Bored Pile Capacity by Different Standard Penetration Test Methods

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ABSTRACT

Designing of piles is done so that the load of the superstructure is transferred to the soil strata which are hard and deep. Usually designing of the cast in situ piles is done by analyzing and applying many empirical formulas. Due to the uncertainties in the behavior of sub soils, and the various types of procedures adopted in the construction procedure of a site, piles are tested so that the design load verifies the design load obtained by the static and dynamic design calculation. Various load tests are done on piles of 450mm and 600mm and length of 10m, 15m and 20m. The data collected from the tests is then converted into graphical forms and the results interpreted through load-settlement curves by application of various methods for determination of load bearing capacity of pile.

Keywords: Piles; Superstructure; Soil Strata; Design Load; Load Tests; In Situ Piles; Static Design; Dynamic Design.

1. INTRODUCTION:

Various methods are involved in the determination of load bearing capacity of the piles that may be either analytical or either empirical in nature. The analytical nature involves evaluating the soil-pile interaction along with the assumptions made. The empirical nature is based on the outcomes of the tests and procedures conducted in situ where the condition of soil is unknown where the pile load test has to be conducted. The piles to be used for testing are constructed and load is applied. Before the construction of actual piles to be used for load bearing for the actual structure so that information can be collected. [1]

Among the various methods, the pile load test represents results reasonably, but the test is very expensive, consumes a lot of time and the costs cannot be justified for small projects.

In some projects it is sometimes found that the pile capacity is much higher as compared to the total allowable load. In this case, the pile foundations actually can be designed again. Constructing this may also reduce the cost of the foundation. If the structure is constructed and completed then any change undergone in the sub structure may be costly and difficult. Performing pile load test may help resolve any problem encountered during initial stages of the construction.

Load tests of Pile foundation are done so that the following objectives can be achieved:

- For the determination of disbursement due to the actual applied load conditions.
- For confirming of the appropriacy of load bearing capability
- Acceptability proof.
- Determining acceptable load bearing capability
- For determination of allowable bearing capacity

The determination of bearing capacity for piles can be done using approaches as under:

- The data interpretation is done by the full scaling of tests of pile loading.
- Dynamic analysis is done on the basis of wave equation analysis.
- Pile driving analyzer to use for dynamic testing.
- Static analysis to use in effective stress or approaches for total stress by applying parameters of soil.
- In situ investigation tests and methods used for finding results.[2]

Due to the rapid development of the tests done on sites and their instruments, there is an understanding of the soil, and also an understanding of different types of soils and their limitations, inadequacies, and laboratory tests.

In the direct methods, different parameters of soils which obtained from the results of SPT and using the approach of bearing capacity of the Pile estimation same as used for static methods.

Nowadays most utilized test performed under in situ conditions is SPT test (Standard proctor test). The
assurance of pile capacity desirable limit by the utilization of standard proctor approach is the fastest use of this test. It basically includes two methods

i. Direct approach
ii. Indirect approach

The direct approach is applicable to the values of N and some modification Factors. A considerable uncertainty is in existence related to filtering and average of data measuring the resisting load capacity of pile foundation, zone of failure near base of pile foundation, etc. The capacity of pile depends upon the compressibility of soil and SPT is amongst one of the methods which is commonly used for testing and is used for indication of onsite compressibility of soil. The blow count /300mm (N SPT) of SPT along with the length of pile, within zone of failure, is used for measuring the compressibility of the soil for purpose of study. [2]

2. METHODOLOGY:
The research shows test results of cast in situ resisting capacity of load of pile foundations taken for the sites in Kashmir region. These tests were carried out with an objective to confirm carrying capacity of single pile under static loads and calculate the behaviour of settlement of pile during test. The primary objective of load bearing test of pile foundation is the demonstration of construction approach and confirming the assumptions for design for the bored pile load capacity and also the actual safety factor applied for piles. The methods used for static analysis do an estimate of the shaft and resistances of bases separately and differently. The dynamic methods do not consider the soil’s physical characteristics. This may lead to misinterpretation of the results from the dynamic formulas calculations which can affect the carrying capacity in long term, reconsolidation, and negative skin friction.

For the observation of design capacity, construction of a test pile is done and the load estimated is loaded upon the pile which has been designed. Three kinds of static pile load test are there:

- Pile load test under compression
- Pile load test under tension
- Pile load test laterally

In the research the testing used was compression pile load testing and it also included the anchor method. The readings were recorded load cells of dial gauges and the jacks measuring pressure at intervals of 1 minute on the data sheets of the time settlement. The load put upon the pile increases to 50%, 100%, 125%, 150%, 175% and 200% and the gross settlement has to be checked, then the already used procedure is applied for the observation of net settlement. The settlement has to be checked at 0.5mm precision on reference points in the following conditions:

- Before the test has to conducted
- Before it rebounds to nearly 100% of the design load cycles
- Before the test rebounds from the 200% of design load (both the cycles)
- When the test ends after the final reading of the rebound is recorded

Pile load tests were done on piles of 450mm, 600mm with length of 10m, 15m and 20m using ASTM D 1143-81 methods. The data from the test loads were collected and then represented graphically. The interpretation of results was done through load settlement curves by application of various methods for the measurement of the permissible load bearing capability of piles. [1]

Table 1 Physical Description of Pile

<table>
<thead>
<tr>
<th>Test number</th>
<th>pile Date of casting of pile</th>
<th>Testing date</th>
<th>Length of pile</th>
<th>Diameter of pile</th>
<th>Load applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH1</td>
<td>12.8-2017</td>
<td>11-09-2017</td>
<td>15</td>
<td>600mm</td>
<td>48MT</td>
</tr>
</tbody>
</table>

Table 2 Equipment Used

<table>
<thead>
<tr>
<th>TEST PILE NUMBER</th>
<th>PLUNGER DIA</th>
<th>PRESSURE GAUGE</th>
<th>DIAL GAUGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RANGE DATE OF CALIBRATION</td>
<td>REGRESSION EQUATION</td>
<td>SENSTIVITY</td>
</tr>
<tr>
<td>BH1</td>
<td>215mm 0-500kg/cm² 12-08-2017</td>
<td>Y=0.533x-0.6193</td>
<td>.01mm</td>
</tr>
</tbody>
</table>

3. DATA ANALYSIS:
At the point when the pile foundation is exposed to loads which are expanded bit by bit in compressive burdens which are kept up in the heap stages, from the start the heap soil framework acts in a versatile way till a point on the settlement load outline and if the heap is acknowledged at any phase to a limited extent the pile
head bounce back to the first level.

![LOAD SETTLEMENT](image)

**Figure 1**: Settlement V/S Load
For finding the total load bearing capacity, various methods that can be used are:

- Meyerhoff
- Bazaar & Kurkur
- Decourt, [3]
4. EQUATIONS

Table 3 Direct methods of Standard proctor tests used for the total load bearing capacity prediction

<table>
<thead>
<tr>
<th>Type of method</th>
<th>Base Unit (QB)</th>
<th>Resistance of Unit shift (QS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meyerhof</td>
<td>$mN_s&lt;(L/D)$, $Q_s(MPa)=kNb$</td>
<td>$Q_s(kPa)=n_sN_s$</td>
<td>$N_b$: mean of $N$ in range of 10 D above and 5D below pile base. $N_s$: mean value of $N$ near the depth of pile inserted. $n_s=1$, $k=.012$, $m=0.12$.</td>
</tr>
<tr>
<td>Bazaar &amp; Kurkur</td>
<td>$Q_s(MPa)=n_bN_b$</td>
<td>$Q_s(kPa)=n_bN_b$</td>
<td>$N_b$: avg of $N$ 1D above and 3.75D below the base of pile, $N_b&lt;50$. $N_b=0.06$, $n_b=2.4$. $N_s$: mean of $N$ around the depth of pile inserted.</td>
</tr>
<tr>
<td>Decourt</td>
<td>$Q_s(MPa)=k_bN_b$</td>
<td>$Q_s(kPa)=\phi(2.8N_s+10)$</td>
<td>For Driven and bored pile foundation in clayey soil, $\phi$ is equal to 1. For Bored pile foundation in granular soil type, $\phi$ lies in range of 0.5-0.6. $k_b=0.325$. $N_b$: average of $N$ near pile base. $N_s$: mean value of $N$ near pile embedded depth.</td>
</tr>
</tbody>
</table>

Table 4 Test Result of Pile

<table>
<thead>
<tr>
<th>Pile test number</th>
<th>Length of pile</th>
<th>Test result</th>
<th>Maximum applied load</th>
<th>Gross settlement</th>
<th>Net settlement</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH1</td>
<td>600mm</td>
<td>54MT</td>
<td></td>
<td>22.44mm</td>
<td>12mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BH2</td>
<td>600mm</td>
<td>200MT</td>
<td></td>
<td>-1.21mm</td>
<td>7.15mm</td>
</tr>
</tbody>
</table>

5. CONCLUSION:

The results of the pile load test indicate that pile design is conservative as the ratios of settlement/pile diameter are less than 1% for the piles. It is as such recommended that optimization of pile design should be done for the determination of the actual ultimate pile load capacity which may lead to conducting of pile test failure or near to failure.

6. ACKNOWLEDGEMENT

The test was conducted in a site situated at Srinagar, Jammu & Kashmir, India for the construction of a shopping mall.
REFERENCES


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