FEA of Pile-Soil Interference Stability Evaluation Under Sensitivity Cases

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Abstract - *The structural response of straight and initially bent piles , with various soil degradation conditions subjected to axial load are examined in the current study through FEM. Nonlinear buckling analysis performed here is using the nonlinear Static method. Analysis is done by combining the weakened pile and degraded soil. The analysis results show that the load-carrying capacity of the piles decreases with increasing pile curvature and increasing the percentage of soil degradation. The study has shown the loss in buckling load of pile in various degradation conditions. Necessary strengthening of piles is done to overcome the excessive collapse and adding the stiffness of pile. This paper deals with strengthening of initially bent piles with micro pile lining method.*

***Key Words*: Pile, Finite-Element Method, Geometric imperfections, Soil degradation, Nonlinear buckling, Micro pile Lining Method**

1.INTRODUCTION

Piles are long, slender elements made of concrete, steel, timber, or polymer used to transfer structural loads to deeper rock or firm soil layers at sites where soft clays or loose sands exist at shallow depth. The major causes of failure for a pile under axial loading is buckling. Buckling failure of slender piles may occur based on the effect of axial load acting on the pile and the loss of surrounding confining pressure offered by the soil or loss of pile strength owing to severe corrosion The allowable bearing capacity of initially bent pile foundations in weak soils such as soft clays, loose silts, or loose sands. It was observed that the initial curvature causes reduction in the axial capacity of the pile as compared with the straight pile. The bearing capacity of pile with imperfection is much less while compared with that of pile without imperfections .The weakened piles can be strengthened using micropile lining method.

In this study, initial bent piles with shapes of quarter- sine wave, have been modeled under axial loads. The load-deflection behavior of initially bent piles and the load carrying capacities of the pile have been investigated. Micropile lining method is used to strengthen the soil-pile interactions All analysis conducted herein are performed for solid steel piles.

2. FINITE ELEMENT MODELLING

2.1 General

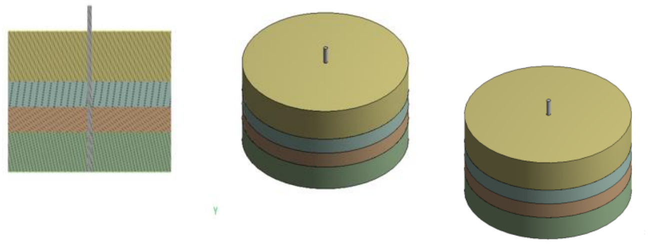
To investigate structural response of initially bent piles and the pile-soil interaction at various soil degradation conditions. Finite element models were developed using ANSYS 190. The piles and soil layers were modeled using SOLID186 element.

2.2 Scope

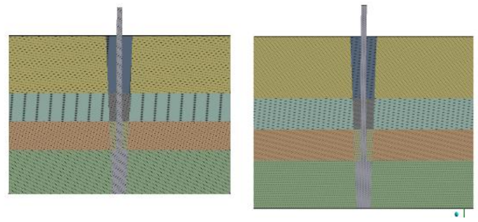
This project aims to predict the collapse of pile on soil structural terrine with various sensitivity imperfection cases .Scope of the study is extended on strengthening the imperfection interaction failure with micro pile pining method. The Axial Loading performance is carried out to evaluate critical buckling load, for different deflections. This study is limited on considering the pile and soil layers modelling.

2.3 Geometry

Three dimensional modelling of steel piles and soil have been considered for analysis .Steel piles of length 10m and diameter 0.5 m is used in this study. Initially bent piles with bent amplitudes of 50mm and 100 mm were first analysed. Second models were of soil in 3 layers with multilayer stiffness overtopping a layer of clay. The modulus of elasticity of steel pile is 200 GPa and Poisson's ratio is 0.3 Geometry of steel piles and soil in finite element modeling is shown in Figure 1.Material properties of soil is given in table.1



a)no imperfections b)quarter sine profile c) half sine profile



d) soil with 25% degradation e) soil with 50% degradation

Fig 1: Geometry of Piles and soil with degradation (without imperfections,with quarter sine ,with half sine,soil with 25% and 50% degradation)

Table -1: Material properties of soil

Soil	*Elasticity*	*plasticity*	*Poisson's ratio*	*Angle of internal friction*
Sand 1	9.32	0.1	0.29	34.0
Sand 2	15.20	0.1	0.29	38
Sand 3	18.12	0.1	0.29	42
Clay	8.15	0.5	0.3	29

2.4 Meshing

Meshing breaks down the continuous geometric space into thousands of small shapes as possible to achieve accuracy. In this analysis, fine mesh was adopted to achieve maximum accuracy in results. Solid models are converted into a finite element model after meshing.

2.4 Loading and Boundary Conditions

To simulate real conditions, columns were modelled with the base of the model fixed at the bottom and the top is free. Load is applied at the top. The exterior of the surface is circumferentially supported. Behavior of pile and soil under axial loading was studied by ANSYS. Boundary conditions of pile-soil interaction are shown in Figure 2.

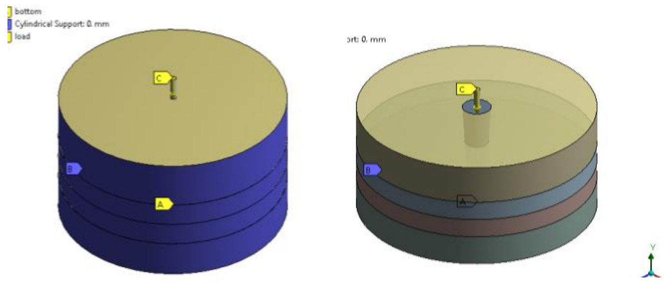


Fig 2: Boundary condition of pile and soil

3.MICROPILE LINING METHOD

In order to strengthen the bent pile in degraded soil, small micro piles can be drilled inside the pileshaft. Here, the weakened pile and degraded soil is combined together and analysed. Small micro piles of 100mm diameter are held at a spacing of 2000 mm at an angle of 45%. The piles are provided in 3 layers and 3 rows and analysed. Then the analysis is done by providing an I section in 3 layers and one row. Providing I section at the collar provides extra stability to pile by arresting the pile at the collar. It prevents the further movement of pile at the collar. Thus the buckling of pile can be controlled and collapse of the structure can be prevented.

4.ANALYTICAL RESULTS AND DISCUSSIONS

4.1 Piles with and without imperfections

Piles are subjected to load at the top of the surface. Figure 3 shows comparison of Load-Displacement curve of Piles with and without imperfections. Table 2 shows values of critical buckling load and corresponding deformations of piles with and without imperfections.

Table -2: Load Vs Deflection of piles with imperfections

Pile type	*Deflection*	*Critical Buckling load*
No imperfections	73.70	9451
Quarter sine-50	105.62	7505.8
Quarter sine-100	96.055	6670.9
Half sine-50	81.109	8876.9
Half sine-100	112.26	7233.4

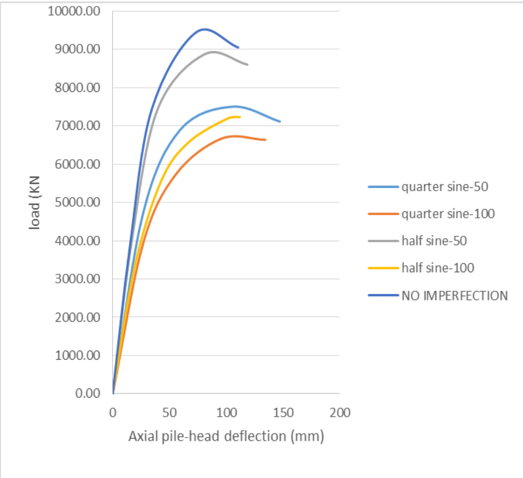


Fig3: Comparison of pile with and without imperfections

From results, it is clear that the piles with quarter sine bent with amplitude 100mm is having least load carrying capacity while compared to others. Displacement controlled force is given in finite element analysis.

4.2 Soil with Degradation Conditions

Soil is analysed with various degradation conditions. The weakest degradation is combined with piles of least load carrying capacity and analysed. Table 3 shows values of critical buckling load and corresponding deformations of soils with degradation conditions and combined case.

Table -3: Load Vs Deflection of soil degradation

Soil Type	*Deflection*	*Critical buckling load*
With out imperfection	73.7	9451
soil degradation 25%	97.4	7374.20
soil degradation 50%	113.7	6803.60
Combined degradation 50%+Qs	110.26	5596.20

From results, it is clear that the soils with 50% degradation condition has least critical buckling load than other degradation conditions. The combined degradation with quarter sine is the weaker among all the analysis. So suitable strengthening method can be used to improve the soil-pile interaction.

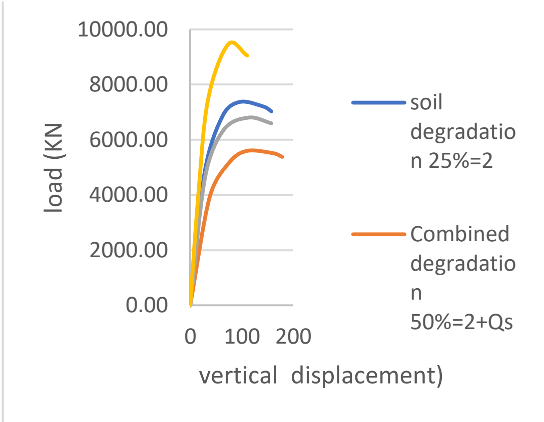


Fig4: Comparison of soil with degradation conditions

4.3 Strengthening of Piles

The weakened pile-soil interface is strengthened by micropile lining. Table 4 shows values of buckling load and corresponding deformations of the structure.

. **Table -4:** load vs deflection of micropiling

Soil Type	*Deflection*	*Critical buckling load*
Combined degradation 50%+Qs	110.26	5596.20
3 L-3R-D100	100.67	7729.8
3L-3R-D100 with collar support	87.53	19413.00
Without imperfection	73.7	9451.00

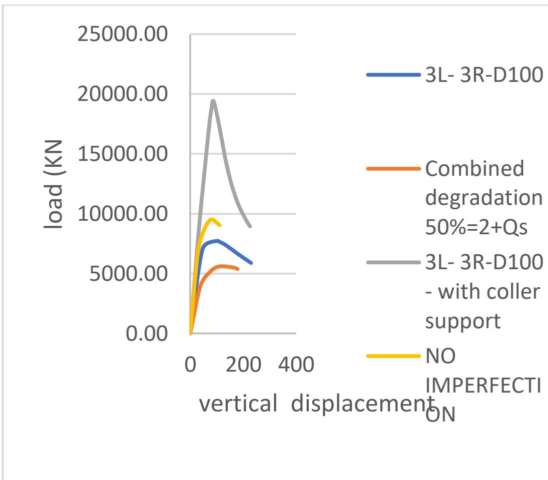


Fig5: Comparison of soil with degradation conditions

The structure is analysed with and without collar support. And from the result, it is clear that the soil is having the highest load carrying capacity ,when collar support is placed along three layers and one row. This is due to the structural support provided by the I section at the collar and lateral movement of pile is arrested at the collar.

5. CONCLUSIONS

In this study, the pile-soil interface with various imperfections and degradation conditions were studied and following conclusions were arrived at

1) All the structures with higher imperfection and degradation conditions have less load carrying capacity.
2) Critical Buckling Load of quarter sine wave 50 is higher than that of quarter sine 100.
3) Critical buckling load for piles with collar support is very high compared to that of piles without collar support.
4) The maximum degradation of soil surrounding initialy bent pile is less than 50%

REFERENCES

[1] Mostafa Jafarian Abyaneh, S.M.ASCE1; Hany El Naggar, M.ASCE; and Pedram Sadeghian, M.ASCE"Numerical Modeling of the Lateral Behavior of Concrete-Filled FRP Tube Piles in Sand" 10.1061/(ASCE)GM.1943-5622.0001725. © 2020 American Society of Civil Engineers

[2] Mohammad Nadeem1; Tanusree Chakraborty, A.M.ASCE2; and Vasant Matsagar3"Nonlinear Buckling Analysis of Slender Piles with Geometric Imperfections" " 10.1061/(ASCE)GT.1943-5606.0001189. © 2014 American Society of Civil Engineers.

[3] Eslami, M. M., Aminikhah, A., and Ahmadi, M. M. (2011). "A comparative study on pile group and piled raft foundations (PRF) behavior under seismic loading." Comput. Methods Civil Eng., 2(2), 185–199.

[4] Basu, P., Prezzi, M., and Salgado, R. (2014). "Modeling of installation and quantification of shaft resistance of drilled-displacement piles in sand." Int. J. Geomech., 10.1061/(ASCE)GM.1943-5622.0000303, 214–229.