

# Effect of Pile Cap Thickness Variation on Load Carrying Capacity of Piled Foundation in Tall RC building

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**Abstract** –Pile foundation is a popular deep foundation type used to transfer superstructure load into subsoil and bearing layers. However, accurate prediction of piles settlement is particularly difficult concerning complicated consolidation process and pile. In this paper, a RC tall building on Piled foundations are analysed. The RC tall building has been analysed by using ETABS and finite element software SAFE is used to analyse the piled foundation of tall building. The analysis has been performed to estimate the settlements, differential settlement and bending moment variation with varying depth of pile cap.

**Key Words:** Pile foundation, pile cap, RC tall building, settlements, SAFE 2012.

## 1. INTRODUCTION

When a soil of low bearing capacity extends to a considerable depth, piles are generally used to transmit vertical and lateral load to the surrounding soil media. Piles that are used under tall chimneys, television towers, high rise buildings, high retaining walls, offshore structures, etc. are normally subjected to high lateral loads. These piles or pile groups should resist not only vertical movements but also lateral movements. It is a common practice in the foundation design to consider first the use of shallow or raft foundation to support a structure, and then if this is not adequate, to design a fully piled foundation in which the entire design loads are resisted by the piles.

### 1.1 The Advantages Of Using Piles

- They can be precast to specifications. They can be pre-made into any length, shape, and size and used on site thus reducing the completion time.
- The piles give a clean and neat presentation thus requiring minimum supervision and less storage space.
- The piles can be used in places that do not allow drilling of holes because of borrowing and finding pressurized underground water tables.

## 2. Methodology

Following methodology is adopted for analysis work-

1. Modelling of a proposed real building plan by using ETABS.
2. Modeling of piled foundation of tall building by using SAFE.
3. Evaluating the settlements, differential settlement and bending moment variation with varying pile cap.

## 3. Modeling and Analysis of Tall Buildings

The superstructure is first analyzed in ETABS software and following design parameters are to be consider i.e. Dead load: 1.5KN/m<sup>2</sup>

Live load: 2.0KN/m<sup>2</sup> (live load of 3kN/m<sup>2</sup> and 5kN/m<sup>2</sup> are provided for passage and stair case slab.)

Siporex blocks of density 8KN/m<sup>3</sup> are used for walls.

Number of stories: 56.

Floor to floor height: 3.5 m.

Slab is modeled using rigid diaphragm.

Wind load is considered as per IS: 875. (Part III)

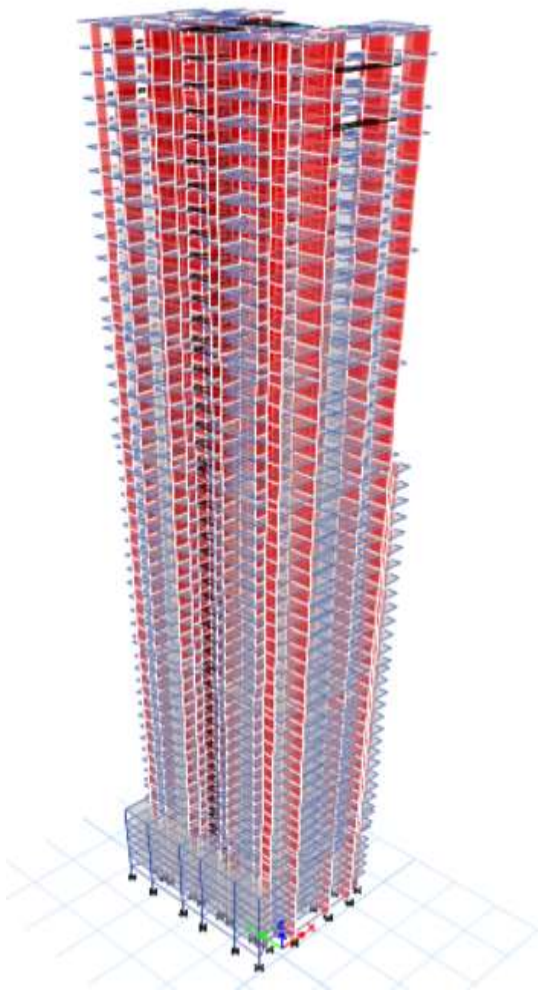
Earth quake load is considered as per IS: 1893-2002.

(Moment resisting frame with response reduction factor of 4, zone III & 5% damping is provided.)

The building is analyzed for dynamic load using Response Spectrum Method.

The maximum top storey displacements for wind in X & Y directions are 257.490 & 251.02 mm respectively. The maximum top storey displacements for earth quake in X & Y directions are 111.518 mm and 195.198 mm respectively.

The maximum top storey drifts for wind in X & Y directions are 0.00168 & 0.00164 mm respectively. The maximum top storey drifts for earth quake in X & Y directions are 0.00736 mm and .00128 mm respectively. Dynamic analysis has been performed and 12 modes are considered. The maximum time period for the first mode is found to be 6.176 seconds. Here is the 3d model of superstructure which is analyzed in ETABS software.



1: 3-D model of 56 storey building.

### 3.1 Modeling and analysis of Piled foundation

The pile foundation of same building has been analyzed In SAFE. The piles are attached as point spring of equivalent stiffness as 1387KN/mm, the length and diameter of pile 20 & 1m respectively. The thickness of pile cap is consider as 2.5m. The piles are uniformly distributed with horizontal spacing of 3m and vertical spacing of 4m. The permissible settlement as 10mm and working load carrying capacity of pile is consider as 10000KN.

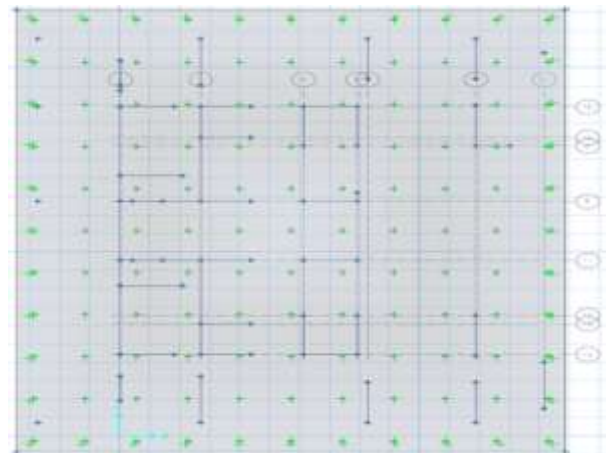


Fig -2: Layout of Pile foundation (Plan view)

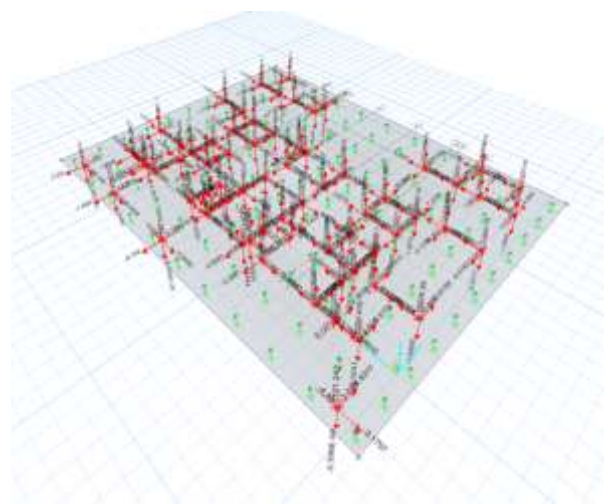


Fig -3: Load acting on piles (3D view)

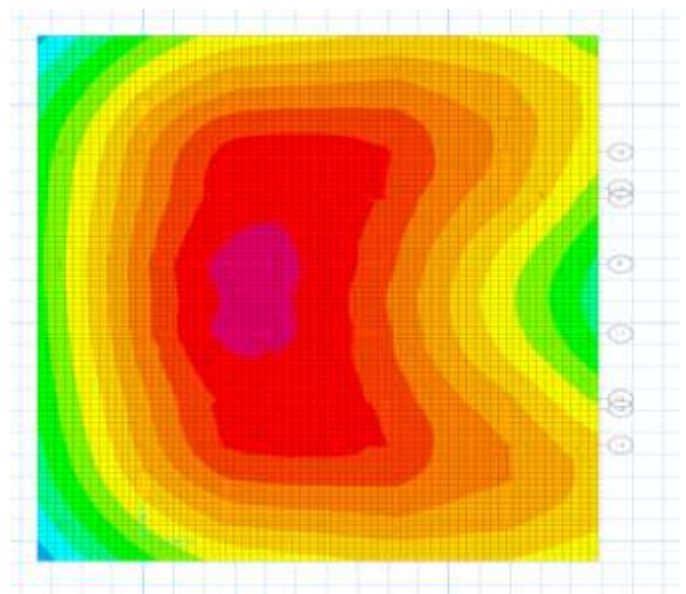


Fig -4: Displacement of pile cap (in mm)

#### 4. Result and Discussion

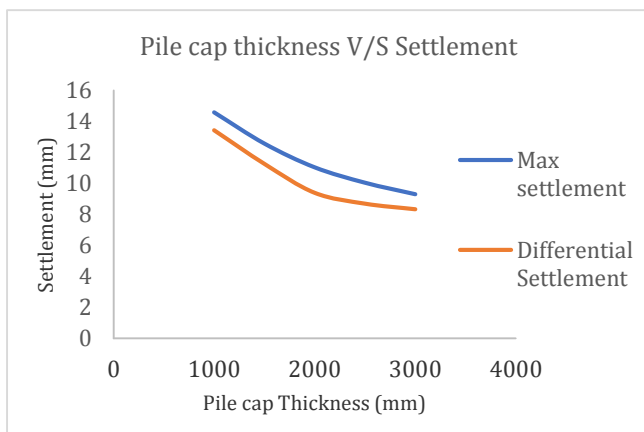
The RC tall building has been studied on piled foundation and results has been evaluated in terms of maximum, minimum and differential settlement with varying depth and also bending moment variation of piled foundation with varying depth of pile cap.

##### 4.1 Maximum Settlement and Differential Settlement

For a 56 storey building, increasing the pile cap thickness settlement reduces up to certain extent also the differential settlement reduces considerably. Initially the thickness of pile cap was 1m and the settlement was found to be 14.58mm and differential settlement was also 13.43mm. After increasing the thickness to 3.0m with an increment of 500mm, it has been observed that the settlement reduces to 9.31mm, whereas differential settlement reduces to 8.34mm.

**Table -1:** Shows effect of varying pile cap thickness on pile.

| Pile Cap(m) | Settlement (mm) | Differential Settlement (mm) |
|-------------|-----------------|------------------------------|
| 1           | 14.97           | 12.929                       |
| 1.5         | 12.51           | 10.75                        |
| 2           | 11.04           | 9.39                         |
| 2.5         | 10.05           | 8.69                         |
| 3           | 9.31            | 8.34                         |



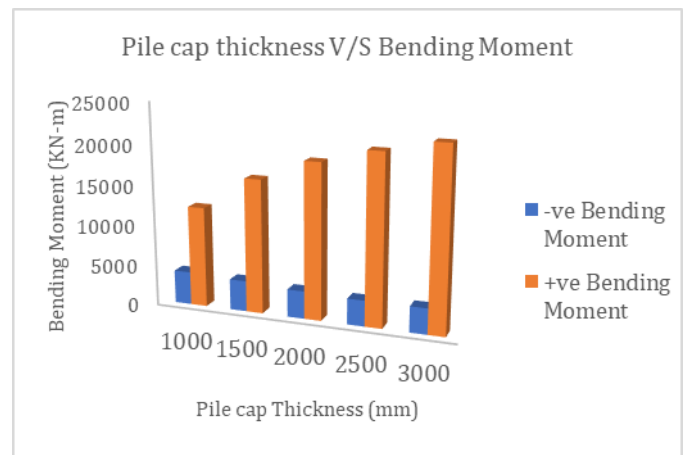
**Fig -4:** Graph shows Pile Cap thickness v/s Settlement

##### 4.2 Bending Moment

It is also observed that with increase in pile cap thickness the dead load increase which results in increase in maximum bending moment. However increase in raft thickness is advantageous for punching shear. Table -2 shows the variation of maximum positive and negative moment with increase in pile cap thickness.

**Table -2:** Shows the variation of maximum +ve and -ve moment

| Pile Cap (m) | Max +ve Bending Moment (kN-m) | Max -ve Bending Moment (kN-m) |
|--------------|-------------------------------|-------------------------------|
| 1            | 12352.97                      | 4081.30                       |
| 1.5          | 16406.63                      | 3795.05                       |
| 2            | 19004.36                      | 3399.01                       |
| 2.5          | 20743.59                      | 3170.54                       |
| 3            | 22147.22                      | 3165.76                       |



**Fig -5:** Graph shows Pile Cap thickness v/s Bending Moment

#### 5. CONCLUSIONS

The studies indicate that pile foundation concept has significant advantages in deep foundation foundation type used to transfer superstructure load into subsoil and bearing layers.

- With the increase in pile cap thickness the positive and Negative bending moment of pile cap increases.
- With the increase in pile cap thickness the settlement and differential settlement decreases.

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