A Review On Analysis And Design Of Pile Foundation Concealing Different Soil Layers

[1]Parth Akbari, [2]Hardik Patel
[1]Post Graduation Student, [2]Assistant Professor
Chhotubhai Gopalbhai Patel Institute of Technology

Abstract - **As the urbanization increases worldwide, the available land for building is becoming scarier and scarier, and the cost of land is becoming higher and higher. Thus the popularity of tall structure are increasing day by day to withstand the load of these structures proper stiff foundation is to be used such as pile foundation which includes the study of static analysis of pile foundation. In this paper, an attempt has been made to review the different types of soils such as clays with different consistency, sand with different density having different angle of internal friction with layers of sand and clay. It also includes different pile cap parameters such as shape (Triangular, square & rectangular), length, spacing of piles in groups and pattern of the pile group. The analysis and design of single pile & group of pile considering the variation in parameters of single pile, pile group, pile cap analysis and design is also been included in this study With the various combinations of soil parameters and loads. The ultimate bearing capacity of the pile and pile group for the given soil condition with the analysis & design gives the number of piles, dimension of the pile, and spacing of piles in the pile group for various soil conditions. The study also includes & shows the reinforcement details for individual pile & pile group.**

keywords - **Sand, Clay, Pile Cap, Static Analysis, Point load , Pile Group, Single Pile, Soil Displacement, Design Details.**

I. INTRODUCTION

Foundation is that part of structure which transmits the load of the structure to the ground. It is the supporting part of the structure. It acts a connecting link between the structure and ground. The pile foundation is a type of deep foundation. A complete pile design project involves determination of pile capacity for given soil conditions to fix the diameter, length and judicious grouping of piles to transfer the upcoming load to soil below for safe functioning of the foundation system throughout its operating life and finally covering the pile with the properly design pile cap.[3] Apart from their ability to transmit foundation loads to underlying strata, piles are also widely used as a means of controlling settlement and differential settlement. For the design of the pile, the designer has to come up with best possible option for the given conditions of the soil by considering the aspects such as bearing capacity, group action and design.[4]

History And Development Of Piles

In Britain, a Roman bridge spanned the Tyne at Core bridge, about 20 miles west of Newcastle on Tyne, using piles to support the construction. The piles used in this were block oak and were 3mts in length. Amsterdam was founded about 1000 years ago, was build almost entirely on pile foundations of 15-20 meters of length. The Romans capped their piles with a mixture of stone rubble and concrete. Creasy (An Encyclopedia of Civil Engineering 1861) says that in Holland piling and capping by planking was still in use, with rough stones rammed between the planks.[3]

Neccessity Of Pile Foundation

The pile foundation is necessary to resist the uplift forces created due to water table rise or any other cause. Uplift forces are more common in the construction of transmission towers and off-shore platforms. These structures will need pile foundations:

- When the strata just below the ground surface is highly compressible and very weak to support the load.
- When the plan of structure is irregular to its outline and load distribution. It would cause non-uniform settlement.
- When horizontal forces in addition to vertical loads are to be resisted.
- When soil layer immediately below the structure are When structure is subjected to uplift, overturning moments subjected to scour.
- Where expansive soils, such as black cotton soil exist, which swells or shrink due to change in water content.
- In areas where settlement issues are common due to soil liquefaction or water table issues, pile foundation is a better choice.
- Pile foundation is necessary for areas where the structure surrounding has chances for soil erosion. This might not be resisted by the shallow foundations.
- Pile foundation is needed near deep drainage and canal lines.[3]

Deep Foundations

A deep foundation is a type of foundation that transfers loads from superstructures to the earth a greater depths from the surface than a shallow foundation does to a subsurface layer or a range of depths. When the soil at/or near ground surface is not capable of supporting a structure, deep foundations are required to transfer the loads to deeper strata.[2] As per Terzaghi, it is defined as foundation whose depth is greater that its width. There are many reasons that a geotechnical engineer would recommend a deep foundation over a shallow foundation, such as for a skyscraper. Some of the common reasons are very large design loads, a poor soil at shallow depth, or site constraints like property lines.[3]

Pile Groupings

Pile is not used singularly beneath a column or a wall, because it is extremely difficult to drive the pile absolutely vertical and to place the foundation exactly over its centre line. If eccentric loading results, the connection between pile and column may break
and the pile may fail structurally because of bending stresses.
Efficiency = It is the ratio average load per pile to load at failure of comparable single pile.
Settlement Ratio = It is the ratio settlement of group to settlement of single pile.[3]

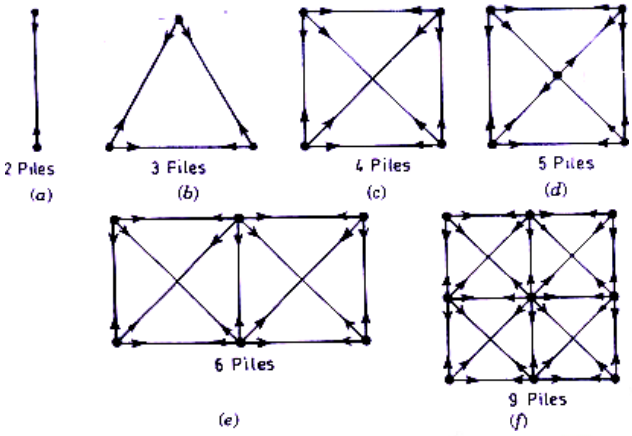

Fig.1 Arrangement of pile in Pile Group

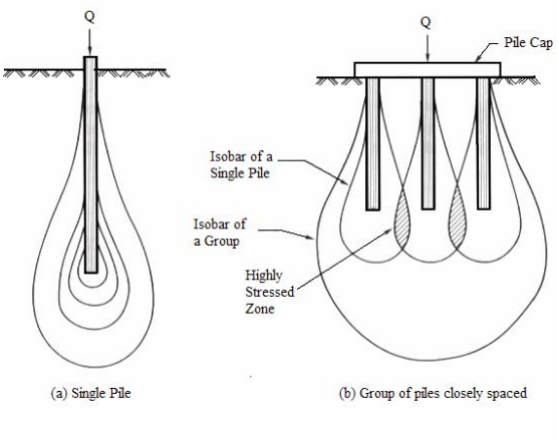

Fig. 2 Stress of individual pile(a) and group of pile(b)

In real practice, structural loads are supported by several piles acting as a group. The settlement of the group will therefore be greater than that of single pile. It is common to term it as "Efficiency" or "Settlement ratio" of groups.[3]

Negative Skin Friction

When a fill is placed in a compressible soil deposit, consolidation of the compressible material will occur. When a pile is driven through the compressible material before consolidation is complete, the soil will move downward relative to the pile. This relative movement will develop skin friction between the piles and moving soil is termed as "negative skin friction".[2] The principal effect of negative skin resistance is to increase the axial load in the lower fixed portion of the pile. It may also result in increased

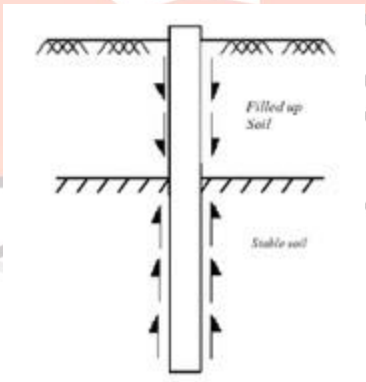

Fig.3 Negative Skin Friction of Pile.[2]

pile settlements due to the axial shortening and/or additional point penetration of the pile under the increased axial load. It causes large tension stresses when the effect is from expansive soils, especially if no or insufficient gap is left between soil and pile cap, the soil expands against both the pile and the cap.[2]

II. Review of Literature

IS: 2911[1] The load carrying capacity calculation formula for single pile for different soil conditions are taken from Code gives the useful information for the design consideration for the bored pile, driven pile and pile cap for the pile group. Spacing, behavior of the pile in the pile group and reinforcement specifications for the pile group are used as per recommended by the code. The lateral resistance of the single pile is calculated using the code method. Bearing capacity is taken from the code.

J.E Bowles[2] had a new concept based on the shifting rate of piles, and the settlement rate of the surrounding soils has been suggested for the study of negative skin friction. Negative skin friction occurs when the settlement rate of the surrounding soils is greater than that of the piles. Some relative equations have been established to define the negative friction zone of piles. Negative skin friction is dependent on the time factor and the degree of consolidation of the soil mass and can be negligible when the soil mass is nearly completely consolidated.

K. R. Arora[3] gives a good idea about the classification of the different types of piles. General theories for the analysis of the single pile and brief knowledge of the pile group are also taken from this reference.

M.J. Tomlinson and V. N. S. Muthy[4] gives a good idea for the understanding of the behavior of pile under load. Murthy also gives a good sense of understanding for the failure of the single pile for specific type of soil and method of analysis for the pile group.

P.C. Varghese[5] carried out the design of pile cap considering the case study of raja garden flyover which is situated in Delhi. The designing of the pile cap was done using the bending theory and truss analogy method. Various load combinations including seismic, longitudinal and transverse loads were considered. Reinforcement details for each method were included. The load combinations considered for design of pile cap were the total vertical load, total longitudinal moment and total transverse moment. Load on pile cap had been calculated considering the maximum effects from normal case, seismic longitudinal case and seismic transverse case. In this paper the analysis was done by the bending theory and truss analogy method for the different pile caps under the flyover and maximum area of steel calculated by either of the method was provided.

S. C. Gupta[6] In this study, work carried out by S. C. Gupta was on the analysis method for calculating the bending moment of piles and results of it were supported by finite element analysis on computers. Most of the methods available for analysis of piles are given in standard books and Indian codes, are for single pile. The behavior of pile under combined axial and lateral loads is not defined in codes and in general literature. Most of the design engineers are designing piles based on length of fixity charts as given in IS 2911 Part 1. Further the work also includes the drawbacks for the moment calculation on the pile as per I.S. code and other formulas from which the code has suggested the method. To prove this drawback true, a pile group model was prepared with the help of finite element and STAAD Pro software. The general theory for the calculating the length of fixity suggested by code was the main concern for this study.

The method for moment calculation on the single pile was suggested by the author and possible checks for the analysis were also included. The piles designed by the suggested method were not only economical but also safer. To prove this statement a case study on a real bridge design was considered, which were earlier designed based on the length of fixity calculation as per IS: 2911 and were crossed checked by the recommended method. This study concludes that the recommended method by not only economies the design by more than 30 percent in terms of flexural reinforcement but also reduces the overall length of the pile.

S. Ramamurtham[7] gives a good example of the design for three pile group i.e. used for the triangular shape pile cap.

Tridibesh Indu[8] had carried out the analysis work for different types of pile caps having different number of piles under it. Principles for the analysis were suggested and an illustration for a 4 pile rectangular cap under biaxially eccentric column load had been done, this principle was utilized for a few types of caps in respect of the application and scope of truss method. The paper includes the method to analysis for three pile group, hexagonal pile group and rectangular pile group. This paper was prepared and presented as the information on the application of the truss method for the design of the pile caps is scarce. The paper concludes that the approach provides conceptually elegant solutions for triangle, hexagonal and rectangular pile group, but then beam method should continue to be used as a safe general procedure.

III. SUMMARY

From the literatures referred the following things are taken,

- A complete analysis of single pile for its load bearing capacity, is considered with different types of soils with different consistency, different density having different angle of internal friction and layers of sand and clay is carried out which also includes different pile parameters such as diameter, length and type of installation of it. The analysis is done with the IS 2911: 1979 code provisions.
- The analysis method solved in the literature gives dimensions of the individual pile as per the soil data and given load.
- Nine cases where solved in it for the evaluation of the bearing capacity of the individual pile considering different pile cap shapes i.e. triangular, square & rectangular for different types of the soil condition i.e. sand, present. The results are tabulated in table in the literature.
- Pile cap with pile group analysis of different shapes mainly triangular, square & rectangular consisting of the different number of shapes is done.
- The analysis for the pile group gives the ultimate bearing capacity of pile group by group action and by individual action, number of piles as per the soil condition and given load.
- To get the idea of load carrying capacity of the pile group, in the literature different number of piles in a group were considered with pile having shape circular and square varying in the size from 0.15 m to 0.40 m in cohesion and cohesion less with different types of soil conditions. The variations of about 9 cases for single pile and pile group capacity were solved in it.
- As given in the literature design of the different pile cap geometry having circular shape of piles under it is prepared showing the reinforcement details, considering the different type of loads i.e. vertical load acting on the pile cap.
- To know the most economical pile group for some given constant load conditions, 9 different cases were taken in the reference, considering the variation in number of piles in a group, shape of pile and soil conditions.

IV. CONCLUSION

From the study of many literatures referred it can be conclude that,

1. The deflection of a laterally loaded pile is found to increase when stress–displacement response of soil strata is higher.
2. The amount of deflection of piles depends on the stiffness of the piles as well as of the soil deposit.
3. The advantage of the studied approach of Negative friction is that it is not the same all the time; it develops during construction and gradually decreases afterwards.
4. Pile-soil interaction is found to affect the behavior of a laterally loaded pile group more.

5. For a particular load, the incremental deflection is decreasing as increasing of spacing of pile group.
6. For particular pile spacing, the group deflection is found to increase with increase in the number of piles in a group (keeping the lateral load per pile as it is).
7. It is observed the pile cap has a good contribution against the lateral load.
8. The different factors like the length of pile, spacing, position of pile cap, depth of pile cap etc. influence the lateral resistance of pile cap.

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