# To Investigate The Optimization of Pile Foundation System In High Rise Building

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***Abstract***- *Pile foundations are mostly adopted for various types of multi storied and industrial structures, buildings and offshore structures. In the design process, ground conditions (soil type) play an major role in terms of seismic loads transferred to foundation and foundation capacity. These soils are characterized by low bearing capacity and high compressibility. Piling is costly but often necessary when buildings are high rise structures. This deals with optimization of pile groups with respect to placement in order to minimize the number of piles, length of piles and diameter of piles. In traditional design of pile foundations with large caps, the super structure loads are assumed to be carried by piles only and contact between the pile cap and ground surface is purposefully ignored. Pile foundation behavior is calculated with many researches and the effect of pile length; pile distance, pile arrangement and cap thickness are obtained under vertical or horizontal static and dynamic loading. The influence of pile length configurations on behavior of multi-storied are calculated under vertical loading. In pile foundations, the optimization is very important for structures.*

***Keywords***- Pile foundations, bearing capacity, optimization, etc.

## I. INTRODUCTION

In foundation engineering, commonly the most popular types of foundations used for high rise buildings or special structures are pile foundations. Now a days, due to quick urbanization all over the world has led to increase in number and height of high rise building because of limited space. Normally while analyzing the building the base is considered as fixed and no reaction from the resting face is considered. But actually the underlying strata have to be considered for the analysis, here comes the soil structure interaction. In this research a high-rise building is analyzed on different parameters, and the foundation is designed for each case. For a single building we can see the variation in the foundation provided according to different angle of internal friction. To reduce the settlement the piles is used. The high-rise building is designed and most desirable foundation design is adopted on the basis of studies conducted on the prototype.

Since many of these large structures are based on pile foundations, the demand for soil-pile-structure analyses is important, thus affecting the functionality of modern engineering structured design according to the most advanced seismic standards. Imaginary research has concentrated on studying and assuming the dynamic behavior of piles and piles groups subjected to seismic excitation since the early 1980s.

## II. METHODOLOGY

The studies are conducted on the mathematical prototype model created in ETABS version 16, with G+25 storey. The three dimensional model is created from the plan with 31.65m x 26.70 m dimensioned plan. Loads considered are taken in accordance with IS-1893(part1)-2016 and IS-875(part3)-2015. All load combinations in code is considered for the analysis and the building conditions are checked after analysis in software. Calculations and design of foundations are based on related codes, IS 2911 (part 1 to 4) -2010 (for pile foundations), and IS 6403-1981. The analysis of the structure, maximum shear forces, bending moments, storey displacements are computed and compared for all cases. From the calculated model the total load acting on the base joints are calculated differently for designing the foundation.

The soil pressure and settlement of each foundation is studied after the analysis in ETABS version 16. The pile foundation is provided in appropriate cases to obtain the optimum design using soil springs and pile springs.

## III. MODELLING IN ETABS

The mathematical model of G+25storey building is created in ETABS with following details given in table 1 and table 2. The table-1 shows the building description including structural details, material details and table-2 shows loadings, seismic load conditions, wind load conditions etc.

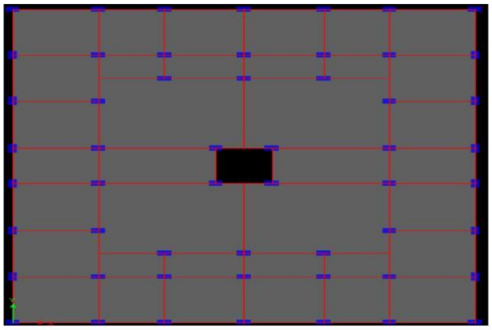

**Fig-1.**Plan view of ground floor of prototype

**TABLE 1.** Building description

| | |
|---|---|
| Number of storey | 26 |
| Height of building | 78m |
| Dimensions of building | 30.185 x 26.70 m |
| Grade of concrete | M50 |
| Grade of rebar | HYSD 550 |
| Size of beams | 300 X 600 mm |
| Size of columns | 500 X 800 mm |
| Width of slab | 150 mm |
| Support conditions | FIXED |

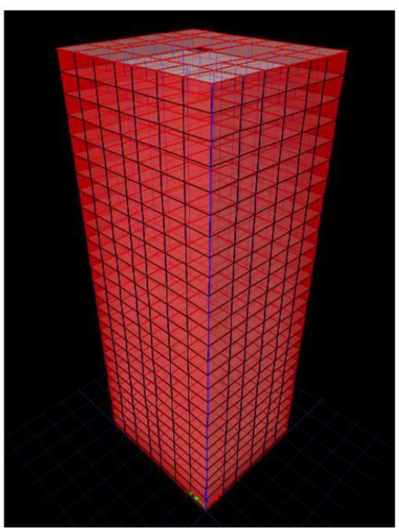

**Fig-2.** 3-D Model of G+25 Storey

**TABLE 2.** Loading conditions

| ShellLoads | |
|---|---|
| Live Load | 3 KN/m$^2$ |
| Dead Load | 3.75 KN/m$^2$ |
| **Seimsic load conditions** | |
| Zone | IV |
| Zone factor | 0.24 |
| Importance factor | 1.2 |
| Response reduction factor | 3 |
| **Wind load conditions** | |
| Structure class | C |
| Terrain category | Category 4 |
| Wind speed | 47m/s |

**TABLE 3.** Pressure Loading for Wind

| Ht.(m) | Sea faces(KN/m$^2$) | Opp. Sea faces(KN/m$^2$) | Wide faces(KN/m$^2$) |
|---|---|---|---|
| 0 | 11.487 | 8.878 | 8.878 |
| 3 | 11.504 | 8.891 | 8.891 |
| 6 | 11.521 | 8.904 | 8.904 |
| 9 | 11.537 | 8.917 | 8.917 |
| 12 | 12.172 | 8.930 | 8.930 |
| 15 | 13.148 | 8.943 | 8.943 |
| 18 | 13.827 | 8.956 | 8.956 |
| 21 | 14.439 | 9.355 | 9.355 |
| 24 | 14.891 | 10.575 | 10.575 |
| 27 | 15.351 | 11.872 | 11.872 |
| 30 | 15.818 | 13.246 | 13.246 |
| 33 | 16.113 | 13.805 | 13.805 |
| 36 | 16.410 | 14.377 | 14.377 |
| 39 | 16.711 | 14.961 | 14.961 |
| 42 | 17.015 | 15.557 | 15.557 |
| 45 | 17.322 | 16.166 | 16.166 |
| 48 | 17.633 | 16.789 | 16.789 |
| 51 | 17.902 | 17.282 | 17.282 |
| 54 | 18.084 | 17.498 | 17.498 |
| 57 | 18.267 | 17.716 | 17.716 |
| 60 | 18.452 | 17.936 | 17.936 |
| 63 | 18.638 | 18.158 | 18.158 |
| 66 | 18.825 | 18.381 | 18.381 |
| 69 | 19.014 | 18.606 | 18.606 |
| 72 | 19.204 | 18.833 | 18.833 |
| 75 | 19.395 | 19.062 | 19.062 |
| 78 | 19.588 | 19.293 | 19.293 |

## IV. RESULT AND DISCUSSION

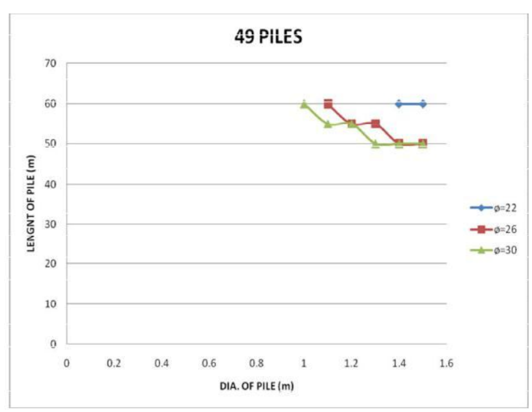


**Fig 3.** For 49 piles

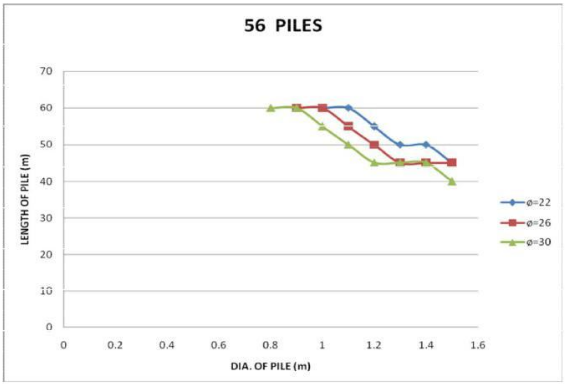


**Fig 4.** For 56 piles

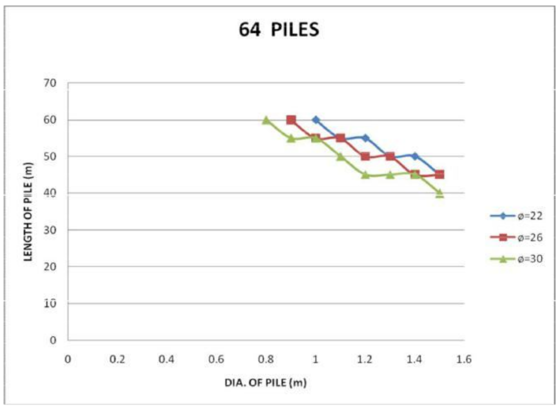


**Fig 5.** For 64 piles

From the above figures, shows that the comparison between length and diameter of pile for variations in angle of internal friction and no. of piles. And, it is also observed that as number of piles increases the requirement of length and diameter of pile decreasing. As the angle of internal friction increases then the length of pile and diameter of pile goes on decreasing for all the variations in number of piles. From above results, finalized the length of pile 55m for various diameter of pile and angle of internal friction.

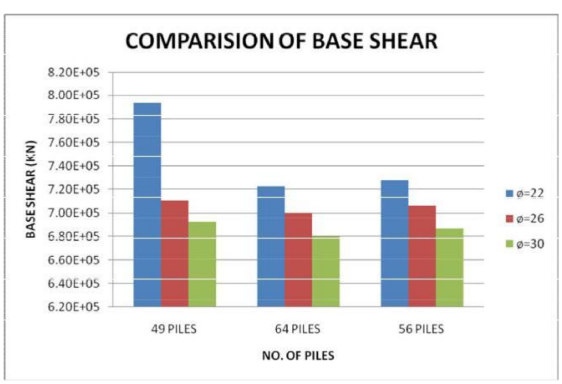


**Fig 6.** Comparison of base shear

From fig.6, it is indicate that the base shear is increases when the value of angle of internal friction decreases. In above fig. shows the more base shear is for the 49 no. of piles for angle of internal friction is 22.For the use of 64 no. of piles the base shear value is minimum for all the value of the angle of friction as compared to other.

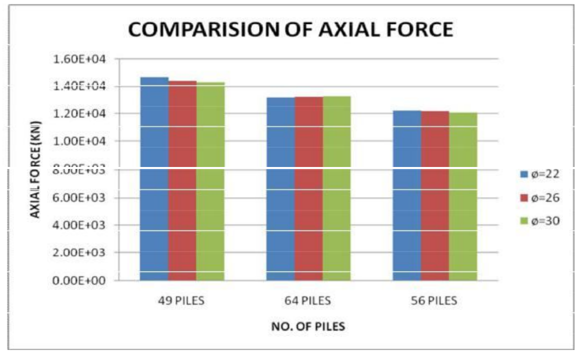


**Fig 7.** Comparison of axial force

From fig.7 it is observed that, the axial force is only link with the dead load of structure so the axial is more in the when the structure subjected to 49 no. piles and the axial force is gradually decreases when the angle of internal friction increases as indicated. The above graph indicate that there is no significant change in the axial force when use of 56 no. of piles and 64 no. of piles for various angle of internal friction and 56 no. of piles will give less axial force as compared to other.

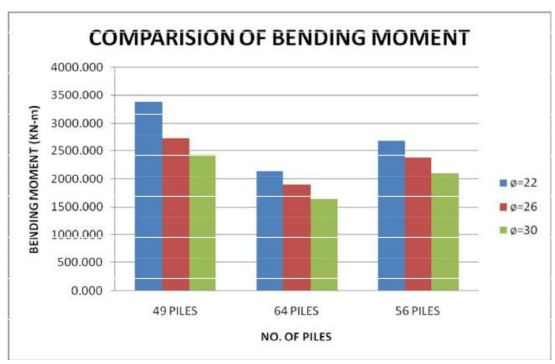


**Fig 8.** Comparison of bending moment

From fig.8, graph shows the comparison of bending moment of various number of piles used in which for the 49 no. of piles of structure shows more bending effect as compared to other. As angle of internal friction increases the effect of bending moment will be decrease as indicated in above fig. For the 64 no. of piles shows less bending moment effect as compared to other.

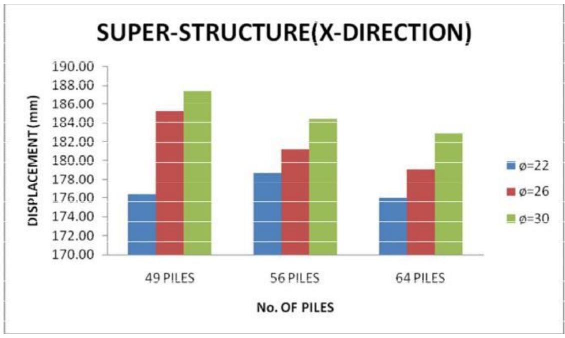


**Fig 9.** Displacement in x-direction (Super-structure)

From fig.9, it is indicate that the comparison of displacement in x-direction for various number of piles by using various number of angle of internal friction in that the 64 number of piles of super structure shows less displacement in x-direction.

As angle of internal friction value increases then the displacement in super structure of various number of piles also increases as indicated in above figure. The displacement in super structure is more than the displacement in sub structure in x-direction

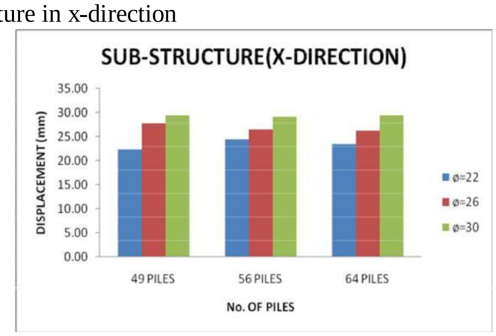


**Fig 10.** Displacement in x-direction (Sub-structure)

From fig.10, there is marginal difference in the displacement in x- direction of sub-structure for all use of number of piles of structure. From the above results of displacement, it is observed that as the angle of internal friction increases the displacement also increases in all the variations of number of piles.

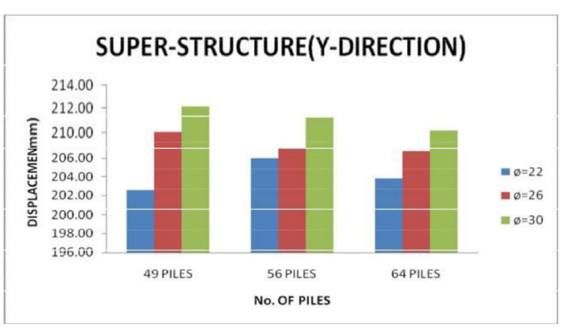


**Fig 11.** Displacement in y-direction (Super-structure)

From fig.11, , it is observed that the displacement in the transverse direction i.e. in y-direction shows more displacement in 49 number of piles of super structure. As angle of internal friction increases the displacement of various no. of piles also increases.

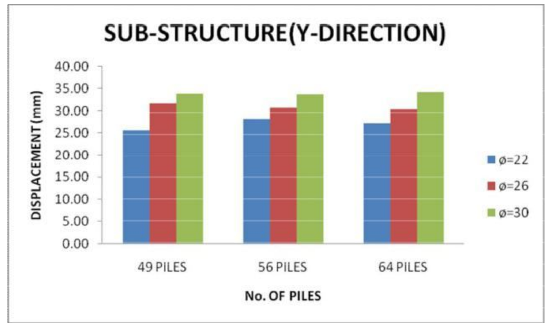


**Fig 12.** Displacement in y-direction (Sub-structure)

From fig.12, it is observed that there is marginal difference in displacement in y-direction of sub-structure for the various number of piles. The displacement in sub-structure is less as compared with super-structure in y-direction.

## V. CONCLUSION

According to our research work, we have come to the conclusion that:

- Above study shows that, the pile foundation concept has convincing advantages for soft soil in comparison to conventional foundation for high rise building.
- The ultimate bearing capacity of piles is increased as the pile diameter increases.
- From the above study we found that, settlement decreases as the diameter of pile is increases.
- The pile foundation with different pile diameter was considered as a suitable option to reduce total and differential settlement when the applied loads are different.
- The displacement in super structure is more than the displacement in sub structure in both the directions.

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