THE BEHAVIOUR OF AXISYMMETRIC PILED RAFT FOUNDATION BY NONLINEAR FINITE ELEMENT METHOD

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ABSTRACT

The piled raft has been analysed under axisymmetric condition.The raft, pile and soil have been discretised into four noded isoparametric finite elements. The raft and piled raft has been considered as linear elastic material. The material nonlinearity of soil has been modeled by Extended Drucker-Prager Yield Criterion , The nonlinear finite element equation has been solved by Full Newton-Raphson Iterative Procedure. For one layer of soil at any loading intensity the settlement of raft is greater than the piles. Pile with spacing to diameter ratio equal to ten settles more than piles of spacing to diameter ratio equal to twenty and thirty. The pile of length to diameter ratio equal to thirty settles least. The loading intensity vs settlement curves are nonlinear. The settlement of raft for one layer of soil is more at all loading intensities than that of layered soil. The settlement of pile is more in one layer of soil but it reduces in layered soil. At any loading intensity pile for length to diameter equal to thirty and spacing to diameter ratio equal to ten experiences larger settlement than the pile for which spacing to diameter is equal to five for same length of pile For length to diameter equal to twenty and spacing to diameter equal to five, the axial load at top is maximum and at bottom it is minimum for all centre, middle and end piles. The centre pile takes least load followed by middle pile and the end pile takes maximum load. For all piles the axial load is maximum at top and minimum at bottom. The axial load distribution curves are nonlinear.The axial load distribution of pile of length to diameter equal to 10 is same for one layer soil and layered soil. The axial load distribution in pile of length to diameter equal to 20 and 30 and spacing to diameter equal to five., is more in layered soil than in one layer soil.

Keywords: Piled Raft, Axisymmetric, Nonlinear, Yield Criterion, Pile, Settlement, Axial Load

INTRODUCTION

In piled raft foundation the raft and piles both contribute in load sharing. The raft carry load through contact with soil while piles carry load through skin friction. Piled raft foundation is an economical foundation compared to pile foundation and undergoes lesser settlement than that of the raft foundation.

LITERATURE REVIEW

Tomono et al. (1987) presented a simple model consisting of a rigid circular raft and a single pile. Karpurapu and Bathurst (1988) have shown the application of coupled finite and infinite elements for linear elastic foundations. Madhav and Karmarker (1982) have reported the elasto-plastic settlement of rigid footing. Gandhi and Maharaj(1996)have found the load sharing between raft and pile in a piled raft foundation by three dimensional finite element method..Liu and Novak (1991) has mentioned the cap, pile and soil interaction by finite and infinite elements. Maharaj (1996) has presented the linear and nonlinear finite element analysis of raft and piled raft foundation. Maharaj (2003). has analysed square raft and piled raft foundation by nonlinear finite element method.. Hooper (1973), Franke (1991), Yamashita et al. (1994) have provided useful information on field investigation of piled raft foundation.

Based on literature review it is found that very few literatiures are reported on nonlinear analysis of piled raft foundation. In the present research axisymmetric analysis of piled raft foundation has been done by nonlinear finite element method

FINITE ELEMENT ANALYSIS

The raft and piled raft have been considered as linear elastic material. The raft, piled raft and soil have been discretised into four noded isoparametric finite elements. The material nonlinearity of soil has been modeled by Extended Drucker-Prager Yield Criterian , The nonlinear finite element equation has been solved by Full Newton-Raphson Iterative Procedure. The analysis has been done for one layer of soil having Modulus of Elasticity equal to 25000 kN/m^2 and cohesion 25 kN/m^2. The layered soil has three layers.. The thickness for first layer is 20 m, second layer equal to 20 m and third layer equal to 59 m.The first layer has modulus of elasticity equal to 25000 kN/m^2 and cohesion equal to 25 kN/m^2. the second layer has modulus of elasticity equal to 37500 kN/m^2 and cohesion equal to37.5 kN/m^2. The third layer has modulus of elasticity equal to 50000 kN/m^2 and cohesion equal to 50 kN/m^2.

RESULTS AND DISCUSSIONS

Fig.1 shows the loading intensity vs settlement curve for spacing to diameter ratio equal to 5 for one layer of soil. At any loading intensity the settlement of raft is greater than the piles. Pile with spacing to diameter ratio equal to 10 settles more than piles of spacing to diameter ratio 20 and 30. The pile of length to diameter ratio equal to 30 settles least.

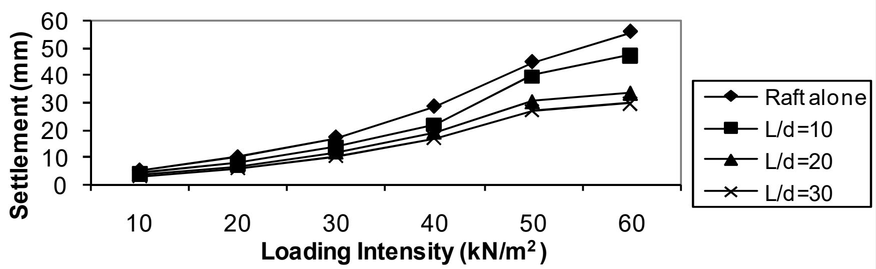

Fig.1 Loading Intensity vs Settlement Curve (S/d=5)

The Fig.2 shows the loading intensity vs settlement curve for S/d=10 for one layer of soil. The description is same as Fig.1. The loading intensity vs settlement curves are nonlinear

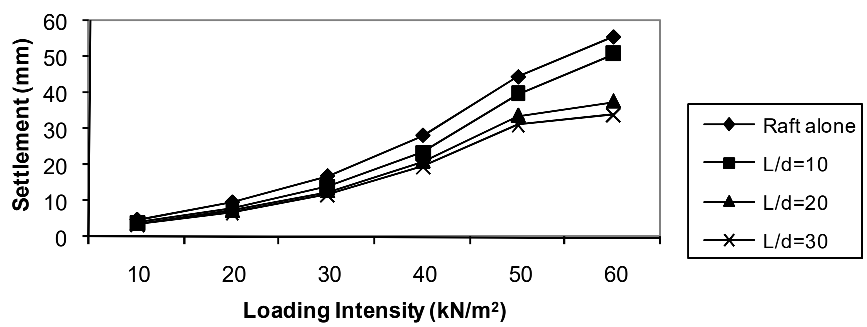

Fig.2 Loading Intensity vs Settlement Curve (S/d=10)

Fig.3 shows the loading intensity vs settelement curve for rafts on one layer of soil and layered soil. The total thickness is same for both one layer and layered soil. The variation of loading intensity vs settlement curve is nonlinear. The settlement of raft for one layer of soil is more at all loading intensity than that of layered soil. This is due to the fact that modulus of elasticity and cohesion of each layer is more with depth.

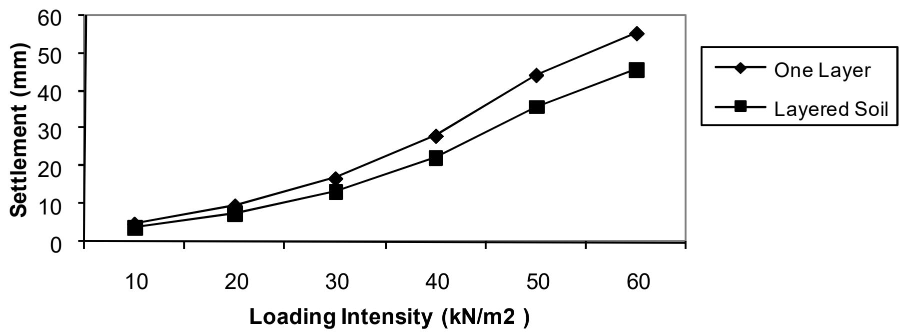

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Fig.3 Loading Intensity vs Settlement (Rafts)

Fig.4 shows the loading intensity vs settelement curve for pile of length to diameter ratio 10 and spacing to diameter ratio 5 for one layer and layered soil. The nature of curves are nonlinear. The settlement of pile is more in one layer of soil but it reduces in layered soil for all loading intensity.

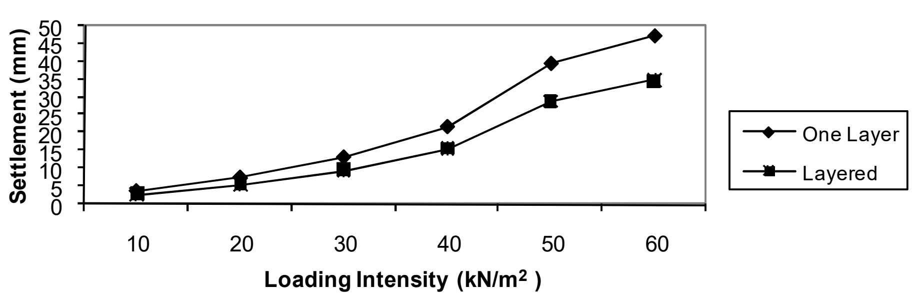

Fig.4 Loading Intensity vs Settlement Curve (L/d=10, S/d=5)

Fig.5 shows the loading intensity vs settlement curve for length to diameter ratio 10 and spacing to diameter ratio 10. The settlement of pile is less on layered soil than on one layer of soil for all loading intensities. The nature of curves are nonlinear.

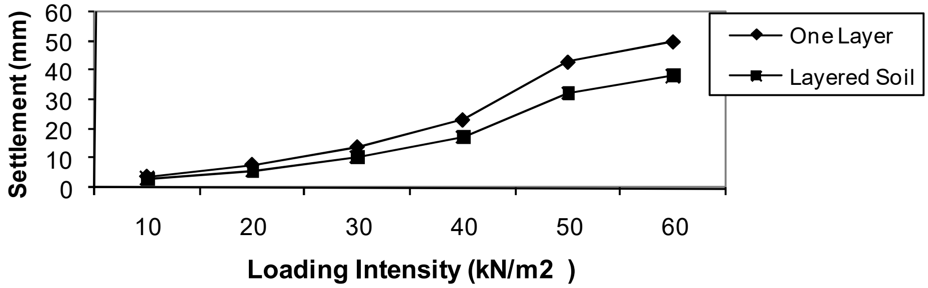

Fig.5 Loading Intensity vs Settlement Curve (L/d=10, S/d=10)

In Fig.6 the loading intensity vs settlement curves are nonlinear. Pile in Layered soil has less settlement than pile in one layer soil. The overall settlement for pile of L/d=20 is less than pile of L/d =10 for the same spacing to diameter ratio.

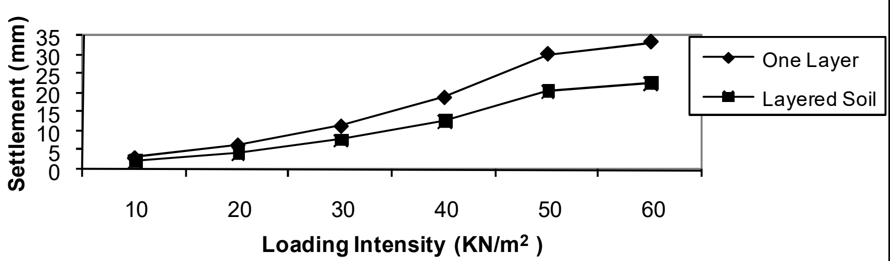

Fig.6 Loading Intensity vs Settlement Curve (L/d=20, S/d=5)

The description of load settlement curve for Fig.7 is same as Fig.6. As the S/d ratio is more the overall settlement of pile is more than for Fig.6. Pile in layered soil has less settlement than one layer soil. This is because the modulus of elasticity of second layer is greater than first layer and modulus of elasticity of third layer is greater than the second layer.

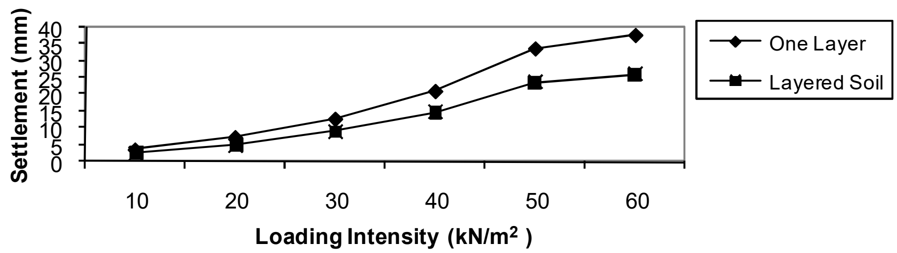

Fig.7 Loading Intensity vs Settlement Curve (L/d=20,S/d=10)

Pile of L/d ratio equal to 30 has least settlement than for piles of L/d=20 and L/d=10. The pile experiences less settlement in layered soil than in one layer soil.

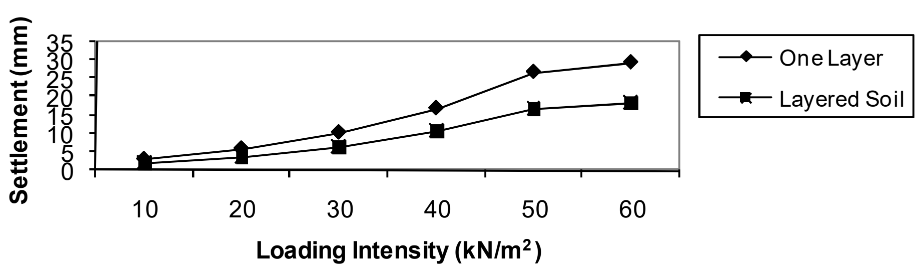

Fig.8 Loading Intensity vs Settlement Curve (L/d=30, S/d=5)

Fig.9 shows the loading intensity vs settlement curve for L/d=30 and S/d=10. This pile experiences larger settlement than the pile for which S/d=5. This is because the number of pile reduces.

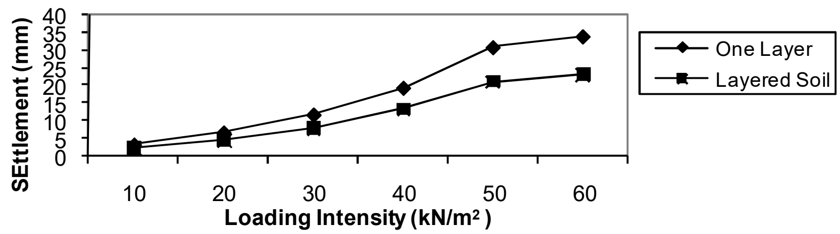

Fig.9 Loading Vs Settlement Curve (L./d=30, S/d=10)

Fig.10 shows the axial load distribution in pile of L/d =20 and S/d=5. The axial load at top is maximum and at bottom it is minimum for all centre, middle and end piles. The centre pile takes least load followed by middle pile and the end pile takes maximum load.

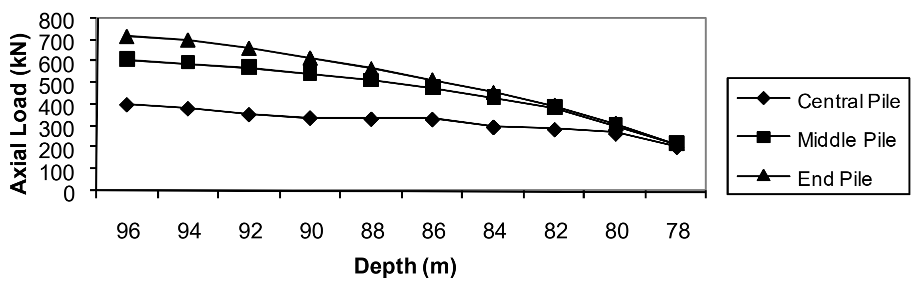

Fig.10 Axial Load Distribution (L/d=20, S/d=5, Udl=10 kN/m²)

Fig.11 shows the axial load distribution for L/d=20, S/d=5 and Udl=50 kN/m^2. For all piles the axial load is maximum at top and minimum at bottom. The middle pile and the end pile has same axial load upto depth 86 metre.

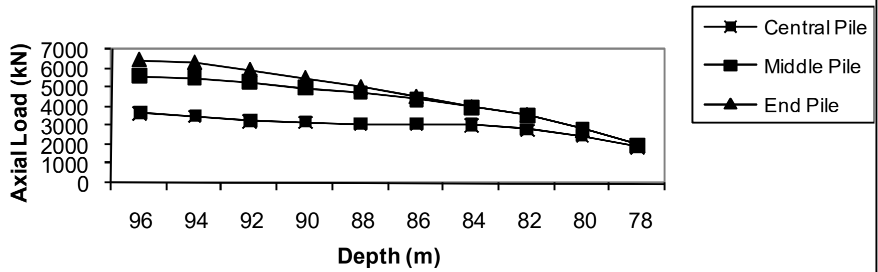

Fig.11 Axial Load Distribution (L/d=20, S/d=5, Udl=50 kN/m^2)

The nature of the curves are nonlinear.
The comparison of axial load distribution for central pile of L/d=10 and S/d =5 and udl=20 kN/m^2 has been shown in Fig.12. Except at bottom portion the pile has the same axial load distribution variation in one layer and layered soil.

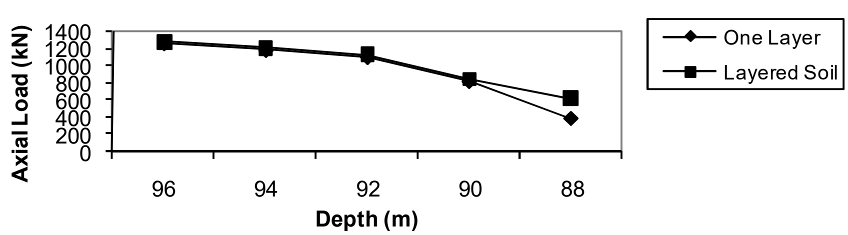

Fig.12 Comparison of Axial Load Distribution (L/d=10, S/d=5, Central Pile, Udl=20 kN/m^2)

Fig.13 shows the axial load distribution for pile of L/d=10 and S/d=5 for middle pile. In this case the axial load distribution is same for layered soil and one layer soil. This is because the first layer has same modulus of elasticity as the one layer of soil.

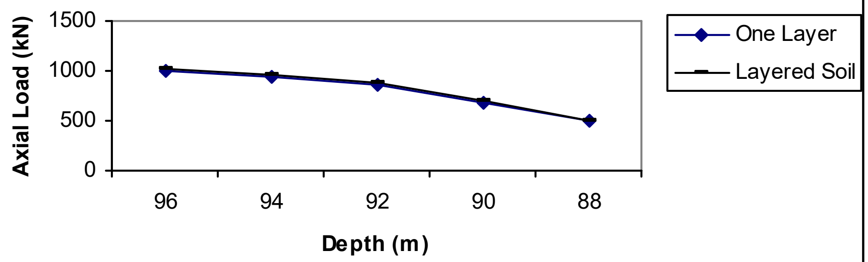

Fig.13 Comparison of Axial Load Distribution (L/d=10, S/d=5, Middle Pile, Udl=20 kN/m^2)

Fig.14 shows the axial load distribution of pile of L/d=10 for one layer soil and layered soil. The axial distribution is same for one layer and layered soil. This is because the pile in both cases terminates in the first layer i.e one layer.

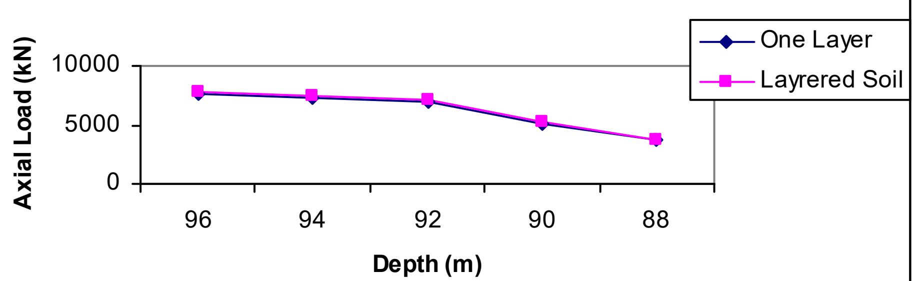

Fig.14 Comparison of Axial Load Distribution (L/d=10, S/d=5, Central PIle, Udl=60 kN/m^2)

Fig.15 shows the axial load distribution in pile of L/d=20 and S/d=5 in one layer and layered soil.. The axial load in pile in layered soil is more at all depths than the pile in one layer soil. This is because the pile terminates in a layer whose modulus of elasticity is more than the first layer.The nature of curves are nonlinear. The axial load is maximum at top and minimum at bottom.

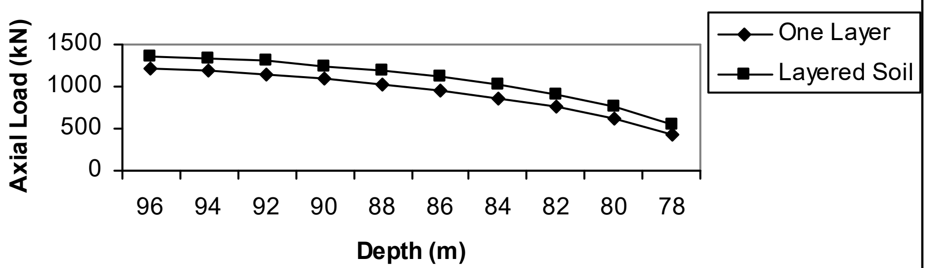

Fig.15 Comparison of Axial Load Distribution (L/d=20, S/d=5,Middle PIle, Udl=20 kN/m^2)

Fig.16 shows the axial load distribution for pile of L/d=30 in one layer and layered soil. The axial load distribution in pile is more for layered soil than one layer soil throughout the depth. This is because the pile terminates in layer for which the modulus of elasticity is more than the first layer.

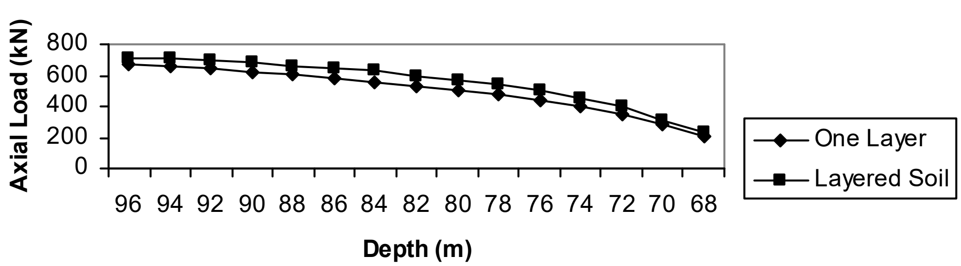

Fig.16 Comparison of Axial Load Distribution (L/d=30, S/d=5,Middle Pile, Udl=10 kN/m^2)

CONCLUSIONS

For one layer of soil at any loading intensity the settlement of raft is greater than the piles. Pile with spacing to diameter ratio equal to ten settles more than piles of spacing to diameter ratio equal to twenty and thirty. The pile of length to diameter ratio equal to thirty settles least. The loading intensity vs settlement curves are nonlinear. The settlement of raft for one layer of soil is more at all loading intensities than that of layered soil. The settlement of pile is more in one layer of soil but it reduces in layered soil. At any loading intensity pile for length to diameter equal to thirty and spacing to diameter ratio equal to ten experiences larger settlement than the pile for which spacing to diameter is equal to five for same length of pile For length to diameter equal to twenty and spacing to diameter equal to five, the axial load at top is maximum and at bottom it is minimum for all centre, middle and end piles. The centre pile takes least load followed by middle pile and the end pile takes maximum load. For all piles the axial load is maximum at top and minimum at bottom. The axial load distribution curves are nonlinear.The axial load distribution of pile of length to diameter equal to 10 is same for one layer soil and layered soil. The axial load distribution in pile of length to diameter equal to 20 and 30 and spacing to diameter equal to five., is more in layered soil than in one layer soil.

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