Design and Analysis of Piled Raft Foundation Using Plaxis using Finite Element Modeling Software PLAXIS 2D

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***Abstract*: A ton of urbanization is taking place these days, which has led to the development of many towering structures. Because of the scarcity of land, the recent structures that will be made are in whatever soil is available, whether soft soils or hard strata. In this report, numerical analysis was done by finite element using PLAXIS 2D on soft soil. Structures built on soft ground are different from a regular strategy in that they are used in raft pile foundations because of the differential settlement property of the ground. In the present investigation, the mathematical examination focused on single raft and piled raft of various arrangements. The results showed that the extreme load expanded and the settlement decreased. The parametric investigation also showed that the decrease in settlement occurs due to the expansion in the length of the piles, as well as in the expansion of the number of piles. The parametric study showed that the reduction of settlement occurs due to the increase in the length of the piles, as well as with the increase in the number of piles. This study is useful in deciding various parameters needed to economically design the piled raft foundation.**

***Keywords*: Piled Raft Foundation; Settlement; PLAXIS 2D.**

1 INTRODUCTION

The piles can be used as a raft foundation as well as a raft pile system where the super construction load is mainly shared by raft and pile which help to decrease settlement. The raft has sufficient rolling limit and reduces differential settlement, but goes through unnecessary settlements. Therefore, to correct the above concern, the pile-side raft is used as a piled raft to establish a satisfactory bearing limit and lower settling within sizable, reasonable and safe cut-off points. Despite having a sufficient rolling limit, it can cause irrational liquidation. Limited component investigations are common in the field of geotechnical engineering. Stacked foundation investigations using the component technique to exploit exposure to reduce settlement support capacity has been completed by many researchers. This technique can generate excellent results for pile foundation investigations. The purpose of this examination is to investigate the settlements of the raft foundation establishment and add piles, such as the pile pontoon establishment, under a similar piling. In this exam, a limited investigation of components using PLAXIS 2D was directed.

2 LITERATURE REVIEW

In recent years, there are many construction projects built on soft ground. Due to the characteristics of the soft soil, the structures built on it are subject to differential settlements. The raft foundation is one of the methods to reduce differential settlement. Although it has an adequate load capacity, it can cause excessive settlement. Piles can be used with a raft foundation as a piled raft foundation system. The addition of piles is to reduce settlements to an acceptable amount. The objective of this study is to analyze the settlements of the raft foundation and by the addition of piles, as the raft foundation, under the same load. Numerical analysis was performed by the finite element method using PLAXIS 2D considering the different numbers of piles. As a result, the addition of piles could reduce settlement, but after reaching a certain number of piles, increasing the number of piles showed that settlement tends to be constant. For an economical project, it is necessary to consider the optimal number of piles in the piled raft foundation system based on the allowable settlements [1].

Raft foundations are used when insulated footings cover more than 70% of the building area under a superstructure. A combination of the use of piles and a raft foundation is known as a piled raft foundation. Pile raft foundations have proven to be more cost effective in the case of tall clay buildings and can provide safe load carrying capacity and maintenance requirements. The use of strategically located piles improves the load capacity of the raft and reduces differential settlement. This research clarifies the philosophy of using piles as settling reducers for raft foundations and also the behavior of the piled raft embedded in sand. Small-scale model tests are performed. The effects of pile length and alignment on the last load reached are investigated experimentally. From the studies carried out, it was concluded that as the length of the piles and the number of piles decrease, the load carried by the raft increases [2].

In recent years, a lot of urbanization is taking place, as a result, many tall buildings are constructed and due to the scarcity of land, structures are built on soft soils using pile foundation, which becomes very expensive. Therefore, in addition to the conventional method, geotechnical engineers are now opting for the piled raft foundation, in which the superstructure load is mainly shared by the raft and the piles act as settling reducers. The raft alone has adequate bearing capacity and reduces differential settlement, but suffers excessive settlement, so to overcome this problem the piles together with the raft are used as the piled raft foundation to have adequate bearing capacity and reduce settlement within limits allowed. It is also an economical method compared to conventional pile foundation. In the present study, experimental and numerical analyzes were studied in single raft and piled raft of different configurations. And 37 and thus experimentally study the behavior of load settlement for different foundation configurations in piled raft and compare them with numerical modeling using PLAXIS 2D [3].

The analysis of the Piled-Raft Foundation is very challenging as the load on the Stack- Raft structures is transferred to the ground not only by the interaction between the soil and the piles, but also by the interaction between the foundation structure and the superstructure. In this interaction, soil deformations are the key factor that will affect the forces and deformations in the foundation and superstructure [4]. Soils below ground level are heterogeneous and often found as layered systems, that is, properties that vary in layers below ground. They demonstrated that ignoring interactions between piled raft foundation elements can lead to a very serious overestimation of foundation stiffness. Case studies on the optimized performance of piled foundations composed of connected and unconnected piles using simple 2D analysis are presented [5].

A simplified procedure applicable for estimating the settlement of rafts was presented. He proposed a simplified design approach for barrier pile foundations under vertical load considering interaction effects. They compared the method results with experimental and other numerical results and found good agreement between the results. An optimization study of raft pile foundation systems was carried out. It is experimentally demonstrated that model rafts, founded on sand reinforced by structurally disconnected piles, will have reduced settlements and bending moments [6]. Field measurements of the observed load for the raft and raft foundation piles on hard clays under working conditions are reported. Suggest that the load ratio on the most heavily loaded piles at the perimeter of the group to that on the least loaded pile near the center could be about 2.5. A displacement-based design procedure is proposed based on the results of simplified finite element models of finite elements with linear elastic deformation and non-linear plane deformation [7].

The effect of the compressive capacity of the raft and pile group was evaluated on raft settlements, raft bending moments and pile-raft load transfer ratio. Performed the dynamic analysis of framings including the effects of soil-structure interaction and concluded that the problem of soil-structure interaction can have beneficial effects on structural behavior when nonlinear models of soil and interface conditions are considered [8]. Presented a new approach to the design of raft foundations using 3-D modeling of each part of the entire structure (superstructure, raft and soil) and considering the soil structure interaction. They developed graphs to show the relationship between raft thickness and the number of design parameters, including soil type [9-10].

3 TYPES OF FOUNDATION

The most common forms of deep foundations are piles, pillars and caissons. The mechanism for shifting the weight to the ground is basically the same in these types of foundations. Raft. Savings in the pile base are realized through the design of piles of suitable diameters, so that the sum of the safety capacity of the piles below a column is almost identical to the weight that arrives at the column. In a pile group there should preferably be only one pile diameter.

4 SOIL LAYERS

Soil stratigraphy can be described in solo mode using the characteristic hole of the program. The holes are placed at the extraction site where information on the positions of the soil layer and water table is provided. If some holes are described, the program will robotically interpolate between hole and derivative.

5 NEED OF PILE

Insufficient soil bearing capacity to support a structure will require a pile foundation. The pile base will be chosen based entirely on Soil Condition, Types of Loads acting on the Foundation, Bottom Soil Layers, Site Conditions, Operating Conditions. When the plane of shape is not always regular, the weight distribution will also not be more uniform in nature. Employing a shallow foundation in these cases will bring about differential settlement. To eliminate differential settlement and instance type, the base of the pile becomes vital. The pile base is vital for regions where the surrounding shape presents possibilities for soil erosion. This cannot be resisted through the shallow base.

6 PLAXIS 2D

The finite detail technique (FEM) is a numerical technique for finding fairly correct solutions of partial differential equations, in addition to critical equations. The solution technique is mainly based on discarding the differential equation absolutely (regular realm issues), or turning the PDE into an approximate device of regular differential equations, which are then numerically integrated using well-known techniques that include Euler's approach. . For the evaluation of the elastoplastic in this project, the commercially available PLAXIS 2D geotechnical software program is being used, which uses Finite Element Analysis (FEA) for version simulation.

7 METHODOLOGIES

The sample geometry is mesh in PLAXIS, open source finite element meshing software. The mesh is produced relative to the second order shape function due to combined flow analysis. One factor is the model of all experimental simulations. The generated correspondence file is included in PALXIS as a geometric input file. Due to the axial symmetry at the left edge and the closed ring at the right edge (cellular compression in the case of triaxial examination), lateral movement is limited to these limits. The friction effect of the closing ring is not considered in the simulation due to the limited scope of this software. Hydraulic pressure is set to zero at the upper limit to allow direct flow of water. Vertical removal is restricted to the bottom edge.

8 GEOMETRY

In this study, a uniformly distributed load of 70 kN/m^2 was applied to a raft with various numbers of piles. It was a model industrial building built on soft ground. In finite element analysis, the raft and piles were modeled as plate elements.

Figure 1 Geometry

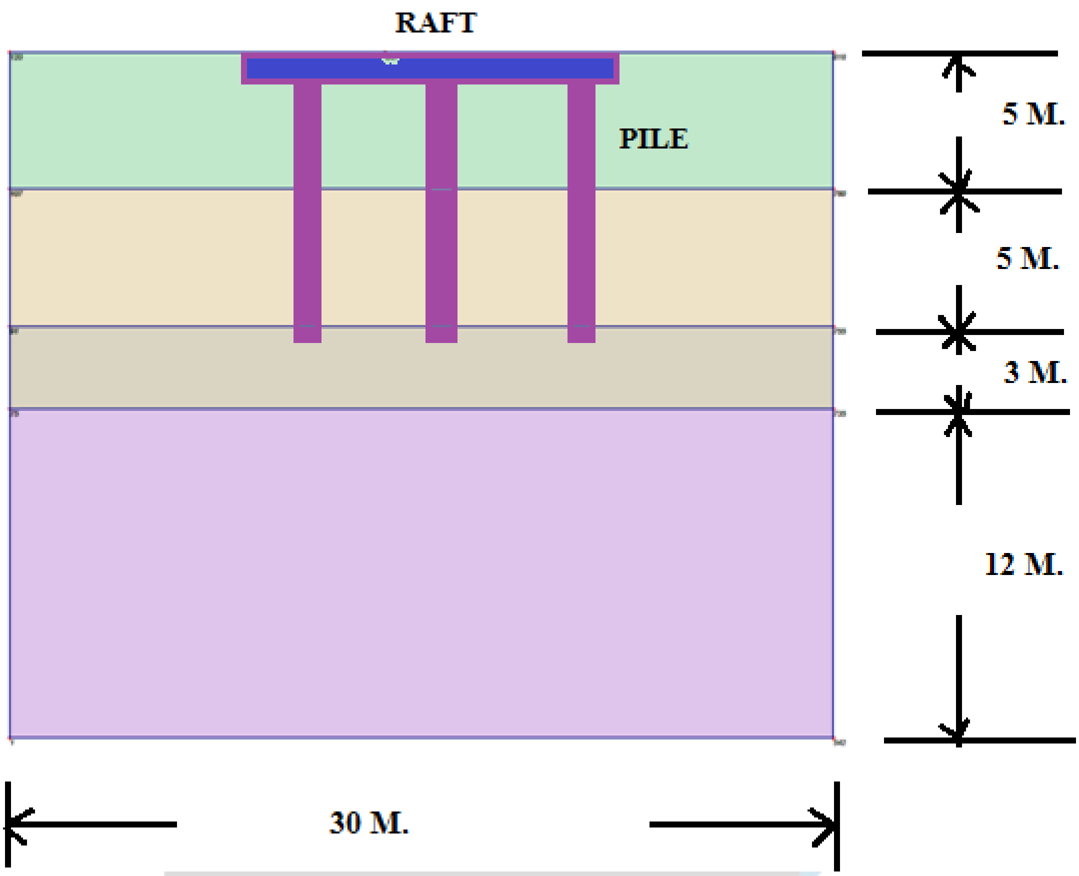

Table 1 Geometry Parameters (Raft and Pile)

Sl.No.	Raft Size	Raft Thickness (m)	Pile Length (m)	Pile Diameter (m)	Pile Spacing (m)	Number of Piles
1	10m x 10m	2 m	10 m	0.3 m	2	3

Table 2 Numbers, type of elements, integrations

Type	Type of element	Type of integration	Total no.
Soil	15-noded	12-point Gauss	96

Table 3 Mohr-Coulomb with parameter

Mohr-Coulomb		Sand	Sand	Clay	Clay
Type		Undrained	Drained	Drained	Undrained
□unsat	[kN/m³]	17.00	19.00	17.00	16.00
□sat	[kN/m³]	17.00	19.00	20.00	18.00
kx	[m/day]	1.000	0.500	0.500	0.000
ky	[m/day]	1.000	0.500	0.500	0.000
einit	[-]	1.000	0.500	0.500	1.000
ck	[-]	1E15	1E15	1E15	1E15
Eref	[kN/m²]	9170.000	12000.000	2.1E12	70000.000
□	[-]	0.300	0.300	0.150	0.330
Gref	[kN/m²]	3526.923	4615.385	913043478261.000	26315.789
Eoed	[kN/m²]	12344.231	16153.846	2.21739130435E12	103715.170
cref	[kN/m²]	15.00	13.00	1.00	18.00
□	[°]	28.00	25.00	34.00	24.00
□	[°]	2.00	4.00	4.00	0.00
Einc	[kN/m²/m]	0.00	0.00	0.00	0.00
yref	[m]	0.000	0.000	0.000	0.000
cincrement	[kN/m²/m]	0.00	0.00	0.00	0.00
Tstr.	[kN/m²]	0.00	0.00	0.00	0.00
Rinter.	[-]	0.67	0.70	0.70	1.00
Interface permeability		Neutral	Neutral	Neutral	Neutral

9 RESULT AND DISCUSSION

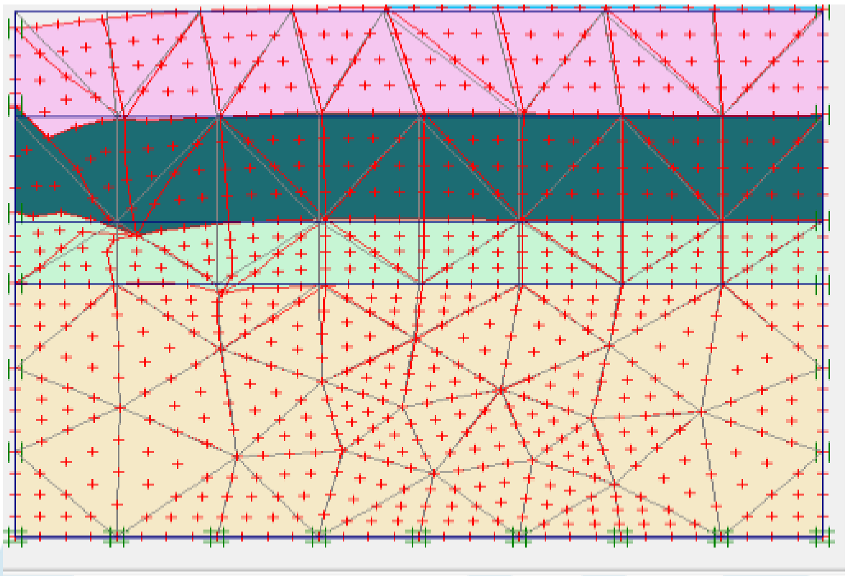

Figure 2 Deformed mesh

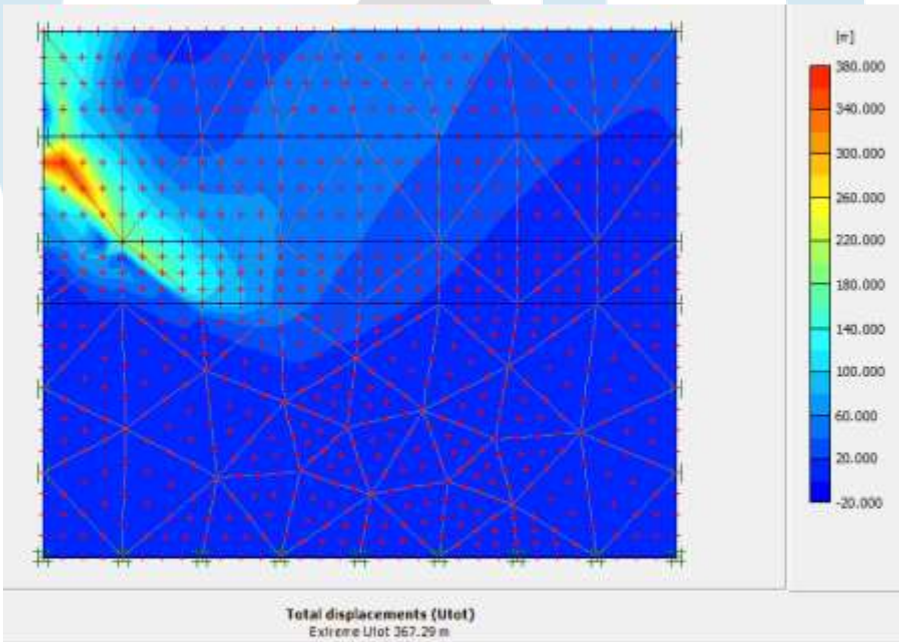

Figure 3 Total displcement 367.29 m

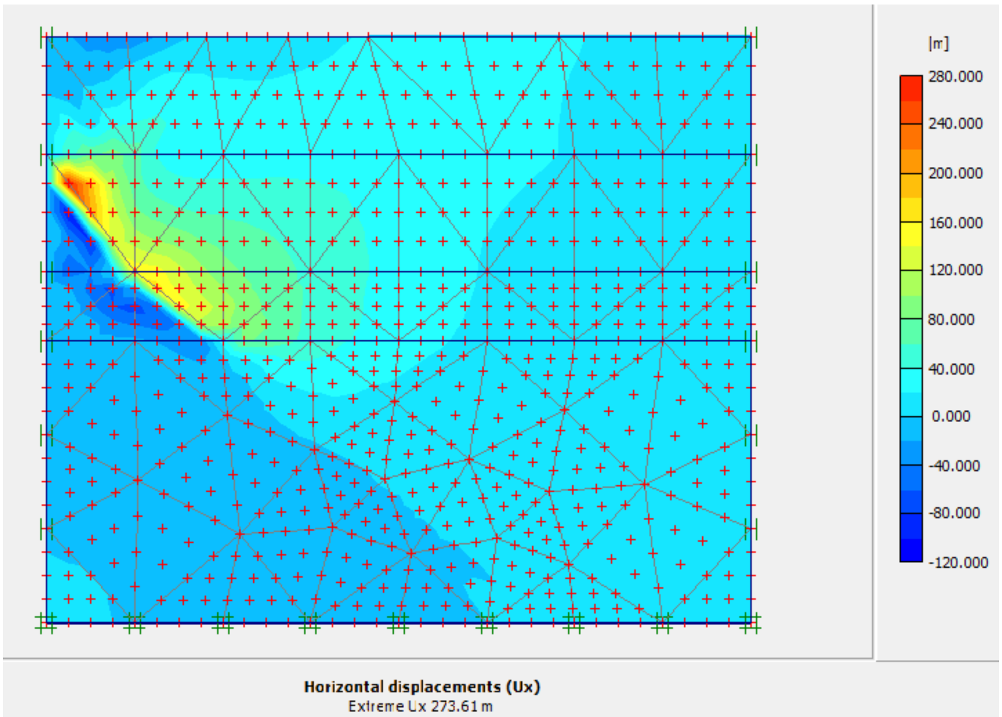

Figure 4 Horizontal displcement 273.61 m

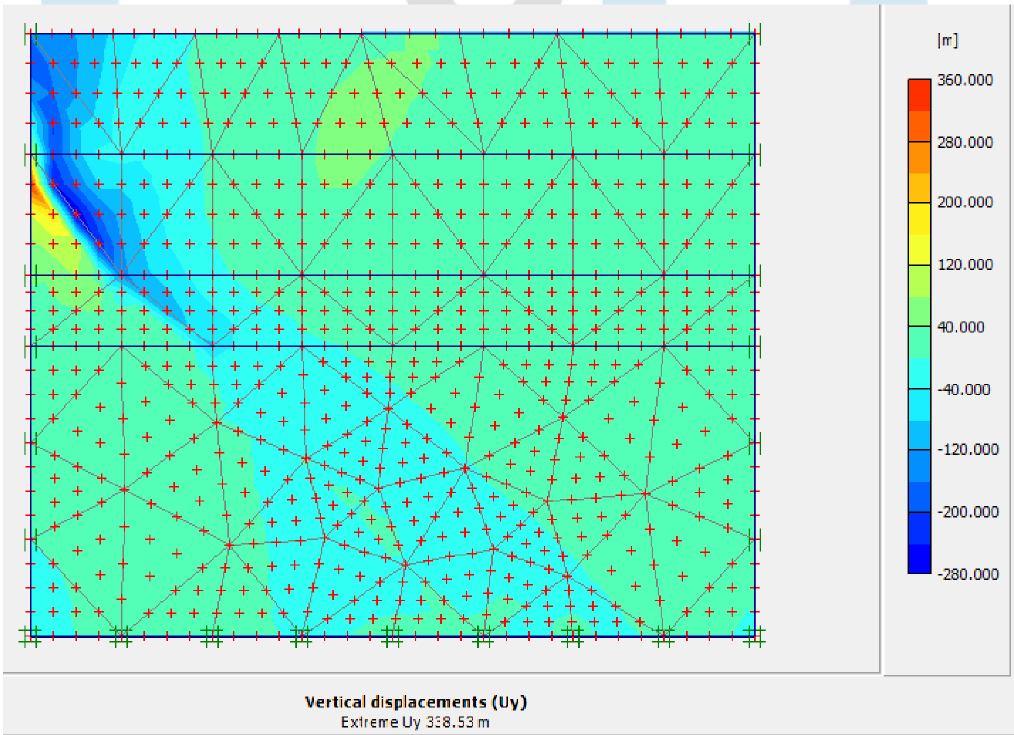

Figure 5 Vertical displcement 338.53 m

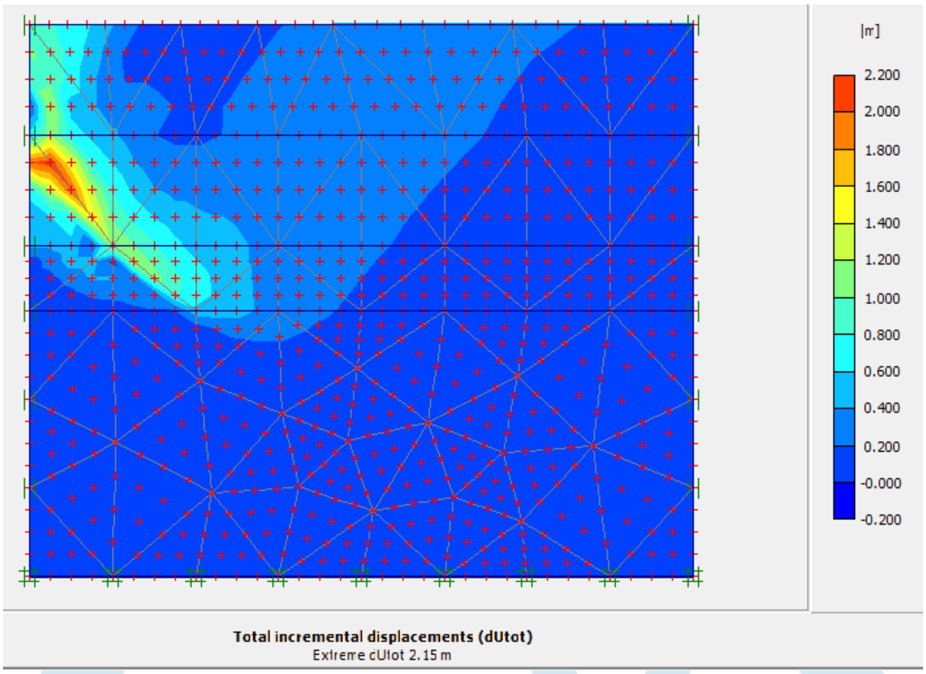

Figure 6 Total incremental displcement 2.15 m

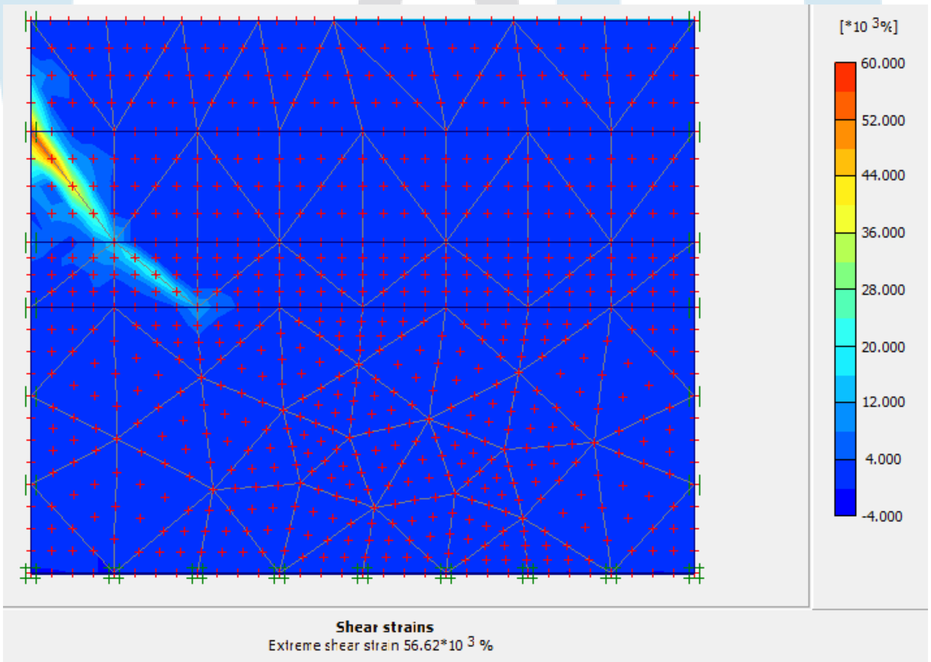

Figure 7 Extreme shear strain 56.62 x 10^3%

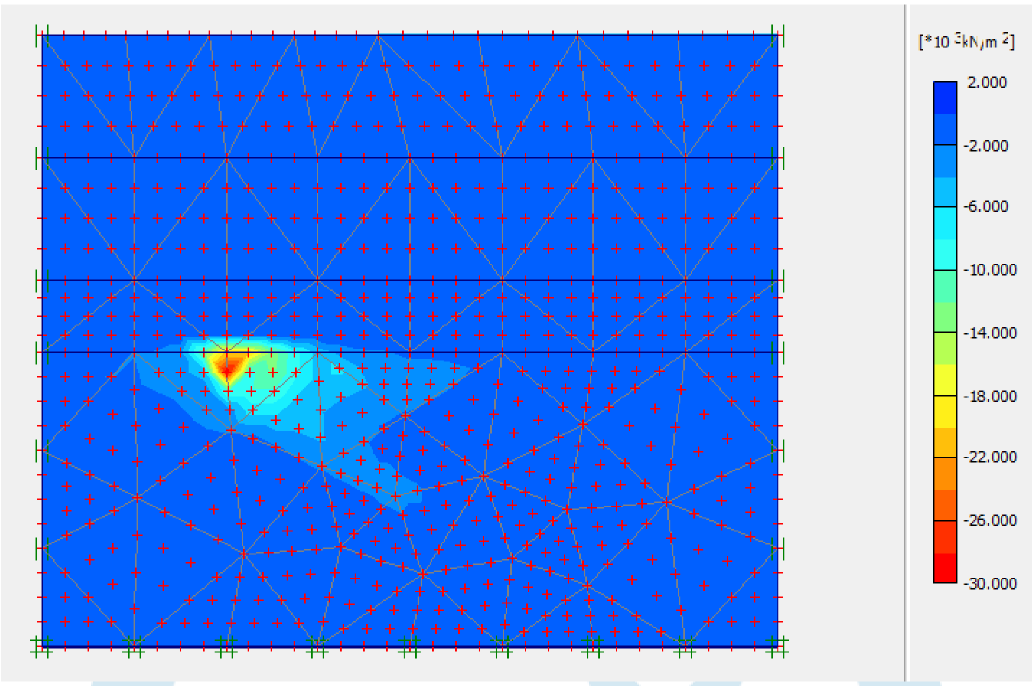

Figure 8 Extreme effective mean stress 29.36 x 10^3kn/m^2

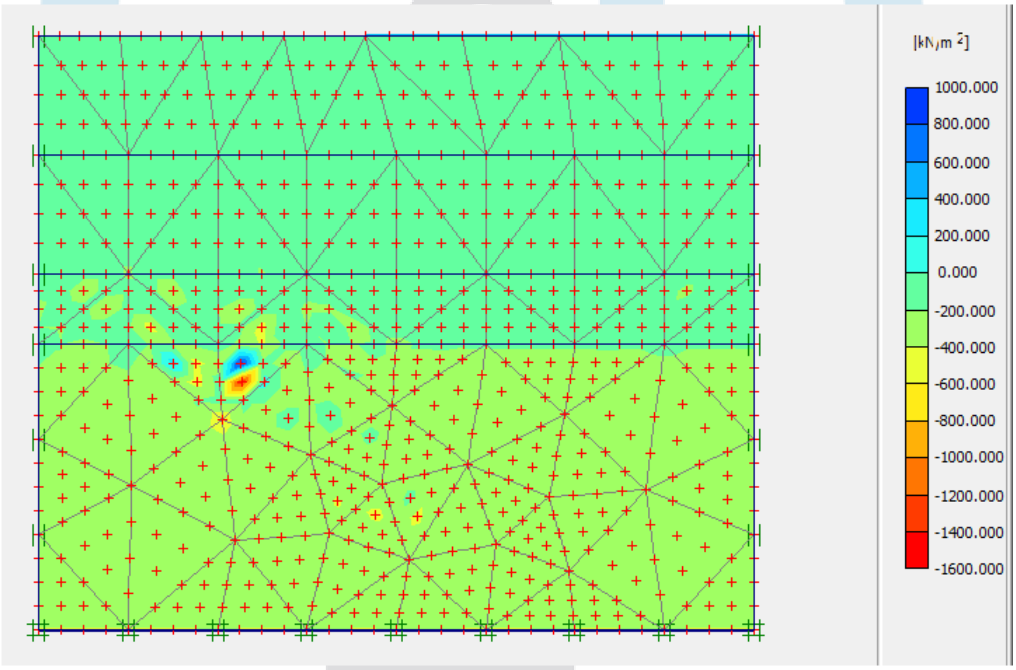

Figure 9 Extreme mean stress 1.43 x 10^3 kn/m^2

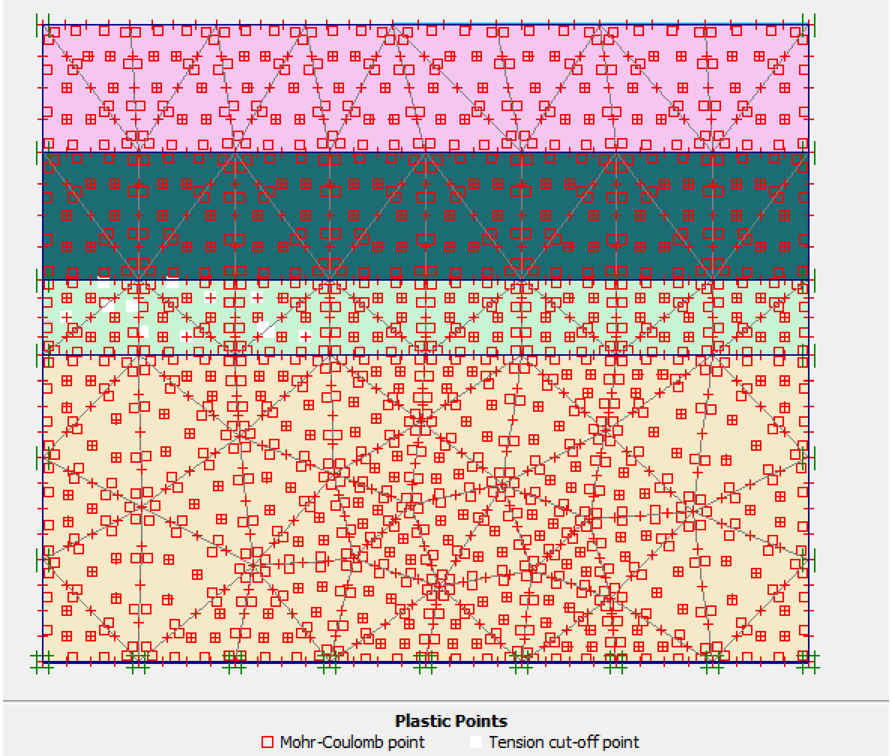

Figure 10 Mohr- Coulomb point and Tension cut-off point

CONCLUSIONS

The study was carried out to investigate the behavior of raft shoes and piled raft on soft clay. Adding a small number of piles below the raft increases the ultimate load of the piled raft, and this enhancement effect increases as the number of piles increases. It is concluded that Total displcement Horizontal displacement, Vertical displcement ,Total incremental displcement, Extreme shear strain, Extreme effective mean stress, Extreme mean stress are 367.29 m, 273.61 m, 338.53 m, 2.15 m, 56.62 x 10^3%, 29.36 x 10^3 k n/m^2, 1.43 x 10^3 kn/m^2, which is shown in Figure 3 to 9.

REFERENCES

[1] Besseling, P. Stuurwold, and A. Lengkeek, Validation and Application of the Embedded Pile Row –Feature in PLAXIS 2D, Plaxis Bulletin Autumn Issue (2013), pp.10-13.

[2] W. A. Prakoso and F. H. Kulhawy. Contribution to piled raft foundation design, Journal of Geotechnical and Geoenvironmental Engineering, Vol 127 No 1 (2001), pp. 1024-1090.

[3] H. G. Poulos, Analysis of pile-soil interaction under lateral loading using infinte and finite elements, Computers and Geotechnics, Vol 15 Issue 4 (1993), pp. 189–220.

[4] J.C. Small, and H. Chow, Piled raft foundations for tall buildings, Geotechnical Engineering Journal of the SEAGS & AGSSEA, Vol 42 No 2 (2011) 78–84.

[5] P. S. Wulandari, Analysis of Piled Raft Foundations in Clayey Soils using Finite Element and Analytical Methods, Proceedings of the Thirteenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-13), September 11-13, 2013, Sapporo, Japan, A-6-2., http://hdl.handle.net/2115/54231.

[6] V. Tandjiria, Numerical Modelling of Chicken-Foot Foundation, Civil Engineering Dimension Journal of Civil Engineering and Application, Vol I No 1 (1999), pp. 14-19.

[7] Brinkgreve R.B.J (2006). Plaxis, Finite Element Code for Soil and Rock Analyses, user manual. Delft University of Technology & Plaxis b.v, The Nederlands. Balkema, Rotterdam.

[8] Randolph, M. F. (1993), an approximate analysis procedure for piled raft foundations. Int. J. Numer. Anal. Meth. Geomech. 17: 849–869. doi:10.1002/nag.1610171203.

[9] Gopinath, B., Juneja, A. (2010)"Numerical Modelling of Piled Raft Foundation in Soft Clays"Indian Geotechnical Conference.

[10] Hameedi, M. K (2011), "Experimental and Theoretical Study for Piled Raft Foundation in Soft Clay", Unpublished M.Sc. Thesis, Building and Construction Engineering Department, University of Technology, Baghdad, Iraq.