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Group of Piles under Lateral Load

Soil Structure Interaction

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***Abstract*- Piles are structural members that are made of steel, concrete, or timber. They are used to build a deep foundation and costs more than shallow foundation. Despite the cost, the use of the piles in groups is often necessary to ensure structural safety. To understand the behavior of group of piles under lateral loading it is very much essential to know the behavior of single pile under lateral loading Hence an effort has been made to study the behavior of single pile under lateral loading by considering different values of nh of cohesion less soil under different conditions. From the analysis it can be concluded for laterally loaded piles group capacity is always less then than individual capacity. Single piles are rarely found in practice group of piles are more essential to carry the load and moment. In this case different parameters are considered that is different lateral load , moment and cross section of piles to know the lateral resistant and the charts and tables are developed in behavior of laterally loaded piles without going in to elaborate design procedure of analysis of Laterally loaded Pile using theoretical analysis.**

Keywords: Lateral loads. Deflection. Shear. Slope. sub grade reaction.

1. INTRODUCTION

Piles are usually slender, having high length to width ratio mainly designed to resist axial loads. Pile foundation is often used in bridges and other structures to support the applied axial loads and lateral loads. A pile may be subjected to lateral force for a number of causes, such as, wind, earthquake, water current, earth pressure, effect of moving vehicles or ships, plant and equipment, etc. The lateral load capacity of a single pile depends not only on the horizontal sub grade modulus of the surrounding soil but also on the structural strength of the pile shaft against bending, consequent upon application of a lateral load. The behavior of lateral loaded piles has attracted much attention in the past decade due to the increasing use of viaducts, marine oil boring platforms, and high rise building. While designing these structures, issues such as wind load, lateral spreading after soil liquefaction and permanent horizontal ground movement occurred after seismic
activities are very important and sometimes become critical condition of analysis. However, load-deflection responses of laterally loaded piles depend on many factors, such as pile geometry, structure material properties, adjacent soil conditions, soil-structure interaction, and loadings, load-deflection responses of laterally loaded piles. Because of the complexity of the problem and limited information on horizontal sub grade modulus of soil, and pending refinements in the theoretical analysis only a procedure for an approximate solution, that is presented in IS codes. And also there is no exact solution for the analysis of laterally loaded piles as in case of vertically loaded piles. Situations that need a rigorous analysis shall be dealt with accordingly.

2. OBJECTIVES

1. To study the behavior of group of piles under lateral loading.
2. To develop the design tables and charts from the parametric study on group of piles.

3. METHOD OF STUDY

3.1 Parametric Study:

The behavior of a laterally loaded pile is a complex function of a number of parameters. In this Study, the soil and pile parameters were varied to determine the effect that these parameters on the pile behavior. In each study only one input parameter was varied while the other parameters were kept constant. It was then determined the effect of variation of this single parameter on the pile behavior. The pile head was free to rotate in these analyses, and the lateral load was applied at the ground surface. In this study, the various charts and graph are generated for different load and soil conditions and various cross sections based on IS 2911. All results are obtained considering pile as free headed concrete pile. The parametric study is carried out for deflection, Slope, bending moment, shear, and soil reaction along pile length. The constant of sub grade reaction for very loose sand, loose sand, medium sand, dense sand is obtained from IS 2911. The sub grade reaction modulus method is followed for the analysis.

3.2 Parameters Variation:

3.2.1 EFFECT OF LATERAL LOAD AND MOMENT ON BEHAVIOR OF PILE:

To study the effect of lateral loads and moment on behavior of group of piles, 18.3m length of each pile of diameter 0.90m, number of piles is 9no's. dense cohesion less soil is considered (Shamsher prakash and Hari D. Sharma). These data were considered for different lateral loads and moment. And deflection, slope, bending moment, shear, and soil reaction is plotted along the pile length. Results were shown as below. This indicates that if the load increases, the deflection, slope, bending moment, shear and soil reaction also increases.

TABLE.1

Parametric study no	constants	Lateral load & Moment	Name of studies	Remark
1	C/S = 0.9M n_h = 14800kN/m^3 E= 22.4Gpa Spacing = 5.5M No of piles = 9	Q_{hg} =1200kN, M_g=2164kN-M Q_{hg} = 1328kN, M_g =2395kN-M Q_{hg} = 1400kN, M_g=2524kN-M Q_{hg} = 1500kN, M_g=2705kN-M Q_{hg} = 1600kN, M_g=2885kN-M	Group of 9 pile, spacing is 5.5M	Variation with Lateral load & Moment
2	Q_{hg} = 1328kN, & M_g = 2164kN-m E = 22.4Gpa n_h =14800kN/m^3 Spacing = 5.5M No of piles = 9	Cross section of piles C/S = 0.5M C/S = 0.6M C/S = 0.7M C/S = 0.8M C/S = 0.9M	Group of 9 piles, spacing is 5.5M	Variation with Cross section

Lateral load and moment Variation

- General data:
  - Length of Pile = 18.3m
  - cross section of Pile = 0.9m
  - Type of Soil = Cohesion less soil
  - Constant Sub grade reaction = 14800kN/m³(dense sand)
  - No of piles = 9
  - Spacing of piles = 5.5M

Varying with lateral load and moment

Qhg= 1200kN Mg=2164.0kN-m
Qhg= 1328.2kN Mg=2395.2kN-m
Qhg=1400kN Mg=2524.7kN-m
Qhg=1500kN Mg=2705.0kN-m
Qhg= 1600kN Mg=2885.4kN-m

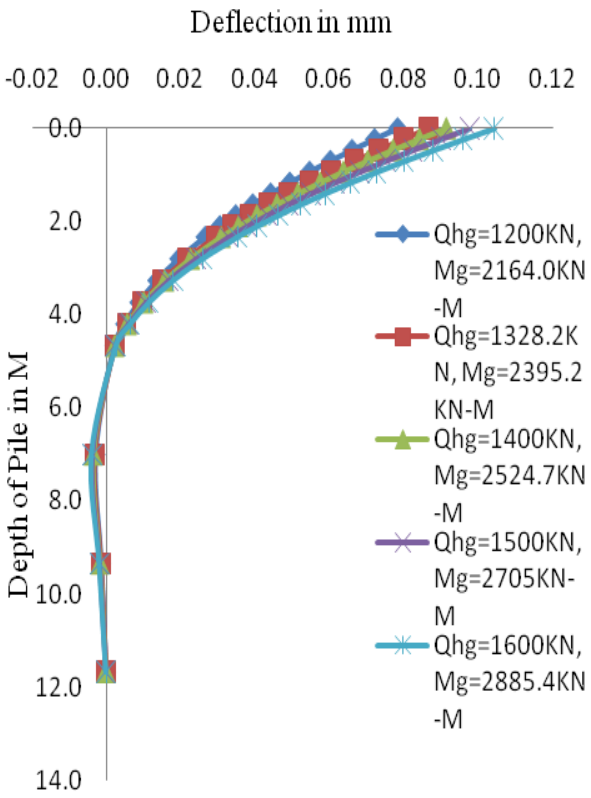

Fig. 1 variation of deflection with different load and moment

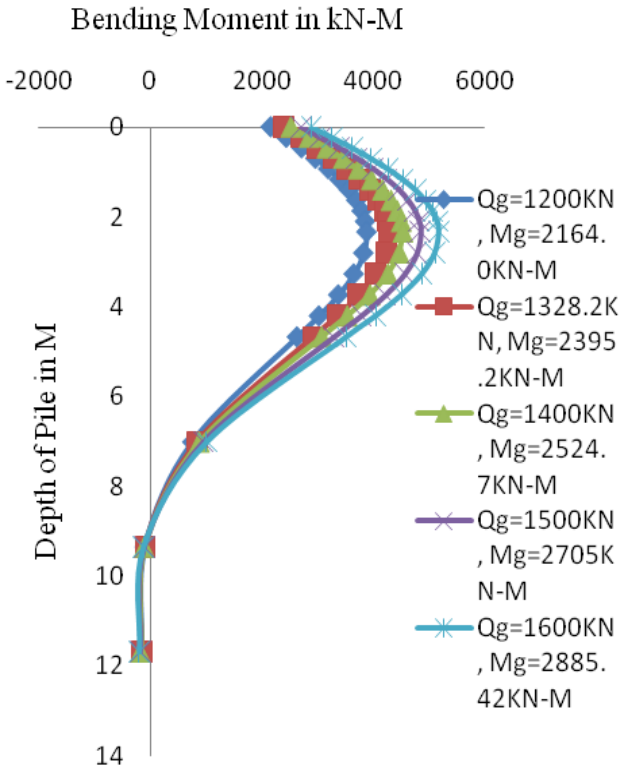

FIG. 2 Variation of bending moment with different load and moment

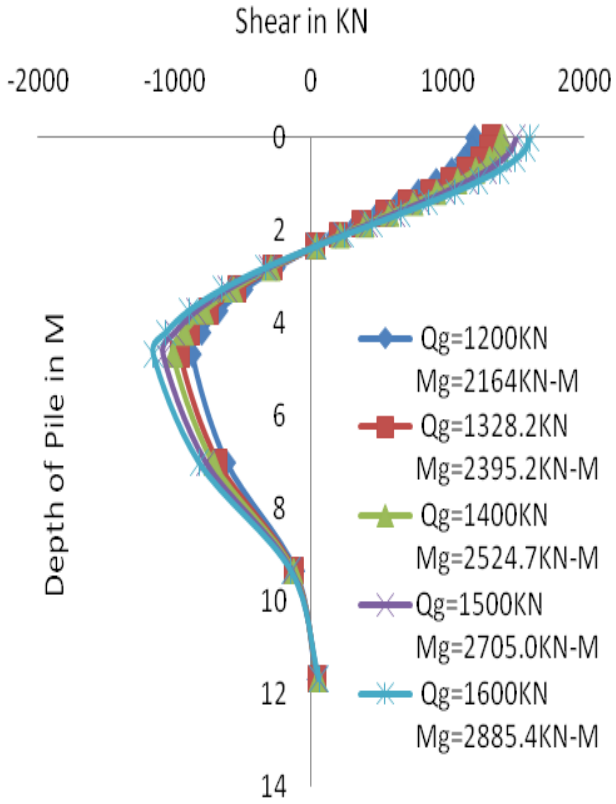

Fig. 3 variation of shear with dfferent load and moment

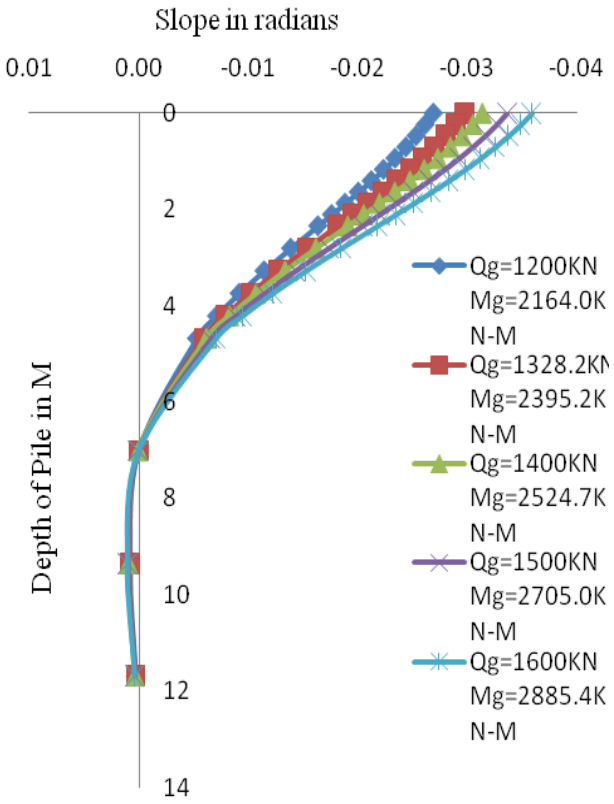

Fig. 4 Variation of Slope with load and moment

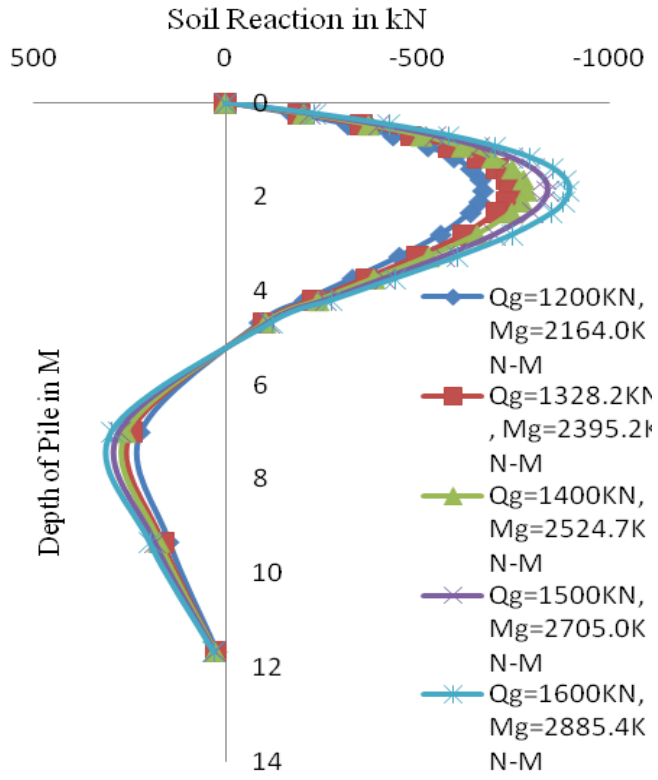

Fig. 5 Variation of Soil reaction with load and moment

- When Lateral loads and moment increase deflection also increases until the necessary reaction in the surrounding soil is mobilized.(Figure 1)
- With increasing Lateral load and Moment Bending Moment go on increasing up to a certain depth and then it decreases.(Figure 2)
- In case of different load and Moment Shear will get change. At some extent it will deform as negative.(Figure 3)
- If the lateral load and moment are increasing , slope of the pile is also increases, the slope of the pile is reduced by increasing the stiffness and diameter of the pile.(Figure 4)
- If the lateral load and moment increases in pile the soil reaction will decrease due to loss of its strength and stiffness to resistance of excessive load and moment.(Figure 5)

3.1.2 Effect Of Diameter On Behavior Of Group Of Piles:

The lateral load carrying capacity of group of piles depends mainly on nh. To study the effect of diameter on behavior of group of piles, 18.3m length of each pile of diameter 0.5, 0.6, 0.7, 0.8, 0.9m (G Srilakshmi1, and Yashwanth M P1*) Number of piles is 9no's. Dense cohesion less soil is considered. These data were considered for different diameter of pile for deflection, slope, bending moment, shear, and soil reaction is plotted along the pile length. Results were shown as below. This indicates that if the load increases, the deflection, slope, bending moment, shear and soil reaction also increases.

Lateral load and moment Variation

- General data:
  - Length of Pile = 18.3m
  - cross section of Pile = 0.9m
  - Type of Soil = Cohesion less soil
  - Constant Sub grade reaction = 14800kn/m³(dense sand)

Varying diameter of the pile

- 0.50m
- 0.60m
- 0.70m
- 0.80m
- 0.90m

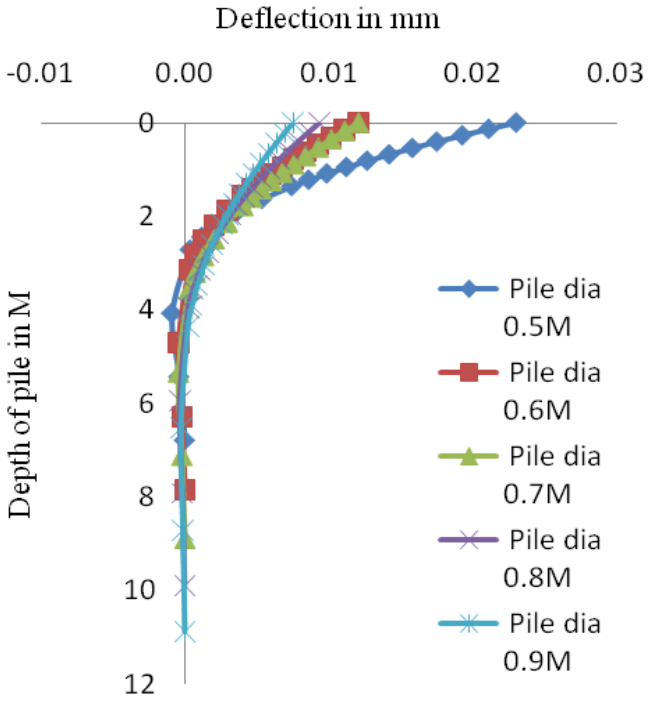

Fig. 6 Variation of Deflection with load and Moment

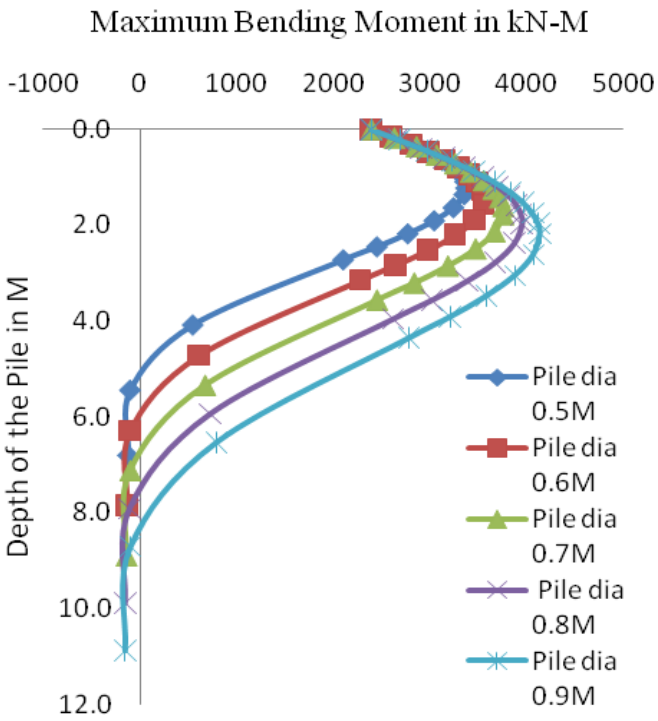

Fig. 7 Variation of Bending Moment with load and deflection

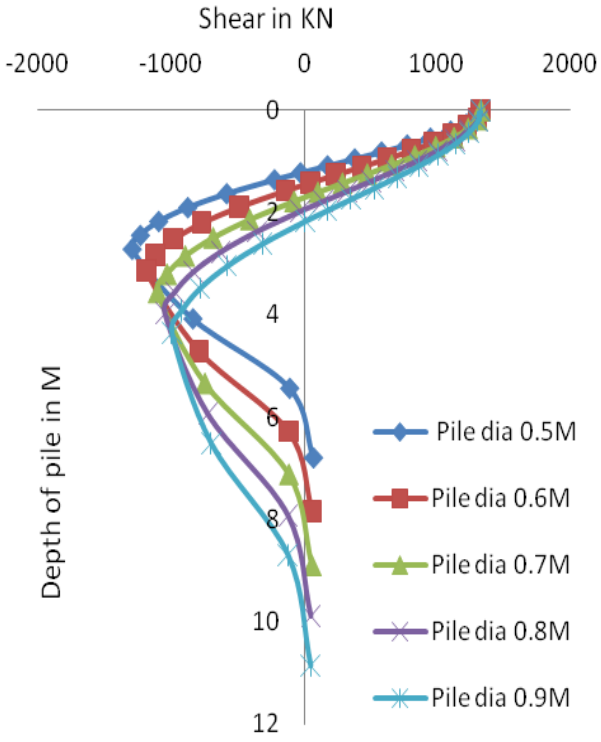

Fig. 8 Variation of Shear with load and moment

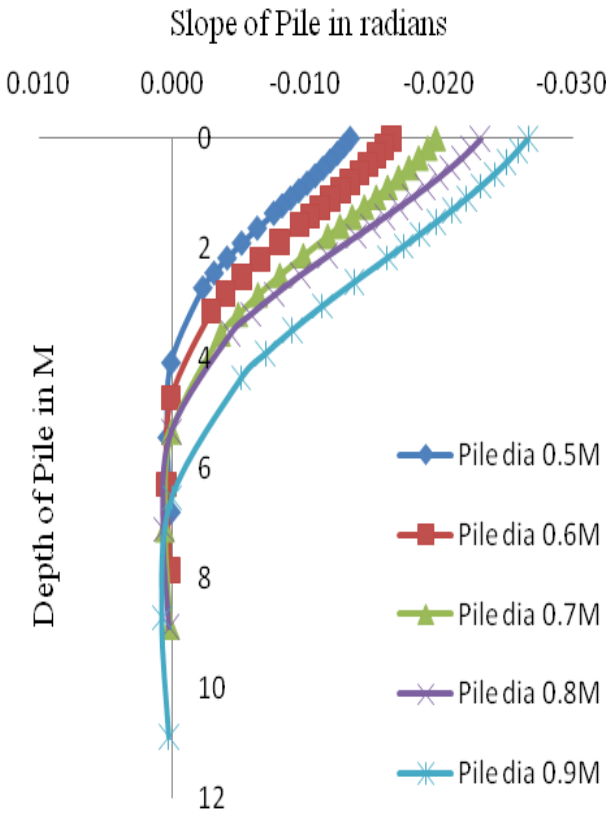

Fig. 9 Variation of Slope witk load and moment

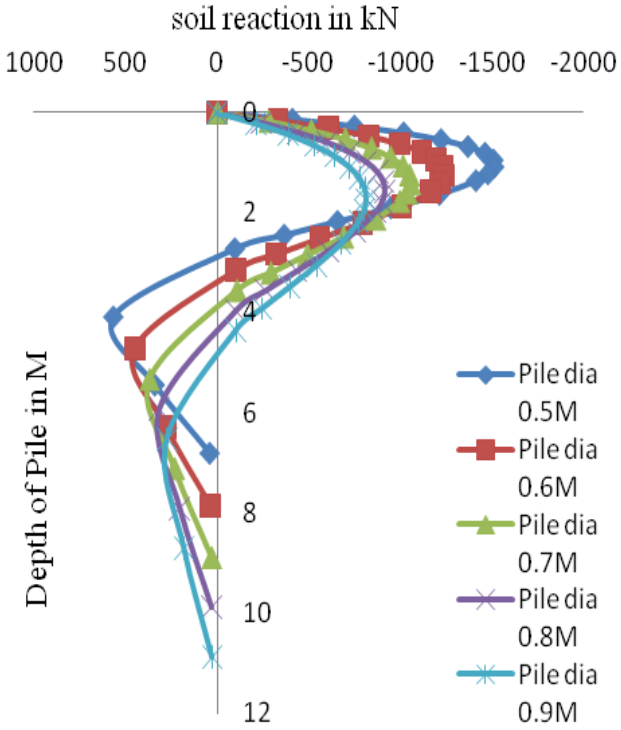

Fig. 10 Vvariation of Soil reaction with load and mment

- The results were shown in fig below which indicated that the lateral load capacity increases with increasing diameter of the pile. This was due to the increasing surface area also the pile stiffness EI increases with increase moment of inertia I, which depend on the diameter of the pile.(Fig. 6)
- As the cross section pile increases the Bending moment also increases and depth of soil Subjected to Bending moment increases with increase in cross sectional area. This is because increase in surface area and Stiffness of the pile.(Fig. 7)
- As the cross section pile increases the Shear force decreases, and depth of soil Subjected to Shear force increases with increase in cross sectional area. This is because increase in surface area and Stiffness of the pile. Soil within few diameter can under go large deformation.(Fig. 8)
- As the cross section pile increases the Slope decreases, and depth of soil Subjected to Slope increases with increase in cross sectional area. This is because increase in surface area and Stiffness of the pile.(Fig. 9)
- As the cross section pile increases the Soil reaction decreases, and depth of soil Subjected to Soil reaction increases with increase in cross sectional area. This is because increase in surface area and Stiffness of the pile.(Fig.10)

4. CONCLUSION

- The lateral load carrying capacity of group of piles is always less than individual load carrying unlike the vertical load carrying capacity.
- Effect of end condition at tip of the pile is also significant on displacement of the pile group. Displacement yields are higher for free tip condition.
- The effect of pile diameter was studied and it was concluded that lateral load capacity increases with increasing diameter of the pile for same length this was due to the increase in surface area, pile stiffness, moment of inertia and young's modulus.

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