INTERACTION BETWEEN TWO PILED RAFTS BY NONLINEAR FINITE ELEMENT METHOD

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ABSTRACT

In finite element analysis the raft, pile and soil have been discretized into four noded isoparametric elements.. The raft and pile have been considered as linear elastic medium while the soil has been idealized as extended Drucker-Prager yield criterion Rigid behaviour at 2. meters thickness of raft is seen than the raft of thickness equal to 0.10. The settlement of piled raft decreases with increase in length of pile. When the distance between the two rafts and two piled rafts is smaller i.e. equal to 0.5 m, due to interaction the settlement of raft and piled raft is more than the raft and piled raft without interaction. The loading intensity verses settlement curves are observed to be as nonlinear The settlement of piled raft with distance 10 m is almost equal to the settlement of piled raft without interaction. Hence piled rafts must be provided at distance greater than equal to raft width. The axial load distribution curves for pile without interaction of piled rafts and the axial load distribution of pile for interaction of piled raft at distance 10 m coincide with each other. The axial load distribution for pile in piled rafts at distance equal to 0.5 m is larger at all depths than piles at other distances The reason is that the piled rafts interact more at distance 0.5 m than at other distances between piled rafts.With increase in distances between two piled rafts the interaction reduces and hence the axial load distribution decreases throughout the depth.

Keywords: Finite element, isoparametric, raft, pile, Drucker-Prager, yield criterion.

1.1 INTRODUCTION

In a soil-foundation-structure interaction problem the behaviour of foundation depends on the behaviour of soil and structure and the behaviour of structure depends on the behaviour of foundation and soil. Soil-structure-interaction in a single integral system has been reported in literature by [1], [2], [3],,[4], [5],[6] and [7]. The interaction between two integral systems has not been reported in literature. This means that interaction between two separate foundations or two separate structures on soil have not been reported in the literature. The present research work concentrates on interaction between two piled raft foundations on soil.

1.2 FINITE ELEMENT ANALYSIS

The two piled raft foundations have been placed at a distance from each other. Both the piled raft foundations are under the application of uniformly distributed and both piled raft are under plane strain condition. The raft pile and soil have been discretized into four noded isoparametric elements. The raft and pile have been considered as linear elastic medium while the soil has been idealized as extended Drucker-Prager yield criterion. Full Newton Raphson method has been used to solve the nonlinear finite element equation. The parameters varied are the length of pile, thickness of raft and distance between two piled rafts.

1.3 RESULTS AND DISCUSSIONS

Fig.1 showes the settlement for various thickness of raft foundation at loading intensity 10 kN/m^2. The settlement of raft for thicknesses 0.10, 0.5, 1.0 and 2.0 m has been shown in Fig.1. At thickness 0.10 the settlement is maximum and at 2.0 m it is minimum. The settlement of raft with thickness 2.0 is uniform while for other thickness it is not uniform.

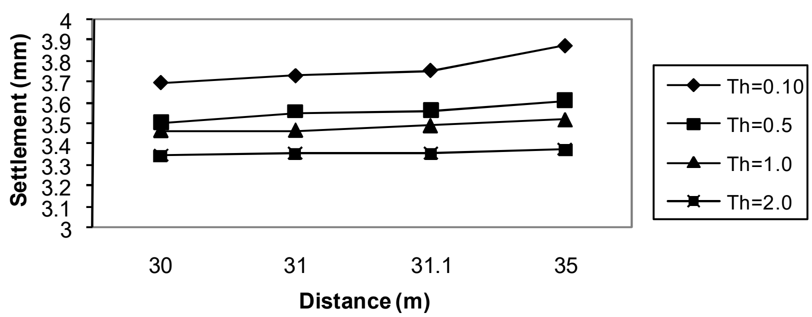

Fig.1 Comparision of Settlement (Loading Intensity=10 kN/m^2)

Fig.2 shows the settlement for various thickness of raft for loading intensity 40 kN/m^2. The total settlement at all thicknesses at this loading intensity is greater than that of loading intensity 10 kN/m^2. Even in this case the settlement is uniform for thickness 2 meters and it is nonuniform for other thicknesses. At 2 m thickness the settlement is uniform. The same thickness has been considered for all interaction analysis of raft and piled raft.

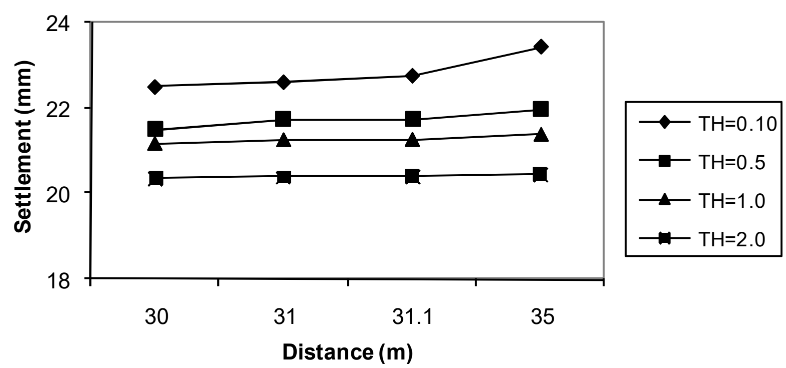

Fig.2 Comparison of Settlement, Udl=40 kN/m^2)

Fig.3 shows the loading intensity verses settlement for different pile lengths of piled rafts and raft alone. The settlement for raft is maximum. The settlement of piled raft decreases with increase in length of pile. The settlement is minimum for L/d ratio equal to 30 and maximum for L/d ratio equal to 10. The settlement of raft is greater than settlement of any of the piled raft of various lengths of piles.

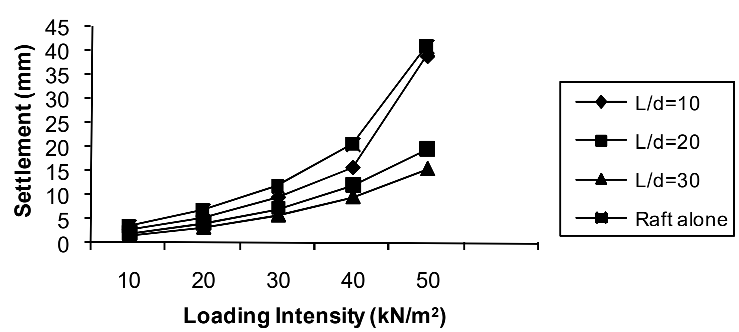

Fig.3 Loading Intensity vs Settlement curve (No Interaction)

Fig.4 shows the loading intensity verses settlement curve for interaction between two rafts and piled rafts. The distance between the two rafts and two piled rafts is equal to 0.5 m. It can be seen that due to interaction the settlement of raft and piled raft is more than the raft and piled raft without interaction (Fig.3). The settlement reduces with increase in length of pile. Even pile of length to diameter ratio equal to 10 reduces the settlement significantly.

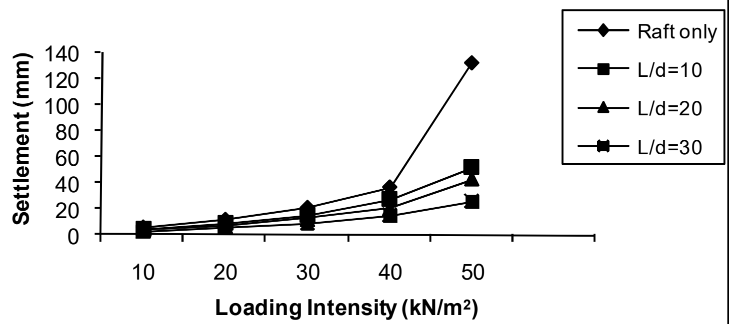

Fig.4 Loading intensity vs Settlement curve (Interaction, D=0.5 m)

Fig.5 shows the loading intensity verses settlement curve for distance between rafts and piled rafts equal to 4m. At a given loading intensity the settlement of raft foundation is maximum followed by piled raft of length to diameter equal to 10. The settlement of piled raft having pile to diameter ratio 20 is less than piled raft of pile length to diameter ratio 10 and the settlement is minimum for piled raft having pile length to diameter ratio 30. For the same loading intensity the settlement of rafts and piled raft (Fig.5) is less than the settlement of rafts and piled raft (Fig.4).

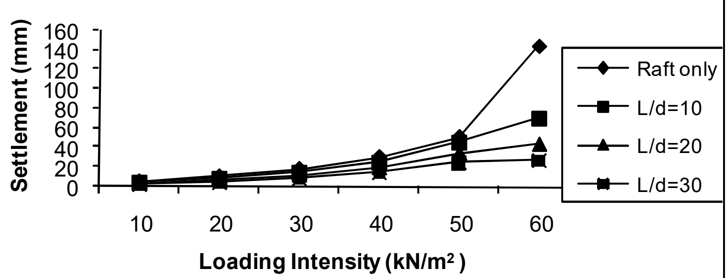

Fig.5 Loading intensity vs Settlement curve (Interaction, D=4 m)

Fig.6 shows the loading intensity verses settlement curve for rafts and piled rafts which are at distance equal to 10 m from each other. The settlement of rafts and piled rafts (Fig.6) is less than the settlement of rafts and piled rafts (Fig.5) for different length to diameter ratio of piles.

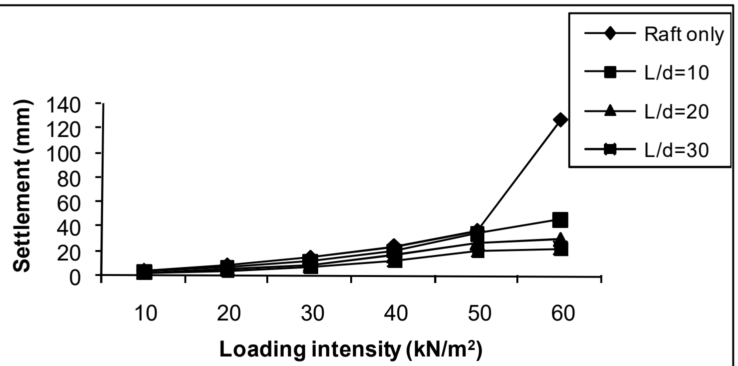

Fig.6 Loading intensity vs Settlement Curve (D=10 m)

Fig.7 shows the comparison of settlement between loading intensity verses settlement curve of raft foundation at various distances between the rafts. When there is no interaction (No.INT) settlement is minimum. When the distance between rafts is 0.5 m, the settlement is maximum. With increase in spacing settlement reduces. This shows that rafts has more interaction between each other at smaller spacing than at larger spacing.

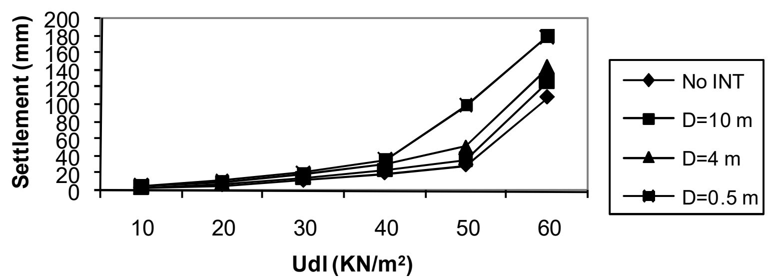

Fig.7 Comparison of Settlement (Raft Alone)

Fig.8 shows the comparison of settlement for various distances between piled rafts having length to diameter of pile equal to 10. The loading intensity verses settlement is nonlinear. The piled rafts at smaller distance between each other interacts more than the piled rafts at larger distances. Due to interaction the settlement of piled raft is more at smaller distance than at large distances between them.

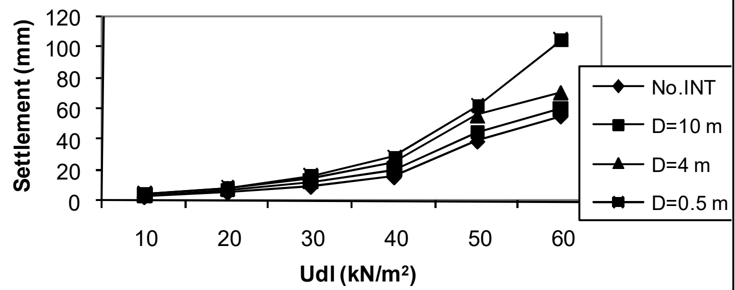

Fig.8 Comparison of Settlement (L/d=10)

Fig.9 shows the comparison of settlement at various distances for piled raft having piles of length to diameter 20. At smaller distance (0.5m) the settlement is maximum and it reduces with increase in distance. This is due to the fact that at smaller distance the interaction is more than at larger distance. The settlement is minimum when there is no interaction between the piled rafts. The piled raft having pile of length to diameter ratio 20 has comparatively less settlement than the piled raft having length to diameter equal to 10 meters for all the distances between piled rafts.

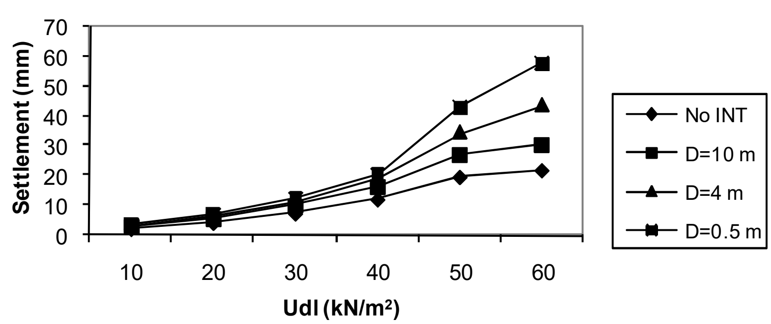

Fig.9 Comparison of Settlement (L/d=20)

Fig.10 shows the comparison of settlement with loading intensities at various distances between piled rafts. The loading intensity verses settlement curves are nonlinear. The settlement is maximum at smaller distance and least for piled raft without interaction(No.INT). Hence interaction between two piled raft are maximum at short distances and then decreases with increase in distance. The piled raft without interaction has least settlement.

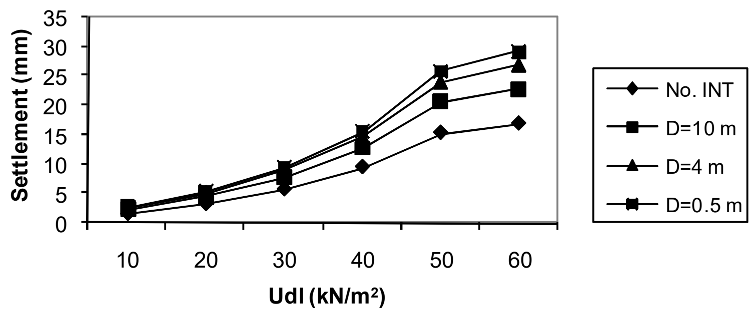

Fig.10 Comparison of Settlement (L/d=30)

Fig.11 shows the axial load distribution curve for various distances between piled rafts for loading intensity 10 kN/m^2 and pile length to diameter ratio equal to 20. For all distances the axial load is maximum at the top of pile and minimum at the bottom of pile. The axial load distribution curves for pile without interaction of piled rafts and the axial load distribution of pile for interaction of piled raft at distance 10 m coincide with each

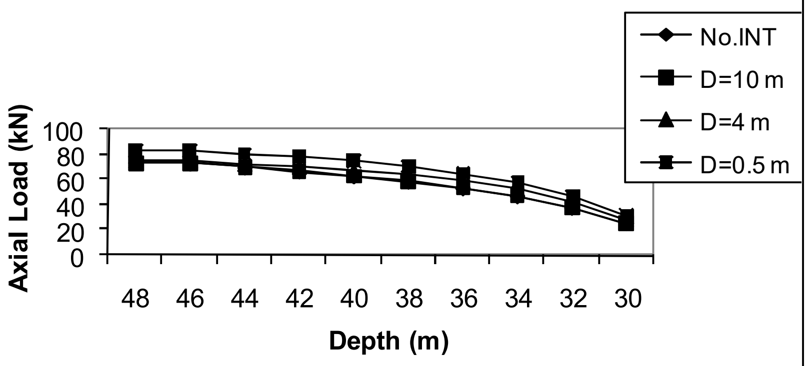

Fig.11 Axial Load Distribution (Udl=10 kN/m^2 ,L/d=20)

other. The axial load distribution for pile in piled rafts at distance equal to 0.5 m is larger at all depths than piles at other distances The reason is that the piled rafts interact more at distance 0.5 m between the piled rafts than at other distances between piled rafts.

The explanation for axial load distribution with depth in Fig.12 is same as Fig.11. With increase in loading intensity the axial load carried by pile is more (Fig.12) than the pile of Fig.11.

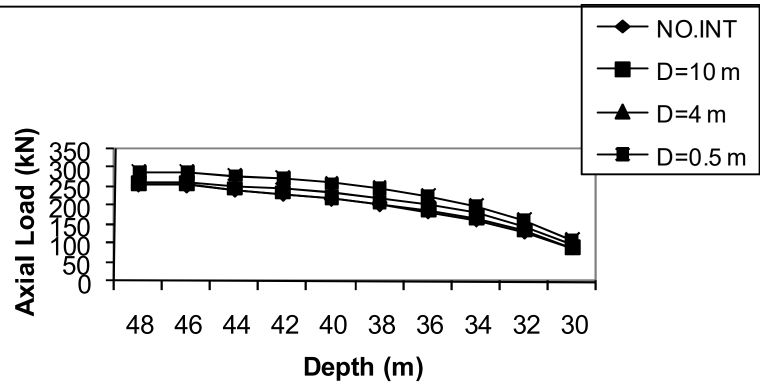

Fig.12 Axial Load Distribution (Udl=30 kN/m^2 ,L/d=20)

Fig.13 shows the axial load distribution in pile for interaction at various distances for length to diameter ratio 20 and loading intensity 60 kN/m^2. When two piled rafts are at closer distance interaction is more and hence the axial load is maximum throughout the length. With increase in distances between two piled rafts the interaction reduces and hence the axial load distribution decreases throughout the depth. At 10 m distances

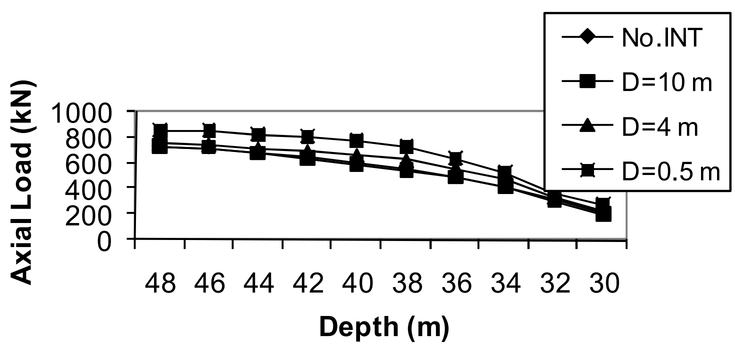

Fig.13 Axial Load Distribution (Udl=60 kN/m^2 ,L/d=20)

between two piled rafts the axial load distribution coincides with the axial load distribution with no interaction. This shows that at 10 m distance between piled rafts the interaction is very very small.

Fig.14 shows the axial load distribution in pile with depth. The axial load is maximum at top and minimum at bottom for all distances between piled rafts. With increase in distance between the piled rafts , interaction is less and hence pile takes lesser load throughout the depth.

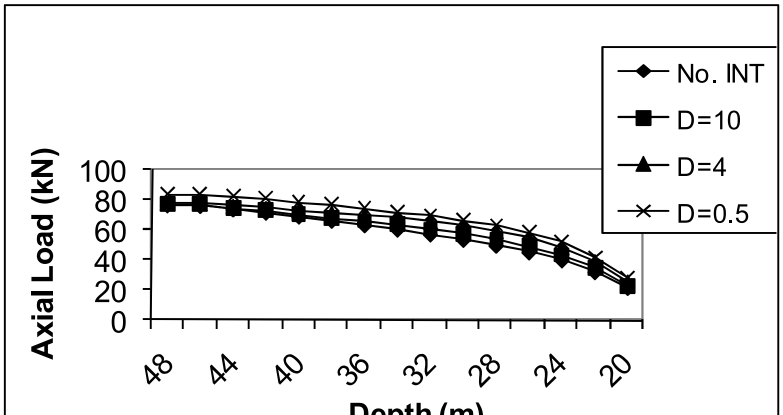

Fig.14 Axial Load Distribution (Udl=10 N/m^2, L/d=30)

Fig.15 shows the variation of axial load with depth for different distances between piled rafts. For all distances the axial load in pile is maximum at the top and minimum at the bottom. The value of axial load at distance 0.5 is maximum throughout the depth. This is so because of maximum interaction between the two piled rafts. With increase in distances the axial force distribution decreases throughout the depth. This is least at 10 m distance which is almost equal to value with no interaction.

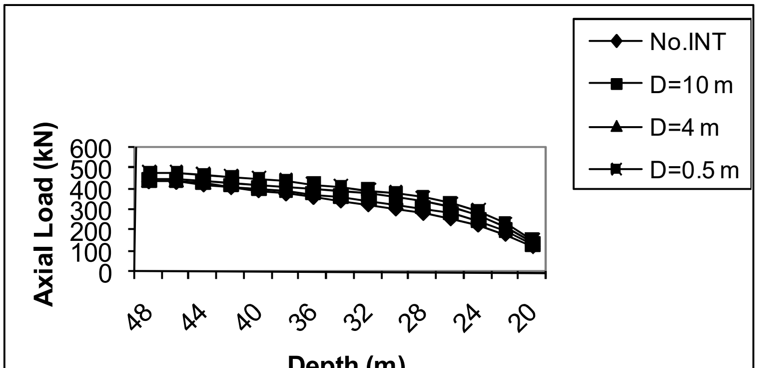

Fig.15 Axial Load Distribution (Udl=40 kN/m^2 ,L/d=30)

Fig.16 shows the axial load distribution for L/d=30. The axial load distribution for pile of piled raft for loading intensity 60 kN/m^2 is greater than the loading intensity of 40 kN/m^2 for all distances between piled rafts. When distance is 0.5 the interaction is maximum and hence the variation of axial load distribution is also maximum through out the depth. At distance 10 m the axial load distribution is almost equal to the value without interaction. Hence the two piled rafts should be placed at 10 m distance i.e when the distance becomes equal to width of the raft for almost no interaction.

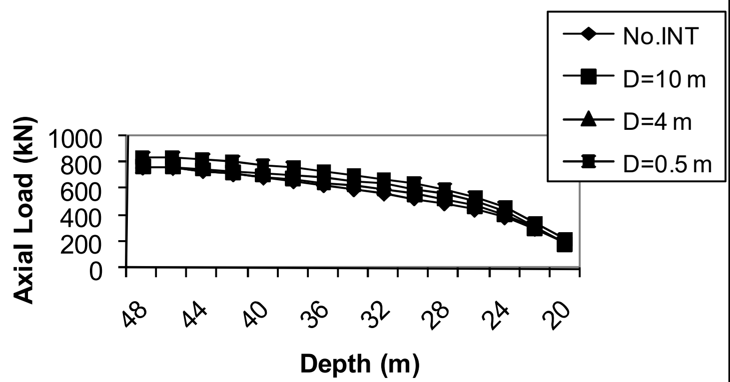

Fig.16 Axial Load Distribution (Udl=60 kN/m^2 ,L/d=30)

1.4 CONCLUSIONS

At thickness 0.10 m the settlement is maximum and at 2.0 m it is minimum. The settlement of raft with thickness 2.0 is uniform while for other thickness it is not uniform. This shows the rigid behaviour at 2. meters thickness of raft. The settlement of piled raft decreases with increase in length of pile. The settlement is minimum for L/d ratio equal to 30 and maximum for L/d ratio equal to 10. The settlement of raft is greater than settlement of any of the piled raft of various length of piles. When the distance between the two rafts and two piled rafts is smaller i.e. equal to 0.5 m, due to interaction the settlement of raft and piled raft is more than the raft and piled raft without interaction With increase in distances between two piled rafts the interaction reduces and hence settlement also reduces. This shows that rafts has more interaction between each other at smaller spacing than at larger spacing. Due to interaction the settlement of piled raft is more at smaller distance than at large distances between them. The loading intensity verses settlement curves are observed to be as nonlinear The settlement of piled raft with distance 10 m is almost equal to the settlement of piled raft without interaction. Hence piled rafts must be provided at distance greater than equal to raft width. The axial load distribution curves for pile without interaction of piled rafts and the axial load distribution of pile for interaction of piled raft at distance 10 m coincide with each other. The axial load distribution for pile in piled rafts at distance equal to 0.5 m is larger at all depths than piles at other distances The reason is that the piled rafts interact more at distance 0.5 m than at other distances between piled rafts.With increase in distances between two piled rafts the interaction reduces and hence the axial load distribution decreases throughout the depth. For length to diameter ratio 30 the axial load distribution for pile of piled raft for loading intensity 60 kN/m^2 is greater than the loading intensity of 40 kN/m^2 for all distances between piled rafts.

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