IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 9, Special Issue 2, September 2022

Lateral Load Capacity of Piles in Layered Cohesive Soil- A Case Study

Soumita Roy[1] and Abhipriya Halder[2]

Student, Civil Engineering, Narula Institute of Technology, Kolkata, India[1]

Assistant Professor, Civil Engineering, Narula Institute of Technology, Kolkata, India[2]

Abstract: In order to transmit the load to a greater depth, the use of pile foundations is encouraged. A pile is subjected to lateral loads due to the presence of forces which are dynamic in nature, for example; load due to seismic activity, or wind etc. For the proper and safe design of a pile foundation, it is necessary to determine the lateral load capacity of the pile. In this paper, a study has been conducted on piles being constructed at a site in Agarpara, Kolkata where the pileis embedded in a layered cohesive soil. The lateral load capacity of the pile is to be determined using PLAXIS 3D software with data collected from the construction site. The values obtained from finite element analysis in PLAXIS 3D and adopting the method as depicted in the IS Code are analysed to observe the desired outcome.

Keywords: Piles, cohesive soil, PLAXIS 3D, lateral load, deflection.

I. INTRODUCTION

Pile foundations are structural members which transfer the load from the superstructure to the ground. They are made of steel, concrete or timber, and due to the transmission of loads at a greater depth compared to shallow foundations, they are not as economical as the latter but pile foundations ensure better soil bearing capacity. Pile foundations also resist horizontal forces by bending inspite of supporting the transmitted vertical load, and uplift forces which are applicable for offshore structures and transmission towers. They find preference for supporting bridge abutments and piers where shallow foundations possess the disadvantage of soil erosion due to harm to the bearing capacity of the soil. Innumerable analysis and investigations conducted in the past for determining the behaviour of the pile foundations with respect to bearing capacity, lateral load carrying capacity which had been calculated using experimental or theoretical methods on cohesive as well as cohesionless soils.

As per [1], where a case study had been conducted at two different petrochemical sites in the Southern part of India in order to analyse the behaviour of dynamically laterally loaded piles. The method of finite element analysis was adopted in ABAQUS for the investigation following a comparison with the data obtained from field that displayed a suitable similarity.

A comparative analysis conducted as per [2] on the estimation of lateral load capacity of piles using the IS code method and the method proposed by Vesic, the required details had been obtained from the concerned authorities of Kerala Public Works Department. STAADPRO software had been used to design the piles for calculation using the IS code method which was validated using Matlock and Reese equation. The IS Code method was conservative as compared to Vesic’s method.

The given paper encloses a case study which has been conducted on pile foundations constructed at the site of JIS University located in Agarpara, a suburb of Kolkata in West Bengal, India. The soil at the site is cohesive in nature, observations and data related to the pile foundation has been provided by the concerned authorities and has been analysed accordingly in order to determine the load at which the deflection of the pile is obtained whose magnitude equals a percentage of the pile diameter that has been taken into consideration. The analysis has been conducted on PLAXIS 3D using finite element method and IS 2911(Part I/Sec 2)2010.

II. DESCRIPTION OF THE SITE

Kolkata and its suburbs around the districts of North 24 Parganas is located on the banks of the river Hooghly which flows at its lower course at this location.The soil is cohesive in nature owing to its close location to the river. Construction of pile foundations was being undertaken at JIS University located at Agarpara(Latitude 22.68N, Longitude 88.38E). The pile is 30.6m long, with a cut-off length of 1.5m. Concrete piles of diameter 0.5m, 1m and 1.2m are undertaken for construction purpose. There are four layers of cohesive soil beneath the ground level, whose data has been collected upon conducting a Standard Penetration Test for 3 boreholes

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 9, Special Issue 2, September 2022

with diameters of 1.5m each. Table 1 describes the properties of the cohesive soil layers of the site, while fig. I and fig. II depict the generalized sub-soil strata and the plan of the area where the construction work has been commenced respectively.

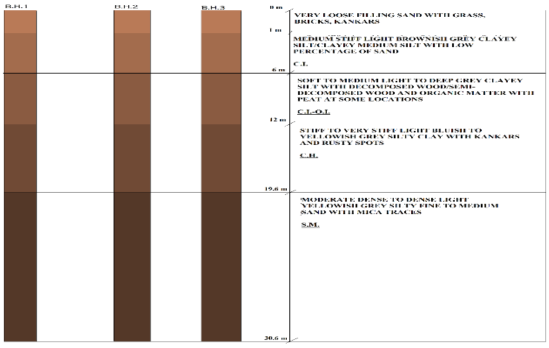

Fig. I Sub-Soil Profile of Site at JIS University

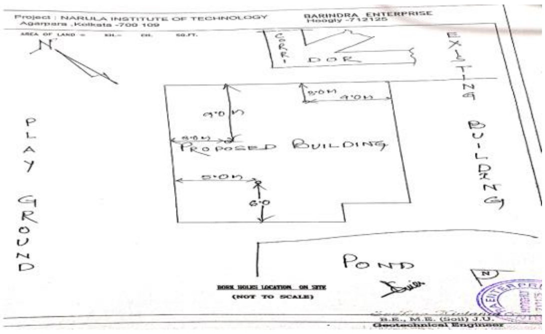

Fig. 2 Map Of The Site At Jis University

TABLE I PROPERTIES OF SOIL LAYER AT SITE

PARAMETERS	LAYER 1	LAYER 2	LAYER 3	LAYER 4
Description of soil	Medium stiff light brownish grey clayey silt/clayey medium silt observed with low percentage of sand. (Clay of Intermediate Compressibility) NOTE: the top layer above layer 1 is just below ground level. It is of 1m depth which comprises of very loose filling with grass, bricks, etc)	Soft to medium light to deep grey clayey silt with decomposed woods/semi decomposed woods and organic matter. Peat observed at some locations(clay here is of intermediate compressibility with a given percentage of organic soil content)	Stiff to very stiff light bluish to yellowish grey silty clay with kankars and rusty spots(clay of high compressibility)	Moderate dense to dense light yellowish grey silty fine to medium sand with mica traces(silty sand)
Depth of soil profile	1-6m	6-12m	12-19.6m	19.6-30.6m
Bulk Density(γ) in g/cc	1.82	1.7	1.9	-
Dry density(γ_d) in g/cc	1.46	1.3	1.56	-
Water content(w) in %	24	31	21	17
Specific Gravity(G)	2.69	2.63	2.72	2.65
Void ratio(e)	0.867	0.943	0.653	-
Cohesion(c)in kg/cm^2	0.28	0.24	0.45	-
Friction angle (Φ)	0	0	0	24
Liquid Limit in %	41	44	50	-
Plastic Limit in %	21	24	30	-
Sand %	5	3	3	-
Silt %	67	65	67	-
Clay %	28	32	30	-

III. DETERMINATION OF LATERAL LOAD CAPACITY OF PILES

Pile foundations are designed in such a way that they not only bear the load from the superstructure but also the lateral load acting on it due to its exposure to external phenomenon like seismic waves, dynamic loads etc. On the application of a lateral load, the pile acts as a beam with transverse load acting on it, transmitting the lateral load to the surrounding soil displaying a tilt in the horizontal direction which ultimately results in deflection of the pile.The lateral load capacity is determined by IS method as given in IS2911/Part 1/Sec.2 Annex C shows the various calculation steps for finding the lateral capacity of the fixed headed pile.

ESTIMATION OF LATERAL LOAD CAPACITY OF PILE AS PER IS CODE:
Pile diameter = 500mm
Cut off = 1.50m from existing ground level
Pile head is fixed
Concrete grade is M25 as per IS 456:2012
With reference to IS 2911(Part I/Sec 2): 2010 Appendix-C,
For a diameter of 500mm,
D=500mm
E= Young's Modulus of the pile material(concrete)=25×10^4 kg/cm^2
I=Moment of inertia of the pile cross section=□$D^4 \div 64$= 306796.2 cm^4
KB=(K is equal to $0.3k_1 \div (1.5 \times B)$ which may be determined from Table 4 in IS 2911 Part I/Sec 2/2010, B is the diameter of the pile here)
= 21.6 kg/cm^2
$R=(EI \div KB)^{1/4}$=244.11cm
From the fig-4 in IS 2911(Part I/Sec 2)
L_1=0,
$L_1/R=0$, $L_f/R=2.15$
L_f= 524.8 cm= 5.25m
Consider, the maximum permissible deflection is 5 mm.

ESTIMATION OF LATERAL LOAD CAPACITY OF PILE USING PLAXIS 3D SOFTWARE:

As per PLAXIS 3D, which is a software that is used in the field of geotechnical engineering in order to conduct a numerical analysis on the soil by considering a finite element model. The pile model has been investigated in the software for all the three pile diameters, 500mm, 1000mm and 1200mm. With reference to PLAXIS 3D, the graph for analyzing the relation between the point load applied for the required deflection has been obtained as an output after the calculation of the phases involving the construction of the pile followed by application of the point load and the consideration of the effect of the negative skin friction of the pile which is depicted in PLAXIS 3D as negative interface.

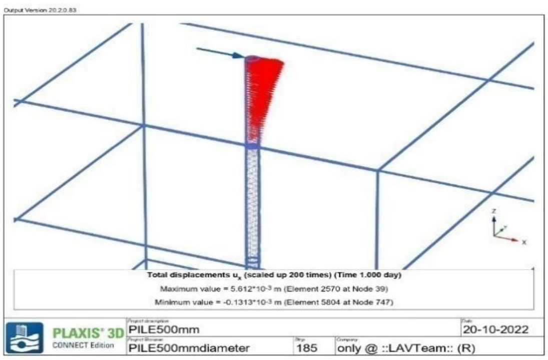

Fig. 3 Representative Image of Output Obtained From Plaxis 3d For 500 mm Pile Diameter

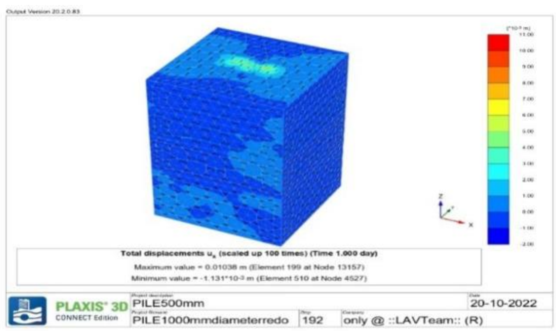

Fig. 4 Representative Image of Output Obtained From Plaxis 3d For 1000 mm Dia Pile

TABLE II COMPARISION OF LATERAL LOAD CAPACITY AS PER IS CODE AND PLAXIS SOFTWARE

Pile Diameter(In mm)	Deflection(In mm)As Per Is Code	Lateral Load(In Kn)As Per Is Code	Deflection(In mm) As Per Plaxis 3d	Lateral Load (In Kn) For Plaxis 3d
500	5.00	32	5.61	26
1000	10.0	127.3	10.34	69
1200	12.0	183.3	12.57	102

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

5th National Conference on Science, Technology and Communication Skills – NCSTCS 2K22

Narula Institute of Technology, Agarpara, Kolkata, India

Vol. 9, Special Issue 2, September 2022

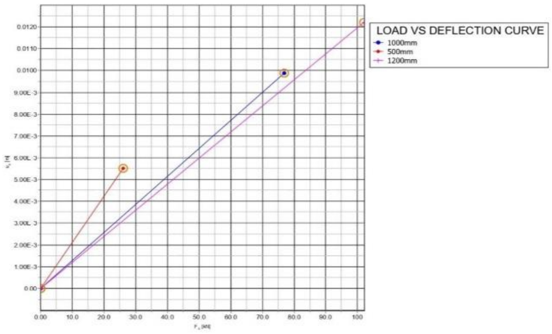

Fig. 5 Load vs deflection curve as per plaxis 3d

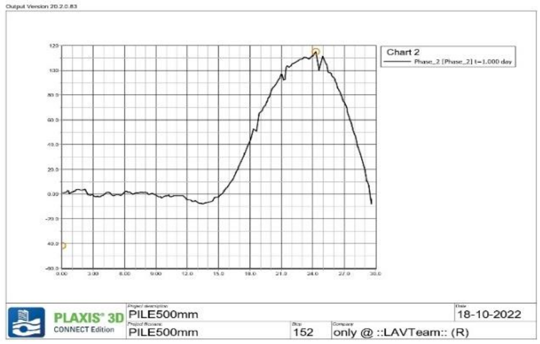

Fig. 6 Length of pile vs bending moment graph for 500mm dia pile

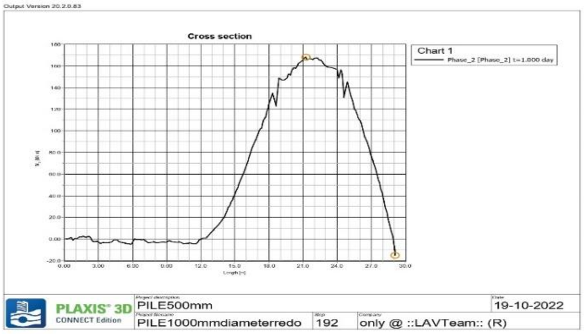

Fig. 7 Length of pile vs bending moment for 1000 mm dia pile

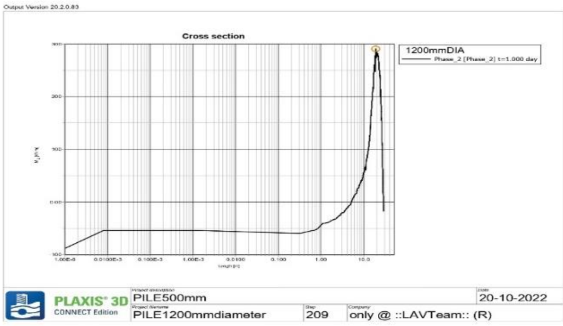

Fig. 8 length of pile vs bending moment for 1200 mm dia pile

IV. CONCLUSION

Based on the present study, the following conclusions are drawn:

- The values of the corresponding load for the deflection of the pile obtained by PLAXIS 3D is less than the value that has been estimated by adopting IS 2911(Part I/Sec 2)2010.
- The lateral load capacity of the pile increases with an increase in the diameter of the pile.
- The increase in the magnitude of the lateral load capacity of the pile enhances the flexural rigidity of the pile.
- The bending moment of the pile shows a variation that is directly proportional to the depth of the pile.
- A similar observation related to direct proportionality with respect to the depth of the pile has been noted for the shear force acting on the pile.

REFERENCES

[1] Ayothiraman, R., Boominathan, A. Depth of Fixity of Piles in Clay Under Dynamic Lateral Load. Geotech Geol Eng **31**, 447–461 (2013).
[2] Braja m. Das, Principles of Foundation Engineering, seventh edition, Cengage Learning
[3] IRC 78 (2000), Standard specifications and code of practice for road bridges. Section-VII, Indian Roads Congress, New Delhi.
[4] IRC: 5 (1998), Standard specifications and code of practice for road bridges. Section1, Indian Roads Congress, Delhi.
[5] IS 2911 Part 1/Sec 2 (2010); Design and Construction of pile Foundations Part 1 Concrete piles; section 2 Bored cast in-situ concrete piles. BIS.
[6] IS 456 (2000) Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi, India
[7] J. E. Bowles. P.E., S.E., Foundation analysis and design, Fifth edition; McGraw-Hill Companies, Inc. 1996
[8] Jayasree, P.K., Arun, K.V., Oormila, r. et al. lateral load capacity of piles: a comparative study between Indian standards and theoretical approach. j. inst. eng. India ser. a 99, 587–593 (2018)
[9] Tomilson M. J., Pile design and construction practice, Third edition, Viewpoint Publication, 1981

