A REVIEW ON ASSESSMENT OF SETTLEMENT IN PILE FOUNDATION

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Abstract: As urbanization increase worldwide, the accessible land for building is becoming lesser, and also the value of land is changing higher and higher. Thus, the recognition of tall structures is increasing day by day and to resist a load of those structures correct stiff foundation is to be used like pile foundation which has the study of static analysis of pile foundation. In this paper, an effort is made to review completely different types of soils like clays with different consistency, sand with different density having a unique angle of internal friction with layers of sand and clay, and find the settlement of pile groups by exploiting completely different types or methods for settlement of pile foundation. The analysis of single pile and group of pile considering the variation in parameters of the single pile, pile group, pile cap analysis, additionally been enclosed during this study with the varied combinations of soil parameters and loads and also included the settlement of pile foundation. The ultimate bearing capacity of the pile and pile group for the given soil condition with the analysis gives the number of piles, dimension of the pile, and spacing of piles within the pile group for various soil conditions.

Key Words – pile foundation, settlement, Negative skin friction, soil-structure interaction

I. INTRODUCTION

A Pile could be a slender structural member made from steel, concrete, wood or composite material. A Pile is either driven into the soil or shaped in-situ by excavating a hole and filling it with concrete. Pile foundations are intended to transmit structural loads through zones of poor soil to a depth where the soil has the desired to transmit the loads. Piles are somewhat kind of like columns in these loads developed at one level are transmitted to a lower level; however, piles acquire lateral support from the soil within which they are embedded so there is no concern with relevance buckling and, it is during this respect they dissent from columns. Piles are comparatively long. The piles could also be driven piles, that along with supporting a structure.

The purpose of Pile foundations is to transmit an excellent structure load to deeper load-bearing strata, to resist lateral, vertical, uplift load and to reduce the settlement. A structure is often based on piles if the soil like a shot its base does not have adequate, show that the soil at shallow depth is unstable or if the calculable settlement is on the far side acceptable limits, a pile foundation is going to be adopted. A structure is often based on piles if the soil like a shot its base does not have adequate, show that the soil at shallow depth is unstable or if the calculable settlement is on the far side acceptable limits, a pile foundation is going to be adopted.

II. NECESSITY OF PILE FOUNDATIONS

The load of the superstructure is heavy and its distribution is uneven. The top soil has poor bearing capacity. The subsoil water is high so the pumping of water from the open trenches for the shallow foundations is difficult and uneconomical. There are large fluctuations in subsoil water level. Where timbering to the trenches is difficult and costly. The structure is situated on the seashore or river bed, where there is a danger of scouring the action of water. Canal or deep drainage lines exist near the foundations. The top soil is expansive. Piles are used for the foundations of transmission towers, off-shore platforms which are subjected to uplift forces.

III. SETTLEMENT OF PILE FOUNDATIONS

The settlement of a pile group is due to the elastic shortening of piles and the settlement of the soil supporting the piles. It is assumed that the pile group acts as a single large equivalent pile.

3.1. Settlement of pile groups in sands:

3.1.1. Skempton method:

The settlement of the pile group is estimated from the settlement of a single pile, as determined in a pile load test. The settlement of the group is generally very large because the pressure bulb for the group is much deeper than that of a single pile

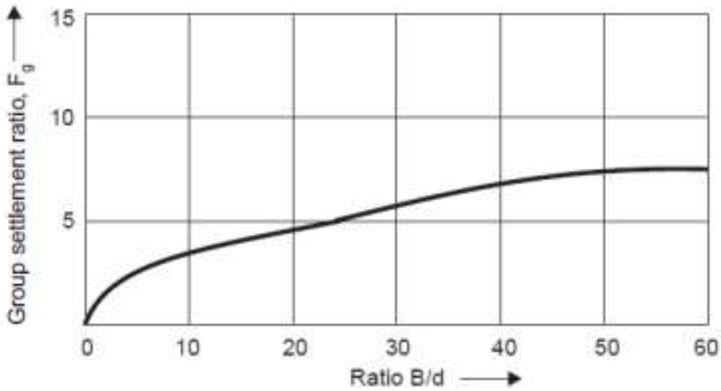

Fig.1 Group settlement ratio v/s width of the pile group curve

(Source: J.E.Bowles, "Foundation Analysis and Design", McGraw Hill Publishers,1996.)

The ratio of the settlement of a pile group to that of a single pile is known as the group settlement ratio.

Thus,

$$F_g = \frac{S_g}{S_t}$$

Where,

F_g = Group settlement ratio
S_g = Settlement of pile group
S_t = Total settlement of individual pile.

Skempton et al. (1953) published curves relating the group settlement ratio (F_g) to the width of the pile group. The curve can be used for both driven and bored piles.

3.1.2. Meyerhof Method:

Meyerhof (1976) suggests the following empirical relation for the elastic settlement of a pile group in sands and gravels.

$$S_g = \frac{9.4_q\sqrt{B_g}\,\mathrm{I}}{N}$$

Where,

S_g = Settlement of pile group (mm)
q = Load intensity = $\frac{Q_g}{A_g}$
Q_g = Total load on the pile group
A_g = Cross-sectional area of the pile group
B_g = Width of the pile group
I = Influence factor = $\left[1 - \frac{D}{8B_g}\right] \geq 0.5$
D = Length of individual pile
N = Corrected SPT value

If static results are available the settlement of the pile group can be obtained from the relation,

$$S_g = \frac{qB_gI}{2q_c}$$

Where,

q_c = Average cone penetration resistance within the seat of settlement.

3.2 Settlement of pile groups in clay:

The settlement of a pile group in clay can be determined by using the equation of consolidation settlement of the soil beneath the pile tip. In the case of friction piles, the total load is assumed to act at a depth equal to 2/3 of the pile length. The presence of the piles below this level is ignored. In the case of end-bearing piles resting on a firmer stratum than the overlying soil, the total load is assumed to act at the tip of the pile.

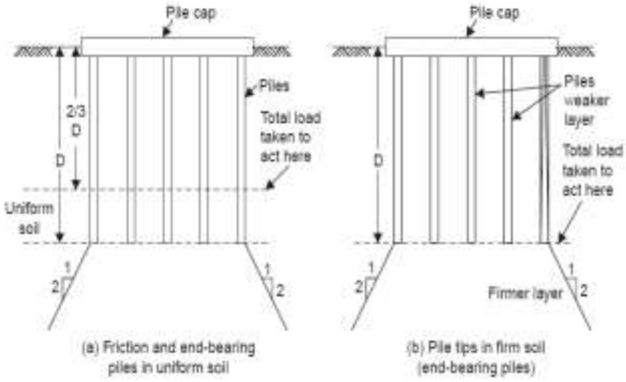

Fig.2 Conditions assumed for settlement

(Source: J.E.Bowles, "Foundation Analysis and Design", McGraw Hill Publishers,1996.)

The load is assumed to be uniformly distributed at the level at which the load is assumed to be acting and it is assumed to spread at an angle of 30° with the vertical or a slope of 2 vertical to 1 horizontal. The soil below this level is divided into many layers and the settlement of each layer is calculated from the expression.

$$S = \frac{HXC_c}{1+e_0}\log_{10}(\frac{\sigma_0+\Delta\sigma}{\sigma_0})$$

Where,

S = Settlement of the layer
H = Thickness of the layer
C_c = Compression index
= 0.009 (w_L- 10)
w_L = Liquid limit of soil
e_0 = Initial void ratio
$\boldsymbol{\sigma}_0$ = Initial stress at Centre of the layer = γ. Z
Z = Depth of the Centre of the layer below the ground surface
$\Delta\boldsymbol{\sigma}$ = Additional stress due to pile load Q
= Total pile load Q divided by the area of spread at the Centre of the layer.

The total settlement S_g of the pile group is equal to the sum of the settlements of the different layers; i.e.,

$$S_g = S_1 + S_2 + S_3 + \ldots. + S_n$$

IV. RECENT RESEARCHES IN PILE FOUNDATION SETTLEMENT

Wu [5] explored the increase of pile length, the pile foundation settlement of existing high-rise buildings has a less and fewer influence on the encircling buildings. Space, the smaller the settlement; with the rise of pile length, the displacement of ancient building step by step decreases. Armen et al. [6] discussed during earthquake specific processes usually occur that negatively affect the interaction of piles with the encompassing soil. Several historical cases show that buildings and among the explanations are that the increase in settlement of the foundation when soil liquefaction. Jiang et al. [7] present an overview of the initial tangent modulus and also the compression modulus of the slope soil, the tangent modulus of the slope soil is obtained combining with Mindlin-Geddes resolution and Hansen formula, and also the resolution of the pile settlement in the sloping ground comes. (en, a series of numerical analyses area unit administrated to look at the practicableness of the projected technique. Bhartiya et al. [8] assessed the interaction between raft and soil will increase with the increase in raft slenderness quantitative relation. The pile-soil interaction depends on pile length, diameter, and elastic properties of the soil and foundation system. The combined result of rafts and pile group as a (pile raft foundation) PRF system and their interaction with soil was thought of to develop equations for PRF stiffness.

Shen et al. [9] showed when end bearing piles were used, differential settlement happened at the bottom of the embankment and therefore the majority of the embankment load was transferred to the piles. Floating piles, however, behaved as rigid inclusions and shaped a composite foundation with their encompassing soil, that shared the entire load beneath a more or less equal-strain condition. Li et al. [10] assessed a hyperbolic soil for the near-pile stiffness degradation was incorporated that additionally considers the consequences of pile unloading. The hyperbolic soil was valid against boundary component technique results that supported an assumed elastic-plastic soil behaviour. Liu et al. [11] analysed the ratio of long-term settlement to immediate settlement will increase linearly with the square root of the number of piles, whereas the influence of the length/diameter ratio of the pile is small. Crispin and Leahy [12] examined a closed-form associate analytical answer that was derived for the inter-action issue between piles during a cluster embedded in a heterogeneous soil obeying a power-law variation in stiffness with depth.

Wang et al [13] presented the distribution of skin frictions on prestressed tubular concrete (PTC) capped-piles is simplified as two forces triangles, and a calculation model for predicting the extra stresses within the composite foundation soil is given. By combining Mindlin-Geddes and Boussinesq solutions, the equation of the extra stresses for a single PTC capped-pile foundation comes considering the influence radius. Mishra and Patra [14] compared parametric studies for 3X2 and 3X3 pile groups were applied on the idea of parameters like the distribution of shear stresses around the shaft over time, load resisted by the bottom over time, displacement of every pile component, and also the effects of an enlarged base, the pile slenderness magnitude relation, and pile group spacing. Interaction factors for the 3X2 and also the 3X3 pile groups obtained by the linear and nonlinear five-element models were compared and shown to possess the most distinctive of seven percent.

Zhou et al. [15] discussed a hyperbolic nonlinear model, considering the influence of cement paste injection, which was created to simulate the behaviour between the skin friction and also the relative displacement developed on the cemented soil-soil interface. Enlarged cemented soil base and therefore the to be effective in promoting the behaviour of a short PGPN pile, whereas increasing the diameter of cemented soil on the shaft is economical in promoting the compressive bearing capability of a long PGPN pile. H. Peiffer [16] suggested axially loaded open-ended pipe piles will collapse in two essentially other ways, with or without plug formation. A new transfer operate is developed for the pile tip resistance and internal friction stress. Lin et al. [17] explored an exponential primarily based load-transfer (t-z) curve is used to explain the nonlinear behaviour of the pile-soil interface throughout pile loading. The evolutions of the three-dimensional strength and also the shear modulus of the surrounding soil is subsequently incorporated into the two model parameters of the projected t-z curve to capture the time-dependent pile-soil interaction behaviour.

V. SUMMARY

The influence of pile foundation settlement on encompassing buildings of existing high-rise buildings is studied and analysed by building models with and without raft in the foundation is explored [5]. The foundation settlement will increase if the influence of soil liquefaction is taken into consideration supported the suggested hypothesis [6]. The compression modulus, cohesion, and internal friction angle of the soil around the pile are negatively associated with the pile settlement and it is found that the compression modulus of the soil is that the additional important parameter [7]. The planned stiffness and settlement equations were verified and valid against different numerical and experimental results of piled rafts [8]. The use of end-bearing piles with low modulus enlarged the entire settlement of the piles and therefore the foundation soil at the bottom of the embankment and promoted the lateral movement of the side slopes [9]. A nonlinear two-stage continuum-based finite component model was projected to review the matter of the tunnel and deep excavation pile interaction. A hyperbolic soil model for the near pile stiffness degradation was incorporated that additionally considers the effects of pile unloading. The model was valid against boundary component technique results that supported an assumed elastic perfectly-plastic soil behaviour [10]. A prediction expression for the long-term settlement of piled raft foundation is given supported by the nonlinear pile-soil interaction model under vertical load [11]. Pile groups embedded in heterogeneous soils with shear modulus variable with an influence law perform of depth the response of a ‘receiver’ pile carrying no load at its head, subjected to the displacement field of a loaded ‘source’ pile [12].

The planned methodology will optimize the planning of the foundation soil reinforcement ensuing from PTC piles [13]. The reliability of the models was assessed by examining the results without their experimental and numerical information, and it was found to be inside a slip-up of eighteen percent for the linear model and a slip-up of three percent for the nonlinear model [14]. The pre-bored grouting planted nodular (PGPN) pile may be a form of composite pile foundation that is thought to be environmentally friendly and economical [15]. To determine the bearing capability and settlement behaviour of driven open-ended pipe piles with a large diameter [16]. A semi-analytical approach to predict the time-dependent bearing performance of an axially loaded jacked pile in saturated clay strata. The results of pile installation and subsequent consolidation on the changes in mechanical properties of the surrounding soil are modelled by the cavity enlargement theory and therefore the radial consolidation theory [17].

VI. CONCLUSION

From the referred literature, the following conclusions are drawn.

When the pile length is 22m, the displacement of the top and bottom of ancient buildings are each capable the quantity, indicating that once the pile length is 22m, the settlement of pile foundation of existing buildings has nearly no impact on the traditional buildings; the displacement and inclination of adjacent buildings caused by settlement of pile foundation in high-rise buildings with raft pile foundation is bigger than those caused by the settlement of pile foundation in buildings without raft pile foundation [5]. The settlement within the foundation due to soil liquefaction supported the prompt hypothesis will considerably increase (up to 87%) compared to the standard calculations, wherever the influence of soil liquefaction is not taken into consideration and might be not among acceptable tolerances [6]. The impact of the slope angle and also the distance of the pile from the slope crest on the pile settlement is coupled. With the rise of α, the impact of X on the pile settlement is increased and, with the rise of X, the impact settlement is weakened [7]. The maximum PRF settlement was 1.2 times the typical settlement [8]. The correction issue reduces the discrepancy between the approximate technique and also the analytical answer conferred here to below 10 percent for many sensible configurations [9]. The effects of ground movements whereas neglecting the impact of effective stress variations (due to the excavations or from pile installation), which may alter the tunnel pile interactions, significantly for displacement piles in the sand [10].

The settlement ratio is more or less 2 for piled raft foundation and 1.5 for raft or box foundation [11]. The influence vary features the lowest influence on the variation of the extra stress field once the influence vary is eight times larger than the pile diameter [12]. The variation of the relative displacements of pile parts with depth followed a nonlinear trend, having the most displacement at the pile high and a minimum at the pile tip. The relative displacement of the lower parts increased attributable to creep effects [13]. A hyperbolic nonlinear model was accustomed to describe the connection between skin friction and therefore the relative displacement between cemented soil and soil. A linear model and a nonlinear model that considers the reduction of the cutting off stiffness were accustomed to simulate the pile tip load-displacement responses within the field and model tests, severally [14]. The enlarged cemented soil base is taken into account to be effective in promoting the behaviour of a short PGPN pile, and a rise within the diameter of cemented soil is economical in promoting the compressive bearing capability of a long PGPN pile [15]. The presence of a concrete plug contains a favourable result on the development of the bearing capability as was indicated [16]. The pile installation effects once assessing the load-settlement response of pile groups [17].

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