

Factors affecting cast-in-situ pile foundation

Gaurav Basavraj Dhang

Research scholar, SSJCET, Asangaon

Abstract - Pile foundation construction has been extensively used in a number of countries for quite some time as a specialized problem solving technique for providing foundation in areas where conventional types of foundation construction are not possible due to many structural and operational constraints. Pile foundation construction is a combination of geological and structural technique which is used to achieve foundation where soil bearing capacity is low. Cast-in-situ pile foundation is been widely used in India for construction of high rise buildings, industrial buildings and bridges. This paper dwells upon various major factors which affect the construction process of cast-in-situ pile foundation.

Key Words: conventional, geological, structural, and cast-in-situ.

1. INTRODUCTION

1.1 General

Foundations are about transferring load to the earth. There are two basic ways of transferring the load, either right below the structure in the form of a spread footing or strip footing or with piles. Piles are used when footing and spread footing do not work with following load behavior like uplift, lateral, or rotation. Pile basically takes that load to a location where the load can be placed. In traditional construction practices wooden piles were used to support the foundation in areas with low soil bearing capacity. Wood piles are still used in construction of houses in hilly areas and also in construction of jetties. There are various materials with which pile can be constructed which are as follows wooden pile, steel pile, rcc pile, concrete pile and composite pile.

Pile foundation carry a lot of load due to which special care should be taken while designing of pile which also determines the overall cost of project. The study of geotechnical investigation plays an important role in designing process. Maximum load carrying capacity of pile in vertical and horizontal direction needs to be determined. The tension in pile is also taken into consideration while designing. Designers usually design a pile group in such a way that few piles are grouped together to top it with a pile cap. This then serves as a base for column. Thus the load of this column is then distributed to all piles in the group. Every pile group has a zone of influence on soil around it, which is taken into consideration.

Soil condition should be favorable for pile construction as it has economic advantages for designing and execution.

The maximum load per unit area at which the soil can bear without any displacement or settlement is designated as safe bearing capacity of soil. According to which designing of pile is done keeping in mind the safe bearing capacity of soil. Bearing capacity is the deciding factor for geotechnical design of foundation. Bearing capacity of soil is defined as load bearing capacity of the soil without having settlement as well as shear failure in the underneath soil layer of the foundation. Generally the bearing capacity of the soil is directly related to the depth from the top soil up to a certain extent after which it again reduces. Terzaghi's and Meyerhof's theory of bearing capacity are mostly used for the geotechnical designs of foundation.

1.2 CASES WHERE PILE FOUNDATION IS USED

- When there is a layer of fragile soil at the surface, this layer cannot support the weight of the structure, so the loads of the building have to bypass this layer and the loads are transferred to the layer of rock that is below the weak layer of soil.
- When a structure has very heavy concentrated loads which are in high rise structures, bridges or water tanks.
- Sub soil water level is more so the pumping of water from the open pit for the shallow foundation is tough or uneconomical.
- Large undulations in subsoil water level that may cause sinking foundation in case of shallow foundation.
- Structure is situated near river bed, where there is a probability of scouring action of water.
- The top layer of soil is of expansive nature.
- The topography of site is not suitable for conventional method of foundation.

2. BASIC TYPES OF PILES

End bearing piles and friction piles are the two main basic types of pile foundation mostly used in today's world for pile foundation construction.

2.1 End Bearing Piles

End bearing piles are used to transfer the load through water or soft soil ground to suitable hard load bearing strata. Such piles are used to carry heavy loads which

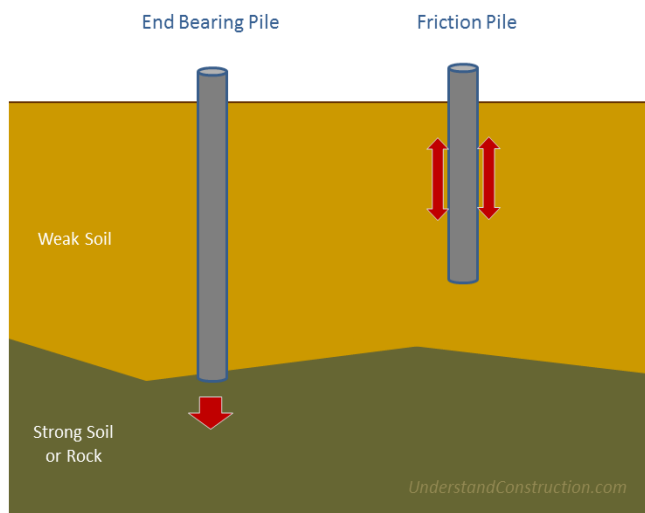
bypass the weak strata safely to hard strata. Multi-storied buildings are generally founded on end bearing piles, so that the settlements are minimized. End bearing piles are typically driven through soft soil, such as loose silt-bearing strata underlain by compressible strata. This factor is determined to calculate the load of the pile which it can support safely.

The stability of any structure is produced by taking the pile to the strongest part of the soil. The end of the pile rests on either the hard part of the soil layer or on the rock at the end of the weak layers of the soil. The end bearing piles are generally used in most of the construction process in pile foundation.

2.2 Friction Piles

Friction piles are used to transfer load at a depth of a frictional load carrying material by means of skin friction along the length of the piles. Such piles are generally cast-off in granular soil where the depth of hard stratum is very high. Some piles transfer the super-imposed load through both, side friction as well as end bearing. Such piles are more frequent, especially when the end bearing piles pass through granular soils. Friction piles are used in the soil of fairly uniform consistency and the tip is not station in a hard layer, the load carrying capacity of the pile is developed by skin friction.

The load is transferred earthward and lateral to the soil. Friction piles are used in place of the end bearing piles for economic or structural reasons. The friction pile gives toughness due to friction that is created in the deeper layers of the soil. When the pile is inserted into the deeper part of the soil, the soil compacts and offers higher resistance and toughness to the pile. The more the pile is lodged into the soil, greater the strength is given to the structure by the piles.

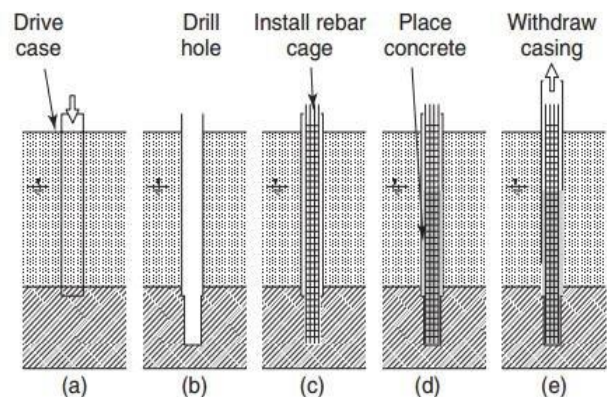


3. CAST-IN-SITU PILE CONSTRUCTION PROCESS

3.1 General

The phrase cast-in-situ is a Latin phrase which translates to “on site” or “in position”. The cast-in-situ piling method of construction includes various materials and equipment which are used at site for the construction of piling foundation. Details of the procedure are discussed herein which can be reviewed periodically and modified on the basis of actual work to be done. The piles which are to be constructed are of theoretical specified diameter, bored through overlying soils into the bedrock strata as end bearing piles or remain in the soil to act as friction piles. The pile boring is designed by the engineer to withstand the axial compressive loads.

Cast-in-situ is the conventional method of concreting. In this method concrete is prepared on the site and poured in pile bored encasing. It often requires more skilled labours and even takes longer time. Driven cast-in-situ concrete piles are constructed by driving a closed-ended hollow steel or concrete casing into the ground and then filling it with concrete. Driven cast in-situ concrete piles can prove to be profitable for sand, loose gravels, soft silts and clays, particularly when huge numbers of piles are required. For small number of piles the on-site costs can prove to be expensive.



3.2 Boring in soil

The pile boring operations are performed using a suitable rotary drill rigs which are generally calculated depending on the diameter, depth, soil condition and construction method. The bore holes are stabilized with a temporary casing in the upper layer depending on the soil and site conditions. The length of the casing will be determined from the actual soil condition which gives the depth of rock encountered for end bearing pile on site. The experience of rotary rig operator plays an important role in construction of pile foundation.

3.3 Setting out the central axis of pile

The location of permanent bored piles are set out and pegged by the surveyor based on approved setting out drawings which are properly checked at site for axis location of pile by the surveyor. The surveying details of each location are to be recorded incorporating reduced level and coordinates of pile location. Record is to be maintained in a survey book. Pile depth is calculated from the reduced level which is then used in making of reinforcement and calculation of concrete quantity. Each individually surveyed pile position should be installed at proper pile centre location. Cut-off level of pile is also established with reduced level. New age surveying technique helps in setting out of pile axis location which then increases pace of work.

3.4 Drilling in rocks

Prior to commencing any piling work it is verified that all associated technical information such as presence of equipment's, pile coordinates, platforms, cut-off levels, validity of drawings are in accordance with the site requirement. After accurately setting out of the pile location by the land surveyor, a temporary casing is set out in position with length of casing which is determined from ground conditions. The vertical accuracy of the casing is checked during installation process using two numbers of plumb bob. Excavation of the soil inside the casing/bored holes will be carried out using the rotary Kelly and the auger or bucket method. The drilling process is continued to the designed founding depth or to the commencement of rock head level by using augers and drilling buckets. Pile lengths are calculated as per the current construction drawings or as otherwise as per depth of rock encountered. At the point of encountering the rock head level for example where the soil drilling tools are unable to penetrate the strata any further, boring shall cease in order that the verification for the occurrence and confirmation of rock socketing is finalized. For drilling through rock, rock drilling tools are to be applied. This shall include rock auger, core barrels, round shank, roller bit, cross cutters and chisels where they are necessary. The final toe level of the pile is to be verified properly. A detailed record of all encountered ground conditions together with the associated times, and type of equipment and materials used are recorded in the pile bore log. Upon reaching the final depth, loose and remoulded material and debris are removed using cleaning bucket. The cleaning bucket is a specially designed flat bottom bucket which picks up all the loose material present at the bottom of the hole. The base of the hole is checked by measuring the depth of the base.



3.5 Installation of reinforcement cage:

The reinforcement cage is fabricated in horizontal sections. The length, type and size of the steel reinforcement are according to the drawings and specifications provided by the structural consultant. The reinforcement cages are provided with helical rings and other setup to enable handling, lifting and installation without permanent deformations. Reinforcement cages are installed into the bored hole using a service crane of the required lifting capacity or with the rotary rig itself. Concrete spacers wired to the cage are provided to lateral support and ensure adequate concrete cover. Spacers are placed at 3 equal levels of each; 12m cage generally has 3nos at each level. If the diameter of bored pile is more than 200cm the spacers are to be placed more than 3nos which is generally preferred.



3.6 Concreting

All piles are concreted by using the tremie method. Concrete of higher slump otherwise specified, are to be used in tremie method. The design mixed concrete is discharged through a tremie pipe, which is lowered centrally to the bottom of the bored hole prior to casting it with concrete. Concrete level of the borehole should be recorded after each concrete stroke is discharged through the concrete pump. One length is continuously embedded

in the concrete during this process to ensure that the discharge of concrete is below the level of the impurities, which are present in the peak part of the rising head of concrete. All testing and sampling of the concrete are carried out as per requirement. A complete record of all concrete cubes is taken to maintain a record of proper form and slump test results. A pile bore log should also be maintained to give record of length which is bored and strata through which it is bored. All compressive concrete tests are to be carried out at the laboratory and independent lab. For a continuous assurance of concrete quality and integrity, concrete should be poured to minimum 0.6m above the theoretical cut off level or otherwise specified in the construction drawings. All completed piles are temporarily barricaded which are then backfilled to ground level with a suitable material next day.

4. CONCLUSION

Subsurface obstacle like occurrence of boulders in soil is of major concern as it halts the pile construction process due to which the site condition needs proper geotechnical investigation before commencement of work. Soil type also plays an important role in pile foundation which determines the speed with which pile can be bored in different strata like clay, boulder, sand, and stiff clay. Pile location fixing is major part of concern as every pile should be at its proper location as per the drawing. Due to advancement of surveying technique it has become slightly easy to locate the pile location with the help of total station. Lack of contractor experience can also affect the quality and the speed of work. Proper site planning is needed to overcome any difficulties which may be faced during execution, and which needs to be rectified and avoided in proper time. Dedicated team under supervision should be allocated for steel fixing and installation. Method and efficiency for rate of pouring concrete is utmost priority. Experienced and skilled labours are required during the construction of cast-in-situ pile foundation.

REFERENCES

1. Garland Likins MASCE, Gina Beim MASCE, C. Michael Morgano MASCE, George Piscsalko, George Goble MASCE "Construction Control for Auger cast piling" .(ASCE-2013).
2. Harry G. Poulos, F.ASCE "Pile Behaviour - Consequences of Geological and Construction Imperfections.10.1061/(ASCE)10900241(2005)131:5 (538).
3. Mark R. Tufenkjian, Arthur H. Wu, and Kenneth Woehler (2016) "Pile Construction Issues at the P-700 Aircraft Carrier Wharf Project" (ASCE-2016).
4. Ben C. Gerwick, HON. M.ASCE (2015) "Pile Installation in Difficult Soils".10.1061/ASCE 1090-0241(2004)130:5(454)
5. Wang Chong "Analysing Control and management of Pile Foundation Cost". (ICSMME 2015)
6. H.G. Poulos (2016) "Simplified Design Procedure for Piled Raft foundations". (ASCE-2002)