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Effect of stress release on vertical capacity of pile

Effet de la relaxation du stress sur la capacité verticale du pieu

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ABSTRACT: At a typical site detailed geotechnical investigations at design stage. At this location both driven piles and bored piles were feasible. However, Bored cast in situ pile has an advantage of using large diameter and can be taken upto the required stratum. The capacity from skin friction and end bearing can be optimally utilised. Rotary hydraulic piling rigs has the advantage of higher production of piles and can be terminated at the required or competent stratum. Bored cast in situ piles on reaching the required founding level the pile bore has to be cleaned of the spoil/muck then lower the reinforcement cage and then lower the tremie pipe and after flushing the concrete is done bottom up. Based on the soil strata and project requirement bored cast in situ pile of 760mm dia. of 250 t in compression has been considered. The pile capacity was estimated as per Indian standard. Before taking the construction of working pile there was required to conduct initial pile load test to arrive at the safe vertical load. The testing procedure, method of loading and measurements was as per Indian standard. This paper presents a case study of three initial pile load tests results in which one test resulted in reduction of pile compression capacity. There were some factors for the under performance of the pile capacity. On observing the behavior of load settlement curve and comparing with the successful tests it was found that there was loss of capacity as compared to estimated capacity. The behavior of load versus settlement observed that initially, the shaft bore the load, and thereafter, with increasing settlement, the pile tip became active. A reduction of 110t load is observed. Based on the field test it was observed that selection of pile type was an important aspect in piling. Pile boring is from top to bottom whereas concreting is from bottom up and therefore continuous care and supervision is necessary at all stages of execution. Workmanship is one of the important factors which can affect the pile construction and may impact the capacity. However, it is found that this could be controlled by continuous supervision and rigorous inspection at all stages. The paper also presents measures taken to reduce the waiting time and various quality control and quality assurances for improving workmanship. Piling is specialised activity and requires expertise at all stages of execution. With advent of state of art technology factors affecting pile capacity can be examined in further detail to achieve sound successful safe capacity.

KEYWORDS: Bored cast in-situ piles, waiting time, initial vertical load test, reduction in pile capacity, workmanship

1 INTRODUCTION.

Bored cast insitu pile has an advantage of using large diameter and can be taken upto the required stratum. The capacity from skin friction and end bearing can be optimally utilised. Rotary hydraulic piling rigs has the advantage of higher production of piles. Bored cast in situ piles on reaching the required founding level the pile bore has to be cleaned of the spoil/muck then lower the reinforcement cage and then lower the tremie pipe and after flushing the concrete is done bottom up. This inherent time from end of boring to start of concreting is called as waiting time. The waiting time should be as short as possible. Bored cast in situ piles has the inherit problem of ineffective cleaning of pile bore bottom which affects the pile capacity. In addition if the waiting time is more than certain period is also found to impact in reducing the pile capacity. To overcome this issue the general practice is on reaching the termination level, flushing with fresh bentonite slurry is resorted for about 30 to 45 minutes before concreting. It looks apparently simple but its not since the pile boring is from top to bottom whereas concreting is from bottom up. Therefore, piling is specialised activity and requires expertise both at design and execution. As per Indian standard before job piling initial pile load test was required to be carried out. This paper presents the results of three field pile load tests carried out on 760mm pile dia. From the behavior of displacement versus applied load, one pile test resulted in reduction of vertical capacity for the same diameter and length and at same site. However, it is observed that this could be controlled by continuous supervision and rigorous inspection at all stages.

2 CASE STUDY

2.1 Soil strata

At one of the project, detailed geotechnical investigation comprising of bore holes, static cone penetration tests, pressuremeter tests, geophysical tests (electrical and seismic refraction tests were carried out at design stage. The extent and depth of investigation were different depending upon the functionality of the structure. The details of investigation are beyond this paper. Soil strata under a particular building comprise of silty Sand followed by silt with occasional clay content generally dense state having SPT 'N' greater than 30 beyond 15m depth below ground level. Ground water table was met with about 2.0m below ground level. The static cone test indicated 2MPa in dense layer below 15m and varies from 4MPa to 8MPa in very dense layer. The idealised soil profile under particular building under consideration is shown in Figure 1.

From	To	Navg	Description
3.00	5.00	17	Silty fine sand
5.00	12.00	26	Silty fine sand
12.00	17.00	27	Clayey Silt
17.00	19.00	33	Sand
19.00	22.00	36	Clayey Silt
22.00	28.00	54	Clayey Silt with kankar
28.00	30.00	60	Silty fine sand
30.00	32.00	55	Silty clay with kankar
below	32.00	51	Silty fine sand

Fig. 1. Soil profile generalised average N value.

Pile

At this location as per soil conditions both driven piles as well as bored cast-in-situ rcc piles are suitable. However, with the advancement of pile construction methods and equipment, the rotary hydraulic pile drilling rig was considered. The rotary hydraulic rig has the advantage of higher speed of pile construction as compared to conventional piling rigs. At this location, the bored piles can be terminated at the required competent stratum, higher diameter with higher load carrying capacity. Considering the work schedule and mix of pile diameter the bored cast in situ rcc piles was found to be technoeconomic. The construction of bored pile further reduces the vibration and reduce noise levels which was important as the present piling site is adjoining existing facilities. The crawler mounted rig has an additional advantage to construct the pile in all weather condition. Based on the loading requirements, and the strata encountered to transmit the stresses to the competent stratum pile foundations bored cast in situ RCC piles of 500mm dia and 760mm dia were considered. The pile capacity has been calculated as per IS:2911. Based on the friction and end bearing component the estimated safe capacity in compression for 760mm was 250t capacity for length 27m below cut off level(COL).

Piling in general was in accordance to IS 2911 and to the technical specification. One of the requirement at termination was that the SPT N was greater than 50. Some of the requirement was Field quality plan to maintain quality control and quality assurance of piling activities. The specification also stipulates that the density of muck after cleaning of pile bore and before concreting shall be less than 1.2 gm/cc. The waiting time (ie) from end of boring to start of concreting shall be less than 6 hours. Each Pile bore shall maintain record data and shall be cleaned as specified in the specification.

2.2 Test pile

One of the requirement before job piling was to conduct the initial pile load test. For this purpose a separate test pile was installed adjacent to the job piling area. The test load is three times the estimated pile capacity which was 750t and additional another 10-15 % over and above the test load was also provided for reaction. The load was applied by means of hydraulic jack butting against the reaction frame. The kentledge was placed on the platform supported clear of the test pile. The load on the pile was applied through hydraulic jack coaxial with the pile. The settlement are measured by four numbers of linear variable displacement transducer (LVDT) placed on pile top and recorded from a remotely digital readout kept outside the test pit. A typical LVDT arrangement on pile top inside the test pit and the digital read out outside the test pit is illustrated in Figure 2. The remotely recording of measurements has enhanced the safety aspects by avoiding exposing the personnel into the pit for recording the measurements.

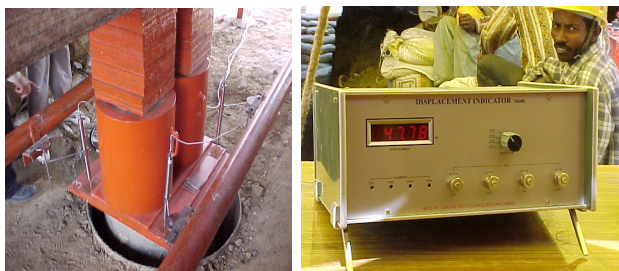


Fig. 2. Typical LVDT on pile top in test pit and digital read out outside the test pit.

The reaction to the pile was given by a static system using kentledge as permitted by the standard. The platform/reaction frame and concrete blocks was independent from the test pile.



Fig 3 Typical platform and kentledge for initial pile load test.

The testing procedure, load increments, measurements were as per IS 2911 part 4. The load application and deflection observation was made from the pile top as stipulated in the standard. The final test load was maintained for 24 hours. The load versus settlement of test pile 1 (column B) is presented in Figure 4.

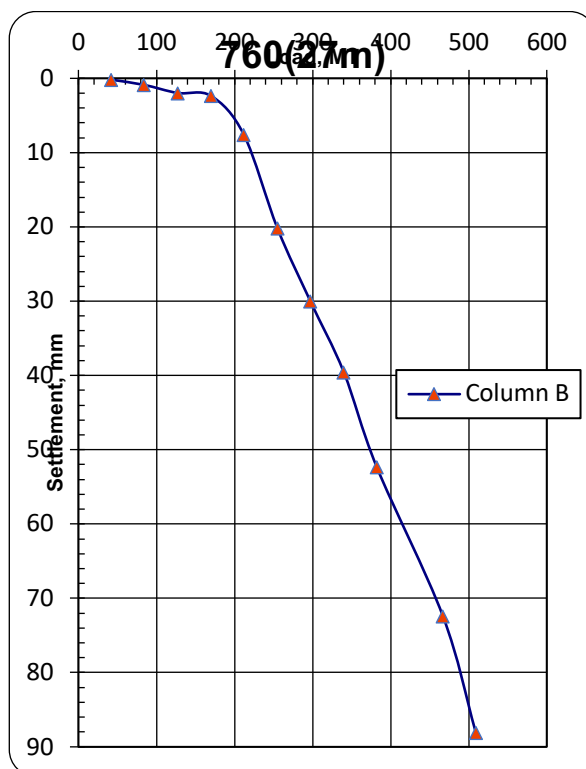


Fig 4. Load settlement curve of column B

The test was continued till the displacement of pile head reaches 10% of pile dia or three times the design load whichever is reached earlier. The acceptance criteria were as specified in IS:2911 part 4. As per the criteria the safe load from initial load test should be least of the following:

- two – thirds of the final load at which the total displacement attains a value of 12mm unless otherwise required in a given case on the basis of the nature and type of structure in which case, the safe load should be corresponding to the stated total displacement permissible,
- 50 percent of the final load at which the total displacement equal 10 percent of the pile diameter in case of uniform pile diameter.

As per the above criteria the safe load was observed to be 140t, which was 110 t less as compared to the estimated safe capacity of 250 t. The performance of the results was observed to be unsatisfactory as compared to the rated capacity.

To establish the termination of pile 100mm soil bore hole was carried out in a group of piles. The above soil data obtained was found to be comparable with the data collected during the detailed investigation carried out at design stage. In view of the above variation in soil data at design stage and as obtained during piling is ruled out.

Another two initial test pile of 760mm diameter, 27m length (Column L and Column N) was installed ensuring proper supervision and careful piling activity meeting the specification requirement. The quality control and quality assurances, trained experienced rig operator in piling activity to improve workmanship was ensured. It may be mentioned that the testing arrangement, procedure, load increment was similar to the test pile Col B. The test results load versus settlement are plotted and presented in Figure 5. The applied load is indicated on x-axis and displacement or settlement at the end of 24 hours is indicated on Y- axis.

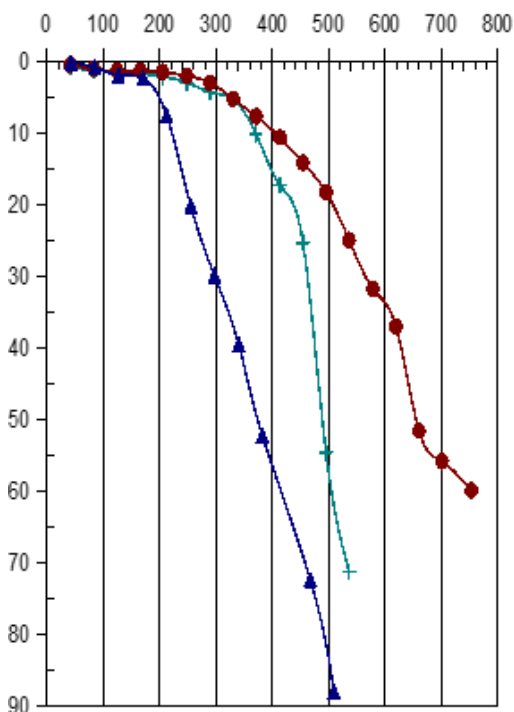


Fig. 5 Load versus settlement

3 DISCUSSION OF RESULTS

3.1 Comparison of load settlement behaviour of pile

Figure 5 indicates the behavior of load vs settlement of the test pile col.L and col.N test. The safe load as per the criteria stipulated as per Indian standard mentioned earlier was found to be 254t and 280t respectively Since safe load from load test was more than the rated capacity of 250 t therefore acceptable. As mentioned earlier the test pile at col.B was observed to be much less than the rated capacity therefore unacceptable.

The general practice on reaching the termination level, flushing with fresh bentonite slurry was resorted for about 30 to 45 minutes before concreting. In between these two operations there are other activities were performed not limited to lowering of reinforcement cage and tremie pipe, cleaning of pile bore. The various other complementary details concerning execution are not described in this paper. At the same site for the same length and diameter at the same site different pile capacity was observed. There could be some factors and shortcoming during execution which may be unintentional but however led to insufficient capacity of curve col.B. Fleming et al. mentioned that "Construction of piled foundation is a specialized activity calling for considerable expertise and reliable workmanship, more so as the completed element can rarely be inspected for defects". It may be mentioned that pile boring is from top to bottom whereas concreting is from bottom up and therefore continuous care and supervision is necessary at all stages of execution. Workmanship is one of the important which can affect the pile construction which may impact the capacity. However as seen from the field tests such situation can be controlled by rigorous inspection at all stages. From the above discussion it may be mentioned that the entire Piling is specialised activity and requires expertise both at design and execution. Hence "*Piling is both science and art*" wherein experience coupled with judgment plays vital role in successful piling activity.

Figure 5 also illustrates that the load transfer of load by consideration of the distribution of total load into shaft friction and base resistance. This in agreement with observation made by Tejchman and Gwizdala (1979) m. Based on the field tests conducted by them they found that initially, the shaft bears the load, and thereafter, with increasing settlement, the pile becomes active. From the displacement versus the applied load curve behavior presented in Figure 5, illustrate that in the initial portion of curve col.B a reduction of 110 t as compared to curve at col.L and N. was observed.

3.2 Scope for further research

Figure 5 shows the load settlement curve a combination of both the skin friction and end bearing. On comparison of curve col.L and N with col.B it is observed that there is wide variation in the nature of the curve for all the three tests for the same length and diameter and at the same site. Even in the initial portion of the curve L and N is similar but was at variance as compared to curve col.B in the top portion. With advent of state of art technology can be examined in further detail to overcome such situation to obtain the estimated pile capacity. Therefore, there is further scope for research in this direction.

4 CONCLUSIONS

Three initial test pile were conducted at piling site before proceeding with job piles. From these tests it was observed that there is wide variation in the behavior of the displacement versus applied load for the same length and diameter and at the same site. One of the test pile, the capacity of pile arrived was

less than the rated capacity. The under performance was unintentional however, there were some factors which affected the pile capacity.

The main findings of this study include:

- The detailed geotechnical investigation carried out at design stage was in good agreement with soil data collected during piling. In view of this finding the rated pile capacity estimated at design stage remain unchanged even at execution stage.
- Selection of pile type is an important aspect especially when various piles are feasible. Due consideration should be given especially constructing pile at an adjoining structure which are sensitive to vibrations.
- Pile boring is from top to bottom whereas concreting is from bottom up and therefore continuous care and supervision is necessary at all stages of execution.
- Workmanship is one of the important factor which can affect the pile construction and may impact the capacity. This may be controlled by continuous supervision and rigorous inspection at all stages.
- Based on the field tests conducted it was found that initially, the shaft bears the load, and thereafter, with increasing settlement, the pile becomes active. A reduction of 110t load is observed.
- With advent of state of art technology factors affecting pile capacity can be examined in further detail to overcome such situation. Therefore, there is further scope for research in this direction.
- Piling is specialised activity and requires expertise at all stages from geotechnical investigation, interpretation and analysis of data, design and execution to achieve the rated capacity.

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