Dia. of pile	Applied load
TP-16	17-06-2014	11-07-2014	35.250 m	600 mm	2,87,814 kg

Table-2: Description of equipment used

Test pile no	Plunger dia.	Pressure gauge			Dial gauge	
		range	Calibration date	Regression equation	sensitivity	range
TP 01	265 mm	0-500 kg/cm^2	16-06-2014	Y=0.516x-0.146	0.01 mm	0-50 mm

IV. Data Analysis

When pile is subjected to gradually increasing compressive load in maintained load stages, initially the pile-soil system behaves in a linear-elastic manner up to point A on the settlement-load diagram and if the load is realized at any stage up to this point the pile head rebound to its original level (Abebe& Smith, 2016).

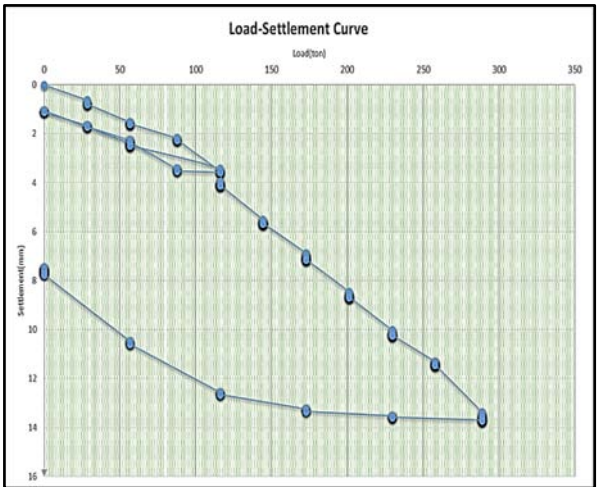

Figure 4: Load Settlement Curve

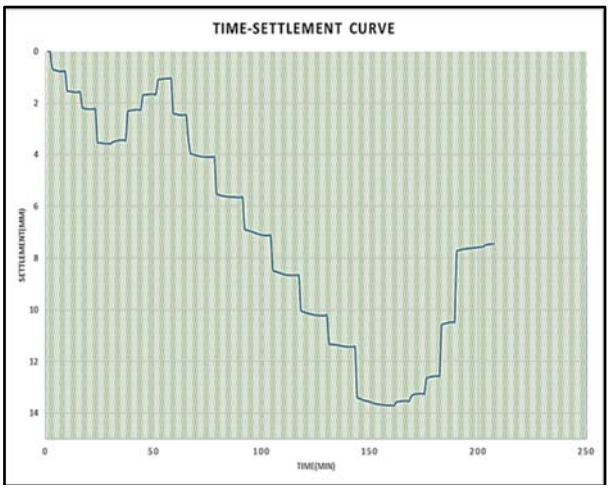

Figure 5: Time Settlement Curve

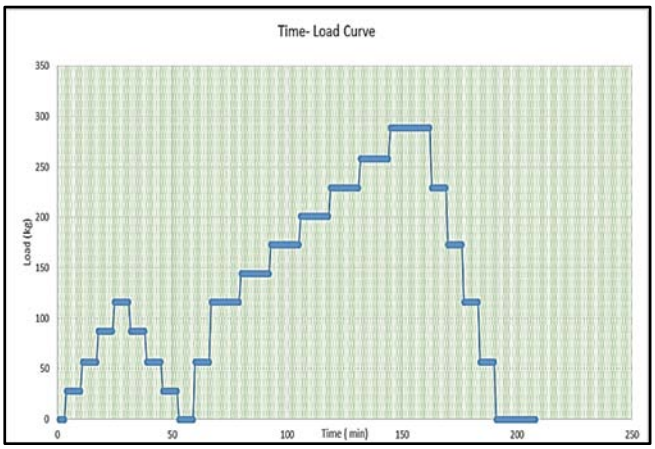

Figure 6: Time Load Curve

There are different methods used for determining Bearing Capacity, such as

- Tangent-Tangent Method
- Hansen Method
- Chin's Method
- Decourt's Extrapolation

The Tangent-Tangent Method has been used to determine the bearing capacity of the pile. According to Tangent-Tangent Method the test result is 118 tons.

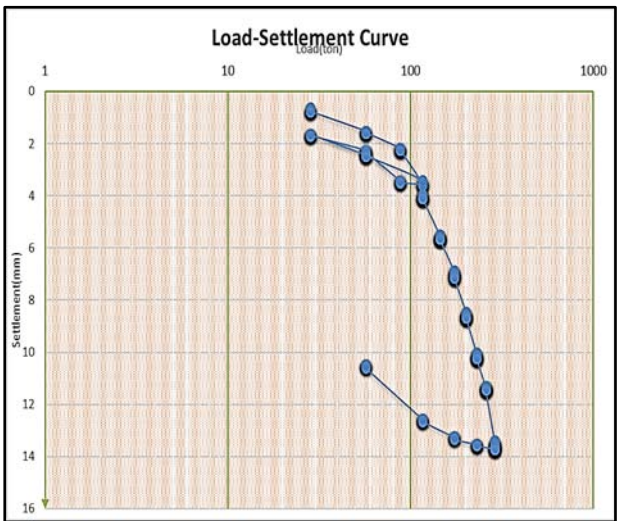

Figure 7: Load -settlement curve 1

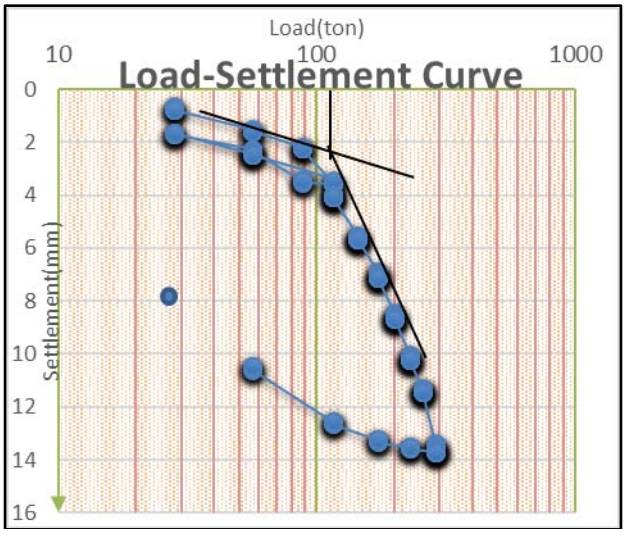

Figure 8: Load -settlement curve 2

V. Result

Ultimate and Allowable load capacities by different methods are presented in table 4 & 5. Initially, the Ultimate load and then the Allowable load have been estimated.

The summary of the test result is as follows in table-3:

Table-3: Test result of the test pile

Test pile no	Length of pile	Test result		
		Max^{m} applied load	Gross settlement	Net settlement
TP 16	35.250 m	2,87,814 kg	13.700 mm	7.455 mm

Table-4: Ultimate load capacity of the test pile

S.L No	Test pile no	Ultimate load capacity in kg			
		BNBC (1993)	Davisson 1973	IS: 2911 (Part-VI)-1979	BSI(1986)
1.0	TP-16	>2,87,814	>2,87,814	2,66,857	>2,87,814

Table-5: Allowable load capacity of the test pile

S.L No	Test pile no	Allowable load capacity in kg			
		BNBC (1993)	Davisson 1973	IS: 2911 (Part-VI)-1979	BSI(1986)
1.0	TP-16	1,43,907	1,91,876	1,77,904	1,43,907

VI. Conclusion

All results of static load test indicate very conservative pile design as the (settlement/pile diameter) ratios are less than 1% for all piles. Therefore, it is strongly recommended to optimize the pile design for projects by determining the actual ultimate pile capacity, which may need to conduct pile test to failure or near to failure. There were two test piles which was observed for both the tests but only the second test result calculation is discussed here. For the 1st test the net settlement was 3.055 mm & the design load was 110,000 kg. For the second test the net settlement was 7.455 mm & the design load was 115,954 kg. From the Load Vs Settlement graph, we found the value was nearabout 118 tons. So the allowable load capacity to be considered is 118 tons.

Acknowledgement

The test was conducted in a site situated at Banasree, Dhaka for the construction of YAMAGAT - DHAKA Friendship Hospital.

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