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MODEL STUDY ON VERTICAL AND BATTER PILE GROUPS SUBJECTED TO LATERAL LOAD IN SANDY SOIL

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ABSTRACT— *Single pile and pile groups are subjected to lateral loads due to impact of ship, wave action, wind and earthquake forces, so it is important to know the lateral load capacity of pile foundation Model tests were conducted to determine the lateral load capacity of vertical and batter piles . The tests were conducted in uniform fine sand . For batter piles and angle of pile was kept 25˚. After conducting the tests it was observed that the negative batter pile showed more resistance as compared to that of a vertical pile for a constant deflection subjected to lateral loads and similarly positive batter piles showed less resistance as compared to vertical piles. Similar effect was observed in the case of pile groups.*

INTRODUCTION

Generally, whenever a soil of low bearing capacity extends to a considerable depth, piles are used to transmit vertical and lateral loads to the surrounding soil media. Piles or pile group may be subjected to static, cyclic, dynamic as well as repetitive loadings. Till now most of research work has been directed towards the response of individual piles to lateral loads. However, piles are more frequently used in groups and a little information is available on the effect of lateral loads on pile groups.

LATERALLY LOADED PILES

Piles are frequently subjected to lateral forces and moments viz.

i) Quay and harbour structures in which horizontal forces are generated due to the impact of ships during berthing and wave action.,
ii) Offshore structures subjected to wind and wave action,
iii) Tall structures like chimneys, transmission towers subjected to wind loads and
iv) In structures situated in earthquake prone areas.

In the design of such pile foundations, not only the ultimate loads shall be worked out to arrive the safe loads but also the deflections need to be worked out to ensure that serviceable limits are satisfied .Davisson and gill (1963) investigated the case of laterally loaded pile embedded in layered soil system with a different modules of sub grade reaction in each layer. Madhav et al.(1971) have employed as elasto-plastic model for obtaining the response of laterally loaded piles. Broms (1964a,b) method is also baseed on earth pressure theory with simplifying assumptions for distribution of ultimate soil resistance along the pile length and this method is applicable for both short and long piles. This method for computing ground surface deflections of rigid and flexible fixed and free head piles was based on modules of subgrade reaction as suggested by Terzaghi (1955). Jamilokowski and Garassino (1977) and provide state of the art discussion on soil modulus and ultimate soil resistance for laterally loaded piles. Randolph (1981) studied the problem of flexible piles under lateral loading and proposed algebraic expressions for pile head displacement and rotation. Karthigeyan et al. (2006) had investigated the influence of vertical load on lateral response of piles. Yang and Jeremic (2002) carried out a finite element study on behaviour of a single pile in elastic-plastic soils for single as well as double layer for both sand and clays and generated p-y curves. Zarmi et al.(2009) have carried out the lateral load behaviour under combined vertical and lateral loads considering variation of water table at different elevations.

BATTER PILES

Normally vertical piles are used in foundations to take vertical loads and small lateral loads. When the horizontal load per pile exceeds the limiting value, suitable batter piles are used in combination with vertical piles. Batter piles are also known as inclined piles or raker piles.

A piles is said to have a positive batter if its inclination with the vertical (i.e. batter angle) is in direction opposite to that of the acting lateral loads. A pile is said to have negative batter if it is loaded in the direction same as that of batter angle. The positive batter pile is also known as "out" batter pile and negative pile as "in" batter pile.. A vertical pile is a special case of batter pile in which the batter angle is zero.

The behaviour of single battered piles has been studied in detail by Murhty (1969) and Prakash and Subraminum (1965). However, reliable experimental data on pile groups containing battered piles are quite scarce. Most of the earlier theoretical analysis concerning the battered pile groups neglects the soil restraint. But the recent theories developed by Hrennikoff (1949) and Vesic (1956) take the soil resistance into account, essentially they are based on beam on elastic foundation theory and involve the concept of modulus of sub grade reactions.

AIM OF STUDY

The present investigation was performed to study the load deformation characteristics of battered piles groups under lateral load conditions. The load was applied at the ground level. Depending upon the disposition of the battered piles in the group load in each case was applied in the direction of batter and against the batter. The deformation behaviour of each pile in the pile group which was subjected to the lateral loads was studied. The spacing of piles at the bottom of the pile cap was kept 2.4d in each case where d is the diameter of pile. The piles were arranged in a plane transverse to the direction of load. Battered piles having a batter angle of 25 degree have been used. Tests were conducted in laboratory under controlled density conditions using dry, clean, uniform sand. Only deflections at the ground level were measured.

The following experimental studies were carried out

1) Behaviour of pile groups under controlled conditions with lateral loads applied at ground level.
2) Single vertical pile at 25 degree positive and 25 degree negative were tested under fixed head conditions where the static lateral loads were applied at ground level.
3) The experimental investigations led to load deflection curves. Attempt has been made to compare the behaviour of single fixed head piles and the groups, to understand the extent of group action in each case. On the basis of above studies, conclusions were drawn on the behaviour of laterally loaded flexible battered piles groups.

   Also thorough review of both the theoretical and experimental reports concerning single battered piles and pile groups containing batter piles have been performed. The behaviour of the pile groups have been assessed from the literature available in addition to those drawn from the experimental works reported.

THEORETICAL DEVELOPMENTS

Many investigations in the past we made analytical studies on the design of pile foundations. A pioneer who Considerable, they are Colman (1866), Westergaard (1917), Hrennikoff (1949), Vesic (1956) and Vandepitte (1957).

The theories of Culman and Wastergaard ignore the lateral resistance of the soil, which according to the experimental and theoretical investigations provides a major part of lateral stability of pile foundation. Vetter and Vandepitte have introduced dummy piles to take care of soil resistance. HreniKoff and Vesic take the soil resistance directly into account of these theories. The effect of vertical load in addition to lateral loads has been evaluated by Division (1960) in terms of non dimensional parameters .Brons(1964,1965) and Poulos and Davis have been given different approaches for solving laterally loaded pile problems. Bron's method ingenious and is based primarily on the use of limiting values of soil resistance.

The method of Poulos and Davis is based on the theory of electricity. Both these methods have considerable in practice. Reese et al.(1974,1975) and Matlock(1970) have been developed the concept of(p-y)curves for solving the laterally load pile problems.

The method of Culman (1866) and Wastergaard (1917) possess the following drawbacks:
By assumptions, the foundation must be three non-parallel groups of pile with one of several pile in each group .From the practical point of view, the requirement of three non-parallel groups of piles may lead to unnecessary complications.
2. The piles are assumed to develop axial forces only and no analysis of lateral deformation is made. It does not certify that even if the axial loads are small, the horizontal deformation would be small enough to limit the design load on piles.
3. No account for soil resistance is made.

DEVELOPMENT OF TEST PROGRAME

JUSTIFICATION FOR MODEL STUDIES:

Full scale field test are an ultimate answer to any engineering problem .But the economic consideration primarily and the other practical difficulties that would be encounter during a field testing program eliminate them or restrict such scope.

MODEL PILES

Mild steel piles having an outer diameter of 19mm and wall thickness of 1.6 mm (with EI of the pipe sections=$4.64*10^8$ N-mm2) were used for the experiment work.

TYPE OF SOIL

The soil used in model testing was fine sand. For filling the tank, rainfall technique of sand filling was used .The sand used was dry and uniform. The tests were conducted on an average density of 1.61gm/cc.

PILE CAPS

A mild steel pile cap of thickness 12mm was used.

TESTING TANK

Rectangular tank and had length 180cm,width 120 cm and a height of 135 cm .Thickness of G.I sheet tank of testing tank is 2mm.

CONCLUSIONS

1. Single positive batter pile is less resistant to lateral loads.
2. Single negative batter piles are more resistant to lateral loads.
3. The battered piles inclined in the direction of loading are more resistant to lateral load than a vertical pile and that a pile inclined in the opposite direction to that of lateral load shows less resistance to lateral load than that of vertical pile.
4. The deflections get increased when number of cycles is increased, as it is quite clear from load deflection curves (here only one cycle has been completed).
5. If the piles are spaced at a sufficient distance a part, the group capacity can be taken as the sum of individual capacity safely.

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REFERENCES

1. A. Brown, C.Morrison, C.Reese, Lateral load behavior of pile group in sand, J.Geotech .Eng.114 (11)(1988)1261-1276.
2. Broms, B.(1964a). The lateral resistance of piles in cohesive soil. *Journal of the Soil Mechanics & Foundation Division ,ASCE* ,90 (SM2)
3. Broms, B.(1964b). The lateral resistance of piles in cohesive soil. *Journal of the Soil Mechanics & Foundation Division ,ASCE* ,90 (SM3)123-156
4. Das B.M (2004).*"Principles of Foundation Engineering",* 5th Edition, 2nd reprint.
5. Comodromos, E.M.(2003). Response prediction for horizontal loaded pile groups. Journal of Geotechnical Engineering of the Southeast Asian Geotechnical Society, 123-133.