Analysis of Pile subjected to Lateral Loading in Clay modeled using ANSYS

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***Abstract* - Piles have been widely used for supporting axial and lateral loads for a variety of civil engineering structures such as high rise buildings, transmission lines, bridge piers and port structures. Pile foundations subjected to horizontal loads and moments is an age-old problem confronted by geotechnical engineers. In many cases, lateral loads govern the design of piles. This project paper is aimed towards a detailed study on the response of pile foundations in cohesion less and cohesive soil subjected to lateral loading. The soil structural interaction analysis of a single laterally loads pile is carried using ANSYS software. In this method the pile is considered as a flexible beam on the elastic foundation and soil is replaced as a series of elastic, closely spaced but independent springs. Pile behavior in uniform clay soils as well as in sand layer in clay deposit were analyzed and cross compared to theoretical results for validation. Linear elastic model of pile was used for modelling the piles.**

***Keywords* - Lateral loads, Flexible beams, Sub grade reaction, Deflection, Bending moment.**

I INTRODUCTION

Mainly piles are used to transfer vertical forces, arising primarily from gravity. Examples of structures where piles are commonly used as foundations are bridges, offshore platforms, tall buildings, defence structures, dams and dock structures, transmission towers, earth retaining structures, wharfs and jetties. Among these structures, it is not only the axial force that the piles carry; often the piles are subjected to lateral forces and moments. In fact, there are some structures where the primary function of piles is to transfer lateral loads to the ground. Wind gusts are the most common cause of lateral force (and/or moment) that a pile has to support. The other major cause of lateral force is seismic activity. The horizontal shaking of the ground during earthquakes generates lateral forces that the piles have to withstand. Certain buildings are also acted upon by lateral earth pressures, which transmit lateral forces to the foundations. That apart, depending on the type of structure a pile supports, there can be different causes of lateral forces. Lateral loads are in the order of 10–15% of the vertical loads in case of onshore structures, while this value may exceed 30% in case of offshore structures. The response of a laterally loaded pile is a complicated soil–structure interaction problem; because pile deflection depends on soil reaction and in turn soil reaction influences by pile deflection.

II OBJECTIVE

The main aim of the project is to understand the concept of pile subjected to lateral loading in sand & clay and to evaluate the deflection, bending moment and shear force calculated along entire length of it using ANSYS software.

III SOIL STRUCTURE INTERACTION

Soil structure interaction affects the distribution of pressure between foundation and soil. The effect of it becomes prominent for structures subjected to lateral loads and massive structures resting on relatively soft soils. Most of the theoretical solutions for laterally loaded piles involve the concept of modulus of sub grade reaction or otherwise termed as soil modulus which is based on Winkler's assumption that a soil medium may be approximated by a series of closely spaced independent elastic springs. The reaction at any point on the base of the beam is actually a function of every point along the beam since soil material exhibits varying degrees of continuity. In this figure below the beam rests on a bed of elastic springs wherein each spring is independent of the other. According to Winkler's hypothesis, the reaction at any point on the base of the beam in depends only on the deflection at that point.

IV FINITE ELEMENT MODELLING

Finite element method is one of the recent methods for analyzing the structures. In the present study it is done in ANSYS 14.5. The pile is created as 3D beam element, and the soil created as linear springs are modeled using COMBIN14 element. The pile foundation has been modeled using Beam 4- 3D elastic beam element. The concrete pile of M20 grade is considered having density of 24kN/m3. The modulus of elasticity of pile foundation (E) and poison's ratio (μ) of pile foundation are 22.4Gpa, 0.15. In the Winkler model soil is modeled as linear springs. In the present study the linear springs are modeled using COMBIN14 element. No bending or torsion is considered, the spring damper element has no mass. The spring stiffness is calculated depending on the type and the contributing area for that spring. The springs are provided only in the opposite phase to the application of load, because there won't be any contact between the soil and pile in the load application phase.

V PROBLEM SOLVING USING ANSYS

The interaction model for the pile-soil system is shown in Figure 4.1 the pile is assumed to be a beam of length L with constant flexibility EI, and to be embedded into soil. H and M represent the lateral load and moment applied at top of the pile respectively; and k1….kn denote the stiffness of the springs.

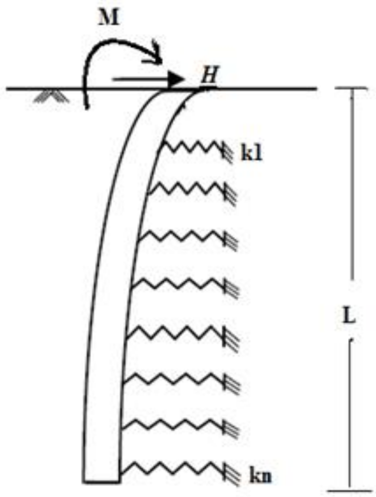


Figure 1 - Winkler model

The steps for modeling the pile are as follows:

1. The pile is modeled as a 3D elastic beam 4 element, to a depth of 8m. The springs are provided at every one meter along the depth of pile from the ground level.
2. As the stiffness of soil is linearly increases with depth, at the ground level the spring stiffness is 0, later on it increases with depth. One meter length of springs is considered because the length of pile is irrespective for the stiffness of springs.
3. The springs are provided at one phase or side of the pile opposite to the application of load, in other phase no need to provide springs because there won't be any contact between the soil and the foundation.
4. Fixed end condition is provided at the bottom pile since there is no rotation. Fixed end condition is also provided for springs it means the soil is fixed somewhere. The lateral load and moment is applied at the top of the pile. After solving the deflection and bending moment is obtained along the length of pile.

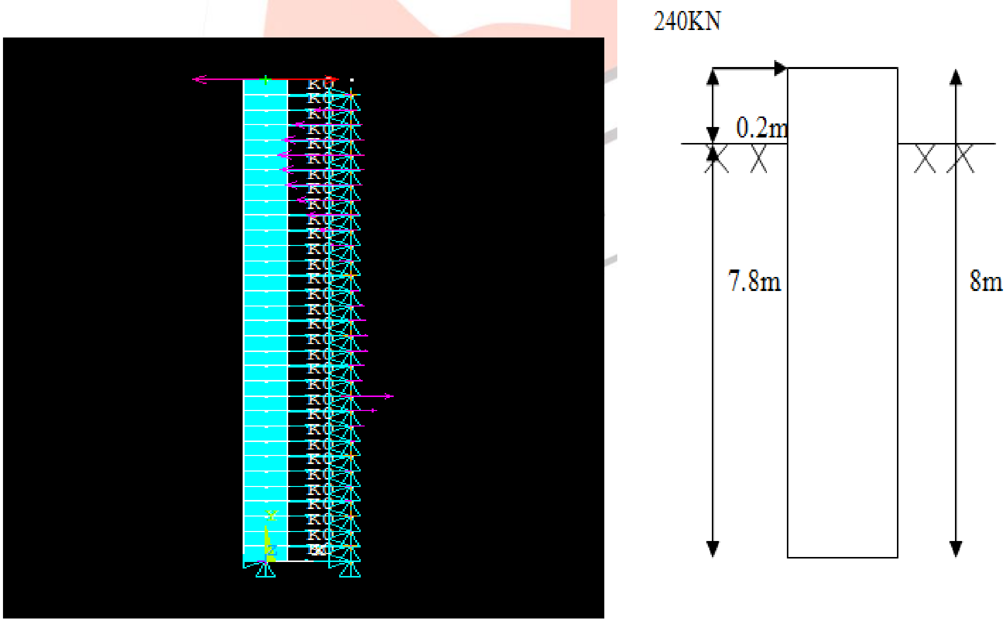


Figure 2 - 3D-FE Winkler model of pile and soil

VI GEOMETRY OF PILE

Pile be a square pile of cross-section 500mmx500mm

Modulus of elasticity of pile be E = 2.24x10^7KN/m²

Moment of inertia, $I = bd^3/ 12 = 0.00521m^4$

T= relative stiffness factor = $(EI/ nh)^{1/5}$

Zmax = Maximum depth coefficient

Ls = Length of Pile below ground level

Zmax = Ls/ T , = 6.64 < 5, Long pile.

Qhg. = Factored lateral load = 240Kn

Mg= Factored moment = 240x0.2 = 48kNm

VII Constant sub grade reaction

The key to the solution of a laterally loaded vertical pile problem is the development of an equation for *nh*. The present state of the art does not indicate any definite relationship between the properties of the soil, the pile material, and the lateral loads. However it has been recognized that *nh* depends on the relative density of soil for piles in sand and un-drained shear strength c for piles in clay.

For piles in sand, $nh = 150\ C\emptyset\gamma^{1.5}(EI/d)^{1/2}/\ Pe$

For piles in clay, $nh = 125\ c^{1.5}\ (EI\gamma d)^{1/2}/(1+e/\ d)^{1.5}/Pe^{1.5}$

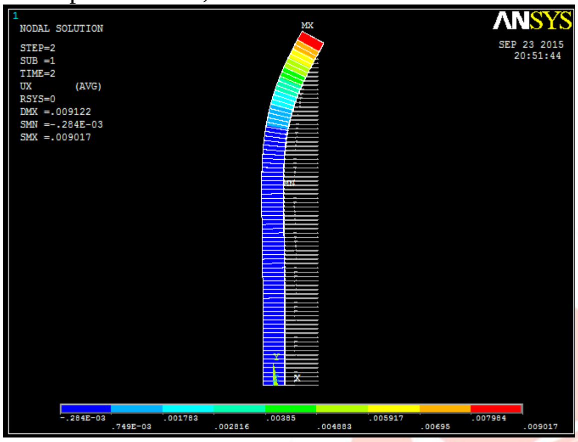
It can be seen in the above equations that the numerators in both cases are constants for any given set of pile and soil properties.

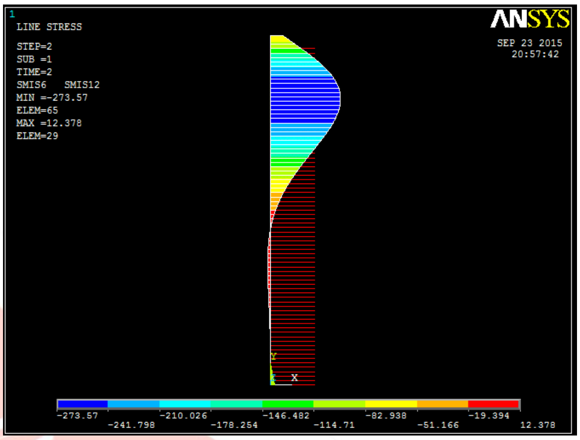
VIII RESULTS AND DISCUSSIONS

After solving the deflection and bending moment is obtained along the length of pile.

(I) Pile in Uniform Cohesionless soil

For piles in sand, $nh = 52400 kN/m^3$

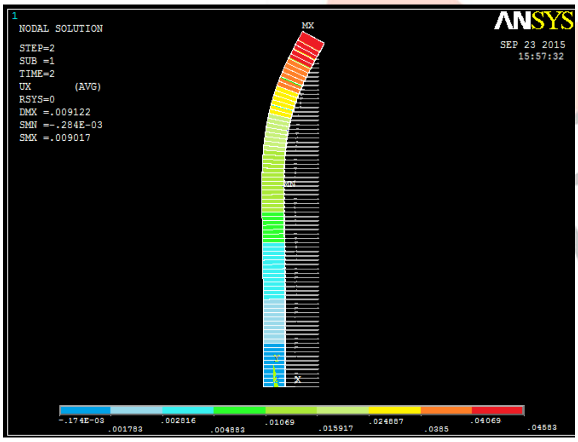


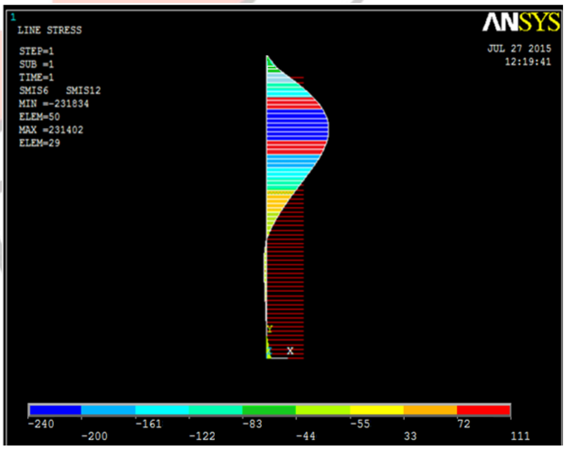


Deflection of Pile in mm **Bending moment of Pile in kNm**

(II) Pile in Uniform Cohesive soil

For piles in clay, $nh = 3500\ kN/m^3$





Deflection of Pile in mm **Bending moment of Pile in kNm**

From the table it can be seen that the deflection, bending moment & shear force is found to be more in multilayered sand- clayey soil system than the uniform clay layer soil.

Table 1 Final Results

Soil type	Deflection at free end (mm)	Bending Moment at free end (kNm)
Uniform sandy soil	9	48
Uniform clayey soil	19.7	50.34

IX CONCLUSION

The analysis of laterally loaded piles is done with FEM based ANSYS software. It has been observed that the analysis of laterally loaded piles can be effectively carried out using ANSYS software. A Winkler method is adopted for the analysis of laterally loaded piles. The analysis of laterally loaded pile embedded in cohesionless and cohesive single soil profile is carried out. This method has the advantage over other procedures in that it is easy to understand and is adaptable to simple computer programs by engineers.

X REFERNCES

[1]. Matlock, H. and Reese, L. C. (1962).” Generalized Solutions for Laterally Loaded Piles. Transactions of the American Society of Civil Engineers” 12, 1220-1247
[2]. Poulos, H.G. and Davis, E. H, Pile Foundation Analysis and Design. John Wiley & Sons, New York.-1980
[3]. Murugan M, Natarajan C, Muthukkumaran K. “Behavior of laterally loaded piles in cohesionless soils” (2011). International journal of earth science and engineering
[4]. Rongqing Li and Jinxin Gong. “Analysis of laterally loaded pile in layered soils” (2008). EJGE
[5]. V S Phanikanth, Deepankar choudhury, G Rami reddy. “Response of single pile under lateral loads in cohesionless soils” (2010) EJGE
[6].. Shamsher Prakash and Hari D. Sharma, “Pile foundations in engineering practice”. John wiley and sons New York - 1990.
[7]. Hetenyi, M. (1946) “Beams on elastic foundations,” University of Michigan Press, Ann Arbor, Mich., United States.
[8]. Ashour, M., and G. Norris (2000) “Modeling lateral soil–pile response based on soil–pile interaction,” Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 126(5), pp 420–428.
[9]. Alice Johny & C. Prabha (2014), “Laterally Loaded Pile in Cohesionless Soil”, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 9, September 2014, pp 931-934.