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EFFECT OF VARYING SOIL STIFFNESS IN PILED RAFT FOUNDATON

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Abstract: Nowadays piled raft foundation is extensively used for construction of high rise buildings. Piled raft foundation can be used in both soft as well as hard soils. In this study, a high rise building is analysed in order to estimate the effect of varying soil stiffness on piled raft foundation. For analysis of superstructure ETABS software is used. SAFE software is used for analysis of Piled Raft Foundation. The analysis has been performed to determine variation of settlements, differential settlements and load carrying capacity of piles and raft with varying soil stiffness.

Keywords: **Piled raft foundation, soil stiffness, settlements, differential settlements.**

1. Introduction

In past few years, the construction of tall structures has become increasingly common and with them new challenges strikes both the structural and geo-technical engineers. There have been many building projects built on soft soil in latest years. Because of soft soil features, the structures constructed on it are subjected to differential settlements. In such cases, raft foundation alone cannot satisfy upward pressure and differential settlement requirements. The layout is one of the ways in which differential settlement can be reduced. To reduce differential settlements and to satisfy upward pressure piles are provided strategically along with raft foundation. Such foundation is called piled raft foundation.

The main advantages of piled raft foundations are:

1. Settlements, differential settlements and tilts can be reduced.
2. Increases overall stability of foundation.
3. No. of piles required are reduced in comparison with conventional pile foundation where bearing effect of raft is not taken into consideration.
4. Bending stresses in raft can be greatly reduced.
5. Overall cost of the foundation is reduced.
6. Piled raft is effective in stiff as well as soft clays.

Following Soil profiles are favourable for piled raft foundation:

- Soil profiles consisting of relatively stiff clays.
- Soil profiles consisting of relatively dense sand.

Following Soil profiles are not favourable for piled raft foundation:

- Soil profiles containing soft clays near the surface.
- Soil profiles containing loose sand near the surface.
- Soil profiles that containing soft compressible layers at relatively shallow depths.
- Soil profiles that are likely to undergo swelling movements due to external causes.
- Soil profiles likely to undergo consolidation settlements.

2. Methodology

In this topic, the philosophy of modelling piled raft has been explained using combined structural-geotechnical approach. Initially to observe the behaviour of piled raft, piles are modelled as spring and raft as beam on elastic foundation as shown in Fig. 1.

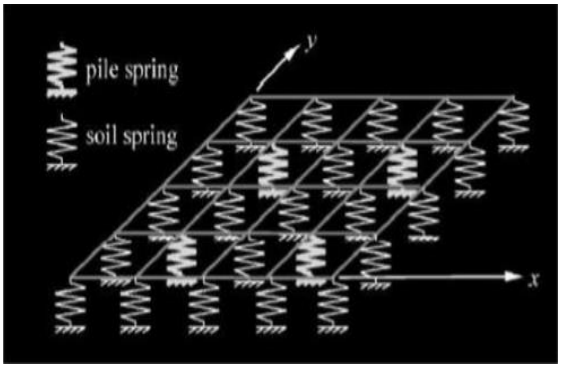

Fig. 1- Structural Idealization for Raft with Pile and Supporting Soil

For this study, SAFE software is used for analysis of piled raft. The superstructure is first analysed in ETABS software and following design parameters are considered:

Table 1 – Data considered for Modelling of Superstructure

Floor Finish	1.5 KN/m^2
Live Load	2 KN/m^2 for Rooms 3 KN/m^2 for Passage and Staircase
Wall Load	8 KN/m^2
Wind Load	As per IS: 875 - Part III (2015)
Earthquake Load	As per IS: 1893 (2016)
Method of Dynamic Analysis	Response Spectrum Method
No. of Stories	G + 45
Total Height of Building	149.7m
Grade of Concrete	M 60
Grade of Steel	Fe 550

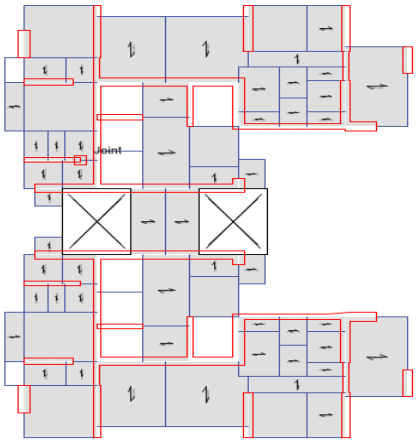

Fig. 2 - Typical Floor Plan of G+45 Storey Building

Modelling of Piled Raft Foundation

Determination of No. of Piles Required for Piled Raft

- .Load from superstructure = 985735 KN
- Safe bearing capacity of soil = 300 KN/m^2
- Permissible settlement = 8mm
- Subgrade modulus = SBC / Settlement
  = 37500 KN/m2/m
- Load taken by raft = Area of raft X SBC
  = 269262 KN
- Load to be taken by piles = Load from superstructure – Load taken by raft
  = 716473 KN
- No. of piles required = $\frac{716473}{10000}$ = 71.64 ~ 72 Nos

However, considering geometry of figure and to satisfy permissible settlement requirements,
Provide 84 No. of 1000mm Diameter piles.

- Stiffness of point spring
  $= \frac{\text{Capacity of one pile in KN}}{\text{Permissible Settlement in mm}} = \frac{10000}{8}$
  = 1250 KN/mm

To consider the effect of soil-structure interaction, piles are modelled as point springs. The spring stiffness value of 1250 KN/mm is applied to each spring. Fig. 3 shows layout of piled raft foundation. Fig. 4 and Fig. 5 shows upward pressure and displacement in piled raft foundation respectively.

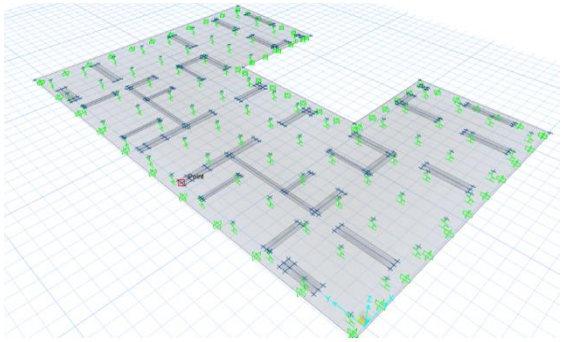

Fig. 3 – Layout of Piles in Piled Raft Foundation

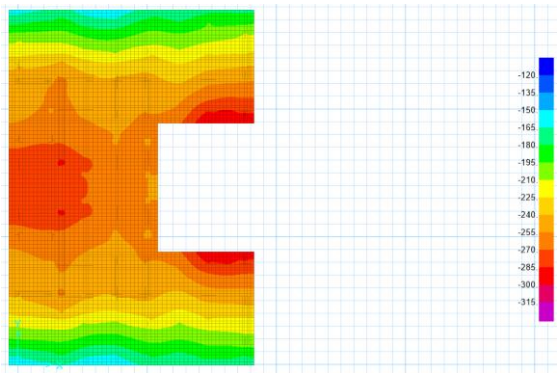

Fig. 4 – Upward Pressure in Piled Raft Foundation (300 KN/m^2)

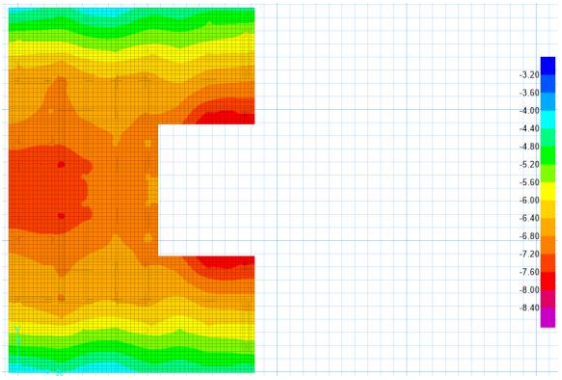

Fig. 5 – Displacements in Piled Raft Foundation (8.00 mm)

Determination of Effect of Varying Soil Stiffness

To determine the effect of soil stiffness on piled raft for same raft thickness, pile length and pile diameter different soil stiffness are considered. (18750KN/m^3, 37500 KN/m^3, 56250 KN/m^3 and 75000 KN/m^3). Effect of varying soil stiffness in terms of settlements, differential settlements and load carrying capacity are then observed

3. Results and Discussions

Effect of Varying Soil Stiffness on Settlements and Differential Settlements in Piles and Raft

The following table shows variation in settlements and differential settlements in piles and raft with variation in soil stiffness.

Table 2- Effect of Varying Soil Stiffness on Settlements and Differential Settlements in Raft and Piles

Stiffness of Soil	18750	37500	56250	75000
Max Settlement in Raft	9.03	8	7.2	6.55
Differential Settlement in Raft	4.39	3.95	3.66	3.42
Max Settlement in Piles	8.47	7.51	6.76	6.15
Differential Settlement in Piles	3.41	3.14	2.93	2.74

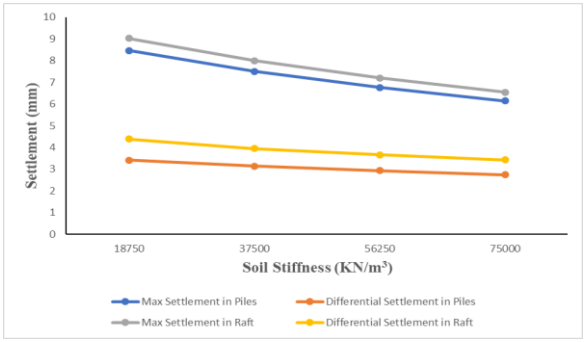

Fig. 6 – Graph of Soil Stiffness V/s Settlements in Raft and Piles

Effect of Varying Soil Stiffness on Load Carrying Capacity of Piles and Raft

For a G + 45 storey building, increase in stiffness of soil below raft results in increase in load taken by the raft. Fig. 7 shows effect of soil stiffness on load carrying capacity of piled raft.

Table 2- Effect of Soil Stiffness on Load Carrying Capacity of Raft and Piles

Stiffness of Soil (KN/m^3)	Load taken by Piles (KN)	Load taken by Raft (KN)	Load Taken by Piles (%)	Load Taken by Raft (%)
18750	741525	55515	93.1	6.9
37500	651310	145730	81.72	18.28
56250	580950	216090	72.89	27.11
75000	524540	272500	65.81	34.19

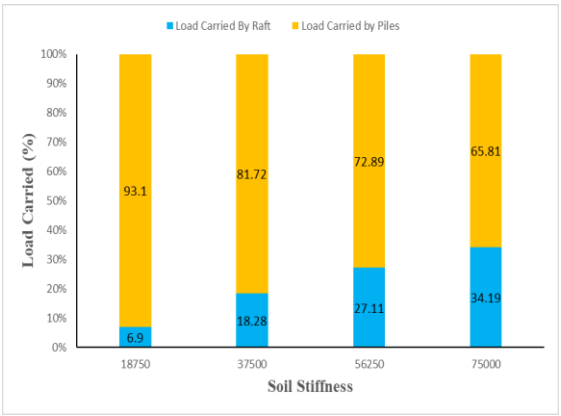

Fig. 7 – Graph of Soil Stiffness V/s Load Carrying Capacity of Raft and Piles

4. Conclusions

From the studies, the following points have been observed.

- Max settlement in raft and piles decreases with increase in stiffness of soil.
- Differential settlement in raft and piles decreases with increase in stiffness of soil.
- Load shared by raft increases with increase in stiffness of soil.

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