PILE DESIGN AND CONSTRUCTION PRACTICES IN INDIA
-A REVIEW

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INTRODUCTION

In last 2 - 3 decades, there has been considerable improvement in our capabilities for design and construction of pile foundation, both on land and in marine conditions. Present construction technology is in no way inferior to the international standards. Piling under very challenging conditions, e.g. rough sea, very soft ground, limited headroom, etc. have been successfully carried out. There are improvements in instrumentation, monitoring and load testing. Our piling contractors certainly deserve appreciation for their achievements.

Similarly, there has also been a matching improvement in the theory and design methods. The actual data from full scale tests have been continuously used to improve the theoretical predictions. Also a number of computer software are now available for design and analysis of pile foundations.

This paper briefly discusses various salient points of design, construction and load testing of pile foundation.

PILE DESIGN

Detailed formulae for pile capacity have been excluded from this note. Only salient features concerning the estimate of pile capacity are discussed.

SOIL PARAMETERS

The soil data is the most important in estimating the pile capacity. In most of the cases the tender provides inadequate soil data and the time available is often inadequate to carry out soil investigation. As a result, the pile penetrations are estimated based on only limited data available. Subsequently, during execution, there can be large variations in the quantities due to change in the strata conditions. It is therefore important that a need for detailed subsoil investigation is emphasised for any project. The quality of subsoil investigation is also generally poor due to stiff competition. It is therefore necessary to identify agencies which have equipments in good condition and also good laboratory facility.

LIMITATIONS IN THEORY

Available theories are to be treated only as guidelines for rough estimate of the pile capacity. The formulae in codes are for general purpose and cannot truly reflect the method of installation. For example, the IS code recommends same bearing capacity for precast driven and driven cast-in-situ piles.

In case of skin frictional resistance, the parameter of earth pressure coefficient (K) varies from 1 to 3. Depending on the value of K adopted, the predicted value will have variations up to 100%. It is therefore necessary to collect more field test data for different types of piles installed in different types of soil and analyse the data. This will enable to arrive at more realistic values.

When the pile is terminated on rock or socketed into the rock, no guidelines are available regarding skin friction and end bearing capacity. The termination of pile is normally based on thumb rule of half to 3 times the pile diameter into the rock. Quite often the criteria is based on chisel penetration rate. Such criteria are very much site specific and also applicable for the set of equipment used for the particular project. Such criteria cannot be generalised as guidelines to be followed for other projects.

In view of the above, in spite of detailed soil data, it is necessary to carry out pile load test to confirm the design even if the total number of piles is small.

PILE CONSTRUCTION

DRIVEN PILES

Precast Piles : Compared to the scenario in other developed countries, the use of ready-made prefabricated piles has not yet developed in our country. This is mainly because the transportation of such prefabricated pile segments from the point of manufacture to the point of installation is very difficult. The process of casting the piles at site requires fairly large casting yard which becomes economical only if the number of piles to be installed is large.
Precast pile has many advantages like good quality control, possibility of using high grade concrete (upto M 60), better corrosion resistance, possibility of providing bitumen coating on the surface to reduce negative drag, etc. The use of jointed pile is also becoming popular. The jointed pile has smaller segments which can be handled easily, requires lesser percentage of steel and the length can be adjusted depending on the changes in the strata.

Apart from concrete piles of solid section, hollow pipe piles have also been used successfully. Such pipe pile has better rigidity and higher lateral capacity compared to solid section for the same given cross sectional area. At present hollow pipe piles upto 1.2 m diameter and 40 m length are being installed for marine structures.

In case of precast driven pile the termination is decided based on the set value. The dynamic formulae available in codes do not truly reflect various parameters like weight of pile cap, properties of cushion, dynamic properties of soil, etc. It is therefore preferable to carry out a detailed pile drivability analysis. Simple software are available to carry out such drivability analysis. This will provide relationship between set and ultimate capacity, maximum and minimum (tensile) stress developed during driving, etc.

**Cast-in-situ Piles**: Driven cast-in-situ piles are usually found to be cheaper compared to precast driven piles. The percentage steel required is less as no handling of the pile is required. Though it is cast-in-situ pile, it has the advantages of compaction of the ground surrounding the pile during the process of driving of the casing pipe. The length of pile need not be predetermined and the casing length can be varied depending on the strata condition.

Some of the important points to be noted while execution of driven cast-in-situ pile are as follows:

i. Pile shoe should have a water tight joint with the casing pipe. If not, this will lead to seepage of ground water into the casing pipe. This can increase the water-cement ratio at the pile tip and affect the strength of concrete, which is not desirable. It is therefore preferable to provide bitumen or other suitable water proofing material at the joint between casing pipe and shoe.

ii. The reinforcement grills should move freely into the casing pipe. In case of initial bend in the reinforcement, it may get stuck with the casing pipe and can even get lifted slightly during the process of initial concreting. It is therefore preferable to monitor the top level of the reinforcement rods to check such upward movements.

iii. The filling of concrete, withdrawing of the casing and tampering of the casing for compaction needs very careful operations. Withdrawal of casing shall be such that minimum 1 to 1.5 m of fresh concrete is always within the casing pipe.

iv. When the ground water table is high, special precautions shall be taken to ensure that fresh concrete is not subjected to seepage forces at the time of withdrawal of the casing pipe.

v. While installing the pile at closer interval, care shall be taken to avoid damage to the adjacent fresh pile. For this, it is preferable to install alternative piles.

**BORED PILES**

Installation of bored cast-in-situ pile upto 2 m in diameter have been adopted successfully. The following different methods of advancing the bore holes are commonly used.

i. Chisel and bailer method

ii. Direct Mud Circulation (DMC)

iii. Reverse Mud Circulation (RMC)

iv. Continuous flight auger

v. Rotary Drill

In all the above methods stabilisation of the bore hole is most important. Usually the steel liner penetrating though the loose strata is provided. If the penetration is small (3 to 6 m) the liner is withdrawn after concreting.

In bored cast-in-situ piles, cleaning of the bottom of bore hole is very important. This is carried out by continuous flushing of bentonite slurry for 15 minutes. After cleaning the bottom the concreting shall be carried out immediately without any delay. To ensure that concreting is smooth, pile length to diameter ratio shall be limited to maximum of 40 to 50. If deeper piles are required the minimum diameter shall be accordingly chosen.

**PILE TESTING**

Conventional pile load test with steel kentledge is very time consuming. Also the loading if applied at very slow rate takes a long time for completion of the test and hampers the other works at site. If a faster rate of loading is adopted, the ultimate capacity obtained is generally lower compared to when the rate of loading is slow. Therefore, result obtained by faster loading will be conservative.

If suitable rock/hard strata is available within reasonable depth, it is possible to provide anchors for the reaction...
required. This will avoid loading of conventional platform.

Dynamic testing of pile using instrumentation is another way to quickly assess the pile capacity. However, enough data and experience is not available at present to avoid the routine pile load test. Wherever possible, pile should be instrumented with additional sensors to arrive at precise sharing of loads between skin friction in various layers and by the end bearing. Such instruments are now commercially available in the country and can be used without difficulty.

The interpretation of load test data is also very important. In most of the routine load test failure load cannot be established and it becomes necessary to extrapolate the failure load based on one of the known methods. Whenever pile is free standing above river bed or sea bed, elastic compression of the freestanding length can be considerable and has to be accounted for while arriving at the permissible load.

SUMMARY

This paper briefly gives various salient points related to pile design, construction and testing as adopted in India. Though there are considerable improvements in design / construction, there is scope for further improvement. I am sure professionals working in this area will certainly try to achieve every possible improvement.