International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 5 ǁ 2022 ǁ PP. 04-07

A Review on Numerical Study on Pile Under Static, Cyclic and Pull out Loading Conditions.

R. Nagaraj[1] and M. Mohamed Younus [2]
[1] Post Graduate student, Department of Civil Engineering, Government College of Engineering Tirunelveli, Tamilnadu, India.
[2] Assistant Professor, Department of Civil Engineering, Government College of Engineering Tirunelveli, Tamilnadu, India.
Corresponding Author: R Nagaraj

ABSTRACT:
Pile foundations are used to support the heavy structure and plays role of carrying the applied load to deeper, strong layers, and also of reinforcing the soil. In the case of foundations of bridges, transmission towers, offshore structures and other type of huge structures it may be subjected to extreme loads. While piles have been used literally for millennia, many aspects of piling are not to this day modelled with much vigour. Before the construction of buildings and structures, where piles are used as foundation, it is required to carry out at least two in-situ pile tests, Existing methods of calculating the bearing capacity and settlements of pile foundations, required is rather cumbersome and take a lot of time on their conduct. Nowadays, the numerical simulation of structures is one of the most popular approaches widely used in geotechnical and structural analysis. Numerical analysis provides immediate and suitable solutions for various field problems which can be used for similar type of field problems that arise in the future as well.
KEY WORDS: *pile foundation, offshore structures, numerical analysis, geotechnical.*

Date of Submission: 28-04-2022 Date of acceptance: 09-05-2022

I. INTRODUCTION

A pile is intended to transmit a structural load into the ground without risk of shear failure or excessive settlement Piles are the most frequently used elements of deep foundations; they transfer a load from the super structure to a suitable bearing stratum when the soil mass immediately below construction is unsuitable. Piles are very often used to reduce the settlement of a superstructure, due to the stringent requirements of the limit deformations of modern project (Zhou et al., 2020). Simulation of pile foundations testing using computer program PLAXIS reduces time for calculation of pile settlement. This method allows to simulate piles and determine their optimal length and diameter in different parts of the construction site in a variety of soil conditions(Jung et al., 2020).

II. LITERATURE REVIEW

This chapter presents the literature review, with specific focus on the suitability of adopting finite element modelling software PLAXIS.

Jasim M Abbas et al., (2010) studied the influence of group configuration on the lateral pile group response subjected to lateral load. Results of the influence of group configuration, pile spacing as well as load intensities is discussed in terms of response of load vs. lateral displacement, soil resistance and corresponding p-y relationship. It can be observed that, the group configurations are largely affected on the lateral pile displacement andultimate soil resistance for same amount of lateral load.

Hararika, P. J. Nath, U.K. (2010) studied the Finite Element Analysis of Pile-Soil-Cap Interaction Under Lateral Load. The 2D finite element analysis with the help of the software PLAXIS 2D is performed to investigate the cap resistance against the lateral load varying the position of cap and length of pile. It is observed from this study that, the pile cap resists a good amount of lateral load and interestingly these resistance increases as increases of position of cap from ground level.

J.-R. Peng et al., (2010) undergoes a study on Finite element analysis of laterally loaded fin piles. The behaviour of fin piles was compared to that of a mono-pile using a 3D finite element analysis (PLAXIS) to generate the pile head P–Y curves.The numerical analyses showed that the lateral resistance increases with the increase in length of the fins.

Jasim M Abbas et al., (2010) carried out Single Pile Simulation and Analysis Subjected to Lateral Load. The effect of pile shape for both circular and square cross-sections on pile response was investigated. In addition, an effect of slenderness ratio L/B is also being carried out in this analysis. A good correlation between the experiments and the analysis was observed in validation example.

Tjie-Liong Gouw (2011) Analysed the Laterally Loaded Group Piles by PLAXIS 3D Foundation. The study revealed that pile group lateral efficiencies were found to be larger when the centre to centre pile spacing were wider. It was also found the greater the number of piles in the group the lower the pile lateral efficiency. However, pile head lateral (horizontal) movement only have marginal effect on the lateral efficiency of group piles.

B P Naveen et al., (2011) carried out numerical simulation of vertically loaded piles. This paper presents a FEM model for simulating these field vertical load tests on large diameter piles embedded in residual soils using PLAXIS 2D. The vertical load versus settlement plots on single pile is obtained from field tests and are compared with the finite element simulation results using PLAXIS 2D, showing reasonable agreement.

Mohammad Mahdi Jalali et al., (2012) carried out a study on Using Finite Element method for Pile-Soil Interface (through PLAXIS and ANSYS). This study investigated the pile-soil interaction and its effect on the pile settlement and shear stress in the interaction zone. The impact of loading on the pile displacement was explored applying Mohr Coulomb as well as Hard-soil behaviour laws. The results revealed that the variance of velocity at the head or the bottom of the pile does not make a significant difference in the interface coefficient.

Serhii Lozovyi and Evhen Zahoruiko (2012) made a study on PLAXIS Simulation of Static Pile Tests and Determination of Reaction Piles Influence. In order to determine the influence of reaction piles on the test pile response in a static load test were performed simulations with group of reaction piles around tested pile and applied respective negative loads. PLAXIS and in situ measured load-displacement curves showed good correlation. Recommendations for PLAXIS modelling were given.

Bhavik S. Parsiya and S. P. Dave (2012) analytically studied the laterally loaded pile group. The greater the spacing between piles in the group the lower the head displacement. There is 40% reduction in pile head displacement when spacing changes 2D to 3D spacing. The modulus of elasticity also affects the head displacement. The head displacement decrease with the higher modulus of elasticity. The total stresses in the soil decrease with the increase in spacing as well as modulus of elasticity.

Asad Munaiwar et al., (2013) studied the safety factor on slope modelling with composite bamboo pile. The study revealed that reinforcing soil with pile improves the safety factor, bearing capacity and maximum limit load. The problem that occurred in laboratory has analysed with finite element software PLAXIS.

Mohd Ahmed et al., (2014) carried out 3D-Analysis of Soil- Foundation-Structure Interaction in Layered Soil. Herein, soil-foundation- structure interaction of buildings founded on Piled-Raft Foundation is evaluated through 3D-Nonlinear Finite Element Analyses using PLAXIS 3D FOUNDATION code. It is concluded that the interaction of building foundation-soil field and super-structure has remarkable effect on the structure.

Michal holko and jakub stacho (2014) compared the numerical analyses with a static load test of a continuous flight auger pile. The numerical analyses were executed using two types of software, i.e., ANSYS and PLAXIS. The method of modelling the interface and the material models of the soil arecompared and analysed. The PLAXIS software uses advanced material models as well as the modelling of the impact of groundwater or over consolidation. The load-settlement curve calculated using PLAXIS is equal to the results of a static load test with a more than 95 % degree of accuracy.

Ihsan Al-Abboodi et al., (2015) made a study on Modelling the Response of Single Passive Piles Subjected to Lateral Soil Movement using PLAXIS. They found a good agreement between laboratory and predicted results is observed in the validation analysis. The software results revealed that the distribution of bending moment along the pile length vary considerably and was in a very good agreement with the real pile behaviour when adopting a variation of soil elastic modulus with depth instead of choosing a constant value.

Paravita Sri Wulandaria, and Daniel Tjandraa (2015) carried out an Analysis of piled raft foundation on soft soil using PLAXIS 2D. The numerical analysis has been done by finite element method using PLAXIS 2D with considering the various number of piles. As the results, the addition of piles could reduce the settlement, but after reach a certain number of piles, increasing the number of piles showed the settlement tends to be constant.

Boonchai ukritchona et al., (2015) studied the load distribution of Pile Group Foundation by 2D Model. It is concluded that the use of a single pile row model to describe the behaviour at the limit state is accurate and comparable to the static method. The present classical method predicting the behaviour of the pile group foundation may not be sufficient, as this method can predict pile loads smaller than those of more realistic analyses, such as finite element methods.

Deendayal Rathod et al., (2016) studied dynamic response of single pile located in soft clay underlay by sand. Finite element software PLAXIS 2D is used to analyze the pile. From the analysis, the deformation and acceleration behaviour of pile with respect to time has been studied. Compare to field tests, the numerical modeling is an economical way to analyze the response of piles

Podolka et al., (2016) tabulated the deformation modulus of the soil, which is one of the most significant geotechnical characteristics from his investigation, he found out that minimum value of the fine grained soil is 1 MPa and a maximum value is 30 MPa. For sandy soils is the lowest value 4 MPa and the highest reaches 100 MPa. Lowest approximate value at gravelly soils is 40 MPa and the highest value is 500 MPa. That means that the maximum value at gravelly soil for class G1 is up to 5 times higher than the maximum value with the same compaction at of sandy soils class F1. The difference between the highest value of sandy soils S1 (100 MPa) and F1 class (30 MPa) is about three times. From all of the above facts it is evident that the differences are very significant between the fine grained, sandy and gravelly earths and needs to be seen in these boundary conditions

Wattamwar Mayur Kishanrao and Arun Prasad (2016) studied the numerical modelling of single pile in a two-layered soil. Finally, it can be observed that the pile in case of sand underlain by clay has significantly higher bearing capacity than the case in which clay is underlain by sand and found that reasonable agreement there when in comparing the single pile's response against simulated results.

D Raddatz and O Taiba (2016) studied the modelling of a lateral load test on piles using simplified and numerical methods. It is concluded that results obtained by simplified methods may be efficient in the early stages of a project and that accurate approximations can be achieved by using design software for continuous elements in the design of isolated elements.

Firoz Ali et al., (2017) conducted an Experimental and Numerical Investigation of Uplift Capacity of Single Piles and Group Piles in Cohesion- less Soil. From the experimental results it was found that the net uplift capacity of single piles increased significantly with an increase in both the L/d ratio and relative density of soil. A numerical analysis of the model piles with the same parametric variation has been carried out using PLAXIS-3D software. The results obtained from the numerical analysis meets the same trends as obtained from the experimental results.

Sjachrul Balamba et al., (2017) Analysed the influence of pile cap thickness to deflection due to lateral load in sand. This study shows the significant effect of various parameters of pile groups to lateral load and lateral displacement. The more piles in total number of pile groups, the smaller deflection of pile occurred in the same PC. The thicker of Pile cap, the smaller deflection of pile occurred in the same

Ahmed Saad et al., (2017) evaluated the effect of lateral soil movement rate on the behaviour of piles in sand using PLAXIS. Results from three-dimensional finite element show that high soil movement rates gave high horizontal displacement and bending moment then the lower rates. Also, the increasing of soil movement rate has more impact on the behaviour of the single pile compared with the effect on pile groups under the same rate.

R. Deendayal (2017) undergoes a finite element analysis of a single pile under cyclic loading. From the analysis, the acceleration, displacement and bending moment of the pile under each case was studied. From the study, it is very clear that as L/D ratio increases, the acceleration, maximum displacement and bending moment are reduced.

Niken Silmi Surjandari et al., (2017) studied slope stability analysis using mini pile. The stability analysis of some configuration of mini pile demonstrate that the installation of the mini pile may cause increasing the safety factor, and show there was optimum configuration mini pile model.

S. **Gowthaman et al., (2017)** did Numerical Study and Comparison of the Settlement behaviours of Axially Loaded Piles using Different Material Models. The results of the analysis suggest that the complete MC model shows good agreement with the settlement behaviour obtained from field static load tests at lower working loads. In addition, it was noted that an interface thickness that is twice the pile diameter with the remaining soil modelled as MC would suffice to ascertain the load transfer mechanism of a typical pile.

III. CONCLUSION

Following are the major conclusions derived from the literature study,

- The PLAXIS software uses advanced material models as well as the modelling of the impact of groundwater or over consolidation.
- The results of the analysis suggest that the complete Mohr-Coulomb model shows good agreement with the settlement behaviour of soil.
- The load-settlement curve calculated using PLAXIS is equal to the results of a static load test with a more than 95 % degree of accuracy.

REFERENCES

[1]. Abbas Al-Shamary, J. M., Chik, Z., & Taha, M. R. (2018). Modeling the lateral response of pile groups in cohesionless and cohesive soils. International Journal of Geo-Engineering, 9(1), 1. https://doi.org/10.1186/s40703-017-0070-y

[2]. Ahmed Saad. Al- Lami, Kais T. Shlash and Mohammed A. Al-Neami (2017) 'Evaluating the effect of lateral soil movement rate on the behavior of piles in sand using plaxis', Journal of engineering science and research management.

[3]. Al-Abboodi.I, Toma-Sabbagh.TM and Al-Jazaairry.A (2015) 'Modelling the response of single passive piles subjected to lateral soil movem ent using PLAXIS', Journal of Engineering Research & Technology.Vol.4, pp.176-180.

[4]. Alekseev, A. G., & Bezvolev, S. G. (2020). In-Situ Customization of the Helical Pile Design Procedure Using Plaxis 2D. Soil Mechanics and Foundation Engineering, 57(1), 77–83. https://doi.org/10.1007/s11204- 020-09640-9

[5]. Ali, F., Supia, K., & Lincoln, A. (2017). An Experimental and Numerical Investigation of Uplift Capacity of Single Piles and Group Piles in Cohesion-less Soil. Indian Geotechnical Conference 2017, December, 8– 11.

[6]. Bhavik S. Parsiyaand S. P. Dave (2012) 'Analytical study of the laterally loaded pile group', Journal of Advanced Engineering Research and Studies.

[7]. Boonchai Ukritchon, Janine Faustino and Suraparb Keawsawasvong (2015) 'A Numerical Study of Load Distribution of Pile Group Foundation by 2D Model', Journal of Engineering and Physical Sciences, pp. 669-688.

[8]. Deendayal Rathod, K. Muthukkumaran and T.G.Sitharam(2016) 'Dynamic response of single pile located in soft clay underlay by sand', International Journal of GEOMATE, Vol. 11, pp. 2563-2567 .

[9]. Deendayal.R.(2017) 'Finite element analysis of a single pile under cyclic loading', Journal of Civil Engineering and Technology, pp.918-924.

[10]. Djenette Mendjel, Souhila Rehab Bekkouche, Ghania Boukhatem (2018) 'Analysis of The Response of Piles Under Lateral Stresses', Journal of Advances in Mechanical and Civil Engineering, pp.40-42.

[11]. Edwin.A.Satish Pranav and D.Murugan Ganesh (2019) 'Experimental and Finite Element Analysis of Laterally Loaded Pile', Journal of Recent Technology and Engineering, Vol.7, pp.713-719.

[12]. Firoz Ali, Supia Khatun, Abraham Lincoln (2017) 'An Experimental and Numerical Investigation of Uplift Capacity of Single Piles and Group Piles in Cohesion-less Soil', Journal of Indian Geotechnical Conference.

[13]. Gowthaman .S., Nasvi M.C.M. and Krishnya.S. (2017) 'Numerical Study and Comparison of the Settlement Behaviours of Axially Loaded Piles using Different Material Models',The Journal of Institution of Engineers,Vol.2, pp.1-10.

[14]. Hararika and P. J. Nath, U.K. (2010) 'Finite Element Analysis of Pile- Soil-Cap Interaction Under Lateral Load',Journal of Indian Geotechnical Conference, pp.809-812.

[15]. J.-R. Peng, M. Rouainia and B.G. Clarke (2010) 'Finite element analysis of laterally loaded fin piles', Journal on Computers and Structures, pp.1239–1247.

[16]. Jasim M Abbas, Zamri Chik ,Mohd Raihan Taha(2010) 'Influence of Group Configuration on the Lateral Pile Group Response Subjected to Lateral Load', Electronic Journal of Geotechnical Engineering,Vol 15, pp.762-770.

[17]. Jasim M Abbas, Zamri Hj Chik, Mohd Raihan Taha(2011) 'Single Pile Simulation and Analysis Subjected to Lateral Load', Electronic journal of geotechnical engineering, Vol.13

[18]. Jung, C., Ceglarek, R., Clauvelin, T., Ayeldeen, M., & Kim, D. (2020). Deep Soil Mixing in Sabkha Soils for Foundation Support in United Arab Emirates. International Journal of Geosynthetics and Ground Engineering, 6(1), 3. https://doi.org/10.1007/s40891-020-0188-4

[19]. Kavitha, P. E., Beena, K. S., & Narayanan, K. P. (2016). A review on soil–structure interaction analysis of laterally loaded piles. Innovative Infrastructure Solutions, 1(1), 1–15. https://doi.org/10.1007/s41062- 016-0015-x

[20]. Kharat Kiran,Deore Karishma, Patel Chirag,Chaurasya Rohit, Navnath Shinde (2018)'Analysis of Piled Raft Foundation using PLAXIS 2D', Journal for Scientific Research & Development,Vol.6, pp.1723-1726.

[21]. Kim, G., Ham, K., & Lee, J. (2020). Effects of Surface Roughness on Lateral Load–Carrying Capacities of Piles Embedded in Sand. Journal of Geotechnical and Geoenvironmental Engineering, 146(8), 04020064. https://doi.org/10.1061/(asce)gt.1943-5606.0002308

[22]. Michal HOĽKO and Jakub STACHO (2014) 'comparison of numerical analyses with a static load test of a continuous flight auger pile', Journal of Civil Engineering, Vol.22.4

[23]. Mohammad Mahdi Jalali, Syed Hasan Golmaei, Mohammad Reza Jalali, Alistair Borthwick, Mir Khalegh Ziatabar Ahmadi and Reza Moradi (2012) 'Using Finite Element method for Pile-Soil Interface (through PLAXIS and ANSYS)', Journal of Civil Engineering and Construction Technology Vol. 3, pp. 256-272.

[24]. Mohd Ahmed, Mahmoud H. Mohamed, Javed Mallick and Mohd Abul Hasan (2014) '3D-Analysis of Soil-Foundation-Structure Interaction in Layered Soil', Journal of Civil Engineering, Journal of Civil Engineering, 2014, 4, 373-385 Vol.4, pp. 373-385.

[25]. Mostafa A. Ismail and Mohamed A. Shahin (2011) 'Finite Element Modeling of Innovative Shallow Foundation System for Reactive Soils'. Journal of GEOMAT, Vol.1, pp.78-82.