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A Study of Pile foundation and Raft foundation for Different SBC

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ABSTRACT

In recent years there is tremendous development in infrastructure going on everywhere in India. Thus there is increase in requirement of more space for construction of offices and residential buildings, and thus evolve the idea o high rise buildings. In the recent years, there has been tremendous increase in high rise buildings due to scarcity of space available and requirement of amenities in major cities. However, structural stability it is matter of great concern on such type of natural or man-made refills, thus what foundation will be proposed is very important. Foundation can be classified as shallow and deep foundation. The foundation of building is dependent on the height of building, soil properties, testing of soil, loading condition and site investigation. Considering all these aspects selection of type of foundation for the proposed structure can be done. In the analysis and design of economic foundation for high rise building both geotechnical and structural design aspect are taken into account. Quantitative study has been carried out for different values of Soil Bearing Capacity (SBC). The behavior of structure also depends on soil strata. Sometimes the strata surface is very loose but below it may consist of rock or solid soil. High rise buildings require stronger foundation while short buildings spread the load over the area of the structure. This work includes the design and analysis of Pile & Raft foundation on different SBC that has been discussed in detail on the basis of geotechnical analysis. The design of pile foundation as well as raft foundation is carried out and then the result is compared.

Keywords: High Rise Buildings, Geotechnical and Structural Design, Pile & Raft Foundation

I. INTRODUCTION

Building foundation is part of a structural system that supports and anchors the superstructure of a building and transmits its loads directly to the earth.

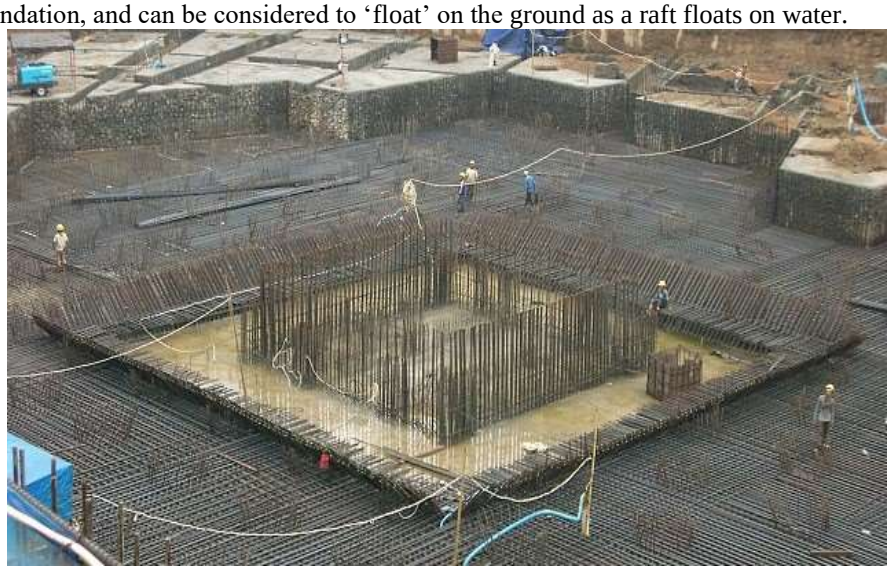
Pile Foundation –

Pile foundations are deep foundations. They are formed by long, slender, columnar elements typically made from steel or reinforced concrete, or sometimes timber. A foundation is described as 'piled' when its depth is more than three times its breadth. Pile foundations are usually used for large structures and in situations where the soil at shallow depth is not suitable to resist excessive settlement, resist uplift, etc.

When loads to be transferred from structure are very high & SBC too low, pile foundation is adopted to take heavy loads to a depth. It is a long and slender structural element which transfer load to some firm stratum at a considerable depth below ground surface. Thick slabs are used to tie a group of piles together to support and transmit loads. The choice of appropriate pile type in any given circumstance is influenced by subsurface soil conditions, location and topography of site. Subsurface soil and water conditions usually represent the most significant factors while design a pile.

Raft Foundation

Raft foundations are formed by reinforced concrete slabs of uniform thickness that cover a wide area, often the entire footprint of a building or more. They spread the load imposed by a number of columns or walls over the area of foundation, and can be considered to 'float' on the ground as a raft floats on water.



It is suitable when underlying soil have a low bearing capacity are anticipated. It is suitable for ground containing pockets of loose and soft soils. It laid on hardcore, usually thickened at the edges, especially in very poor ground. The foundation may stiffened by beams built in during construction which will add extra strength and rigidity. For building with ground basement storey in high water table condition, raft foundations are provided.

II. LITERATURE REVIEW

A broad review is necessary to study the advantages and disadvantages of raft foundation and pile foundation and challenges that come under construction of raft foundation and pile foundation are discussed. This literature review reveals the amount of research work done in India.

Suman M. Sharma[1] provides design and analysis of foundation for high rise building considering geotechnical and structural design aspect. Raft foundations are preferred for soils that have low load bearing capacities. It reduces the bearing pressure to a minimum. Beam and slab raft foundation is used to support the heavier loads of columns a solid slab raft would require considerable thickness. To make the economical use of reinforced concrete in a raft foundation supporting heavier loads it is practice to form a beam and slab raft. Different approaches are available for analysis of the raft foundation like rigid approach and flexible approach. In flexible approach finite element method is used to analyze the structure.

V. Suneetha[2] provides a design of foundation in black cotton clay. The foundation of any structure must satisfy 2 independent design criteria. First, it must have an acceptable factor of safety against bearing failure in soils. Second, settlements during life of the structure must not be of a magnitude. An effective foundation system is develop in which it is found that under-reamed piles provide an ideal solution. It is also used for providing safe and economical foundation in expansive soils. In this type of foundation the structure is anchored to the ground at a depth where ground movement due to changes in moisture content is negligible.

Nabanita Sharma[3] gives an attempt to design a raft foundation based on its geotechnical analysis. A detailed survey of research works had been done to study the geotechnical parameters affecting the behavior of raft foundation. The site investigation for parking lot is done which is situated in Guwahati, Assam. Geotechnical properties are examined by performing different tests. Calculation of loads and bearing capacity of soil are done. Then calculation of supporting beams, shear reinforcement and design of slab had carried out. A study and observation of the soil for shear failure are made. Safety requirements are considered while constructing the design of the foundation for different types of soil.

B.K. Maheshwari[4] provides model for pore pressure response on undrained tests has been study for liquefaction phenomenon. The excess pore pressure generated during liquefaction gives effective stresses in soil and changes its behavior. During strong ground motion, piles are prone to severe cracking or even fracture. The moving soil can exert damaging pressures against the piles which may lead to failure. The pile foundation are subjected to axial vibration in many situations such as loading and during earthquake. It is observed that the response of a single pile due to axial vibration in liquefiable soil is greater than that of non-liquefiable soil, specially at higher frequencies.

III. DESIGN STEPS FOR PILE FOUNDATION

Plan & column reaction of G+5 building

Data	Pile Foundation	Raft foundation
Grade of steel	F_y 415 N /mm^2	415 N/ mm^2
Grade of concrete,	F_{ck} 20 N / mm^2	20 N/ mm^2
Column size	300 x 300 mm	300 x 300 mm
Angle of repose	15^o	
Unit weight of soil	16 KN / m^2	
Coefficient of earth pressure	0.4	
Safe bearing capacity		50 KN / mm^2

A. Results & discussion

1) *Results for building*

Column size = 300 x 300 mm for 5 & 7 storeys

Column size = 400 x 400 mm for 9 storeys

a) Model I- Foundation with SBC 50 KN/m2

b) Area of reinforcement & depth for raft slab, secondary & primary beam is given in table 1 below. It is observed that the area of reinforcement & depth increases as the stories increases.

Table 1: Details of Raft foundation

Sr. No.	Storeys	Depth (D) mm				Ast (mm^2)				
		R.S.	S.B.	P.B.		R.S.	S.B.		P.B.	
				A	B		Bottom	Top	A	B
1	5	360	700	800	850	2908.33	1422.94	8039.77	2153.72	2297.30
2	7	450	750	950	1200	3707.35	1506.59	10820.59	2584.46	3302.37
3	9	550	900	900	1550	4556.38	1576.64	12181.15	3254.51	5743.25

Size & no's of pile, length of pile type, depth of pile cap & depth of beam used in cap are given in table 2 given below. It is observed that almost the length of pile is same for all storeys.

Table 2 Details of Pile Foundation & Pile Cap

Sr. No.	Storeys	Size of Pile (mm)	Nos. of Pile	Length of Pile (m)			Size of beam (mm)	Depth of cap (mm)
				Type I	Type II	Type III		
1	5	300 X 300	4	14	14	12	300	700
2	7	300 X 300	4	13	15	13	300	700
3	9	400 X 400	4	15	16	13	400	900

Reinforcement & percentage of steel for pile & raft foundation is given in table 3 below. It is observed that weight of steel increases as the stories increases. While in case of percentage of steel raft foundation requires more steel as that of pile foundation.

Sr. No.	Stories	Pile foundation (tons)	Raft foundation (tons)	% of steel
1	5	22	32	68.75
2	7	24	41	58.54
3	9	27.5	54	50.93

Table 3: Comparison of Pile & Raft foundation (M20)

Fig. 3 shows no's of stories acting on it in 'X' direction. While in 'Y' direction, reinforcement (in tons) for both foundation. It is observed that for 5th & 7th storey raft foundation requires 10 &17 tons more reinforcement than that of pile foundation. For 9th storey raft foundation requires 26.5 tons more reinforcement than of pile foundation.

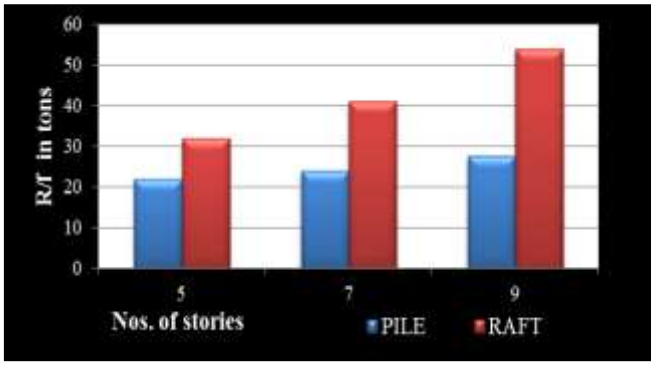


Fig. 3 Comparison of Pile & Raft foundation (M20)

Area of reinforcement & depth for raft slab, secondary & primary beam is given in table 4 below. It is observed that the area of reinforcement & depth increases as the storeyes increases but in G + 9 store the depth of raft slab & depth of beam almost become same.

Sr. No.	Storeys	Depth (D) mm				Ast (mm^2)				
		R.S.	S.B.	P.B.		R.S.	S.B.		P.B.	
				A	B		Bottom	Top	A	B
1	5	200	600	900	950	2277.92	1219.42	5842.66	2440.88	2584.46
2	7	300	700	800	950	3679.72	1311.24	8079.35	2153.72	2584.46
3	9	360	760	850	900	5074.18	1506.31	9339.92	3063.07	3254.51

Table 4: Details of Raft foundation

Size & no's of pile, length of pile type, depth of pile cap and depth of beam used in cap are given in table 5 given below. It is observed that almost the length of pile is same for all stories

Sr. No.	Storeys	Size of Pile (mm)	Nos. of Pile	Length of Pile (m)			Size of beam (mm)	Depth of cap (mm)
				Type I	Type II	Type III		
1	5	300 X 300	4	9	9	7	300	700
2	7	300 X 300	4	8	10	8	300	700
3	9	400 X 400	4	10	11	8	400	900

Table 5: Details of Pile Foundation & Pile Cap

Reinforcement & percentage of steel for pile & raft foundation is given in table 6 below. It is observed that weight of steel increases as the stories increases. While in case of percentage of steel raft foundation requires more steel as that of pile foundation.

Sr. No.	Stories	Pile foundation (tons)	Raft foundation (tons)	% of steel
1	5	9	21	42.86
2	7	13	31	41.94
3	9	17	41	41.46

Table 6: Comparison of Pile & Raft foundation (M20)

Fig. 4 shows number of stories acting on it in 'X' direction. While in 'Y' direction, reinforcement (in tons) for both foundation. It is observed that for 5th & 7th storey raft foundation requires 12 & 18 tons more

reinforcement than that of pile foundation.. For 9th storey raft foundation requires 24 tons more reinforcement than of pile foundation.

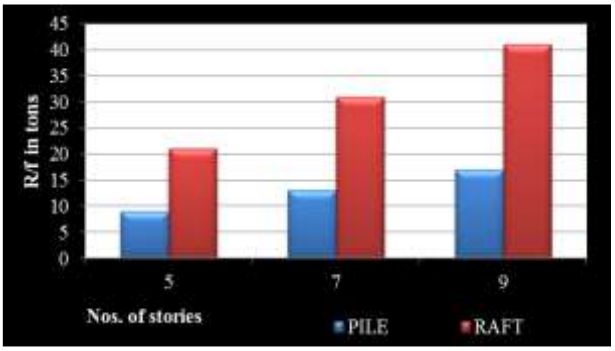


Fig. 4: Comparison of Pile & Raft foundation (M20)

2) *Results of 5th storey for building*

Fig. 5 shows SBC acting on it in 'X' direction from 50KN/m2 & 75 KN/m2. While in 'Y' direction, % of steel for both foundation. It is observed that for SBC 50 KN/m2 the percentage of steel decreases as grade of concrete increases, i.e. for M20 68.75%, for M25 64.71% and for M30 57.89%. For SBC 75 KN/m2 the percentage of steel decreases as grade of concrete increases, i.e. for M20 42.86%, for M25 40.91%, for M30 37.5%.

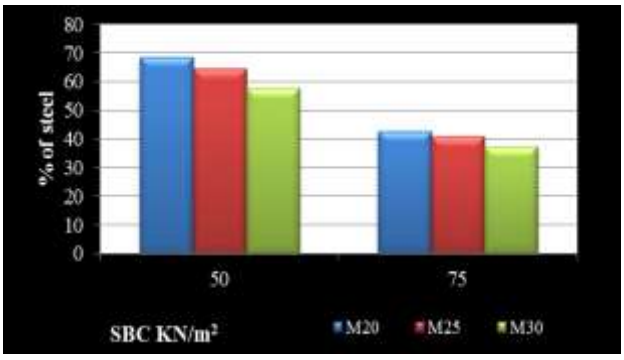


Fig. 5: Comparison of Pile & Raft foundation for 5th storey

3) *Results of 7th storey for building*

Fig. 6 shows SBC acting on it in 'X' direction from 50KN/m2 & 75 KN/m2. While in 'Y' direction, % of steel for both foundation. It is observed that for SBC 50 KN/m2 % of steel decreases as grade of concrete increases, i.e. for M20 58.54%, for M25 53.33% and for M30 48%. For SBC 75 KN/m2 the percentage of steel decreases as grade of concrete increases, i.e. for M20 41.94%, for M25 38.24%, for M30 36.11%.

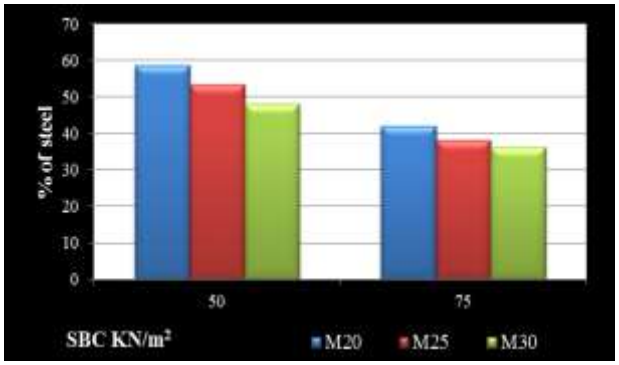


Fig. 6: Comparison of Pile & Raft foundation for 7th storey

4) Results of 9th storey for building

Fig.7 shows SBC acting on it in 'X' direction from 50KN/m2 & 75 KN/m2. While in 'Y' direction, % of steel for both foundation. It is observed that for SBC 50 KN/m2 the % of steel decreases as grade of concrete increases, i.e. for M20 50.93%, for M25 47.46% and for M30 43.65%. For SBC 75 KN/m2 % of steel decreases as grade of concrete increases, i.e. for M20 41.46%, for M25 36.96%, for M30 34%.

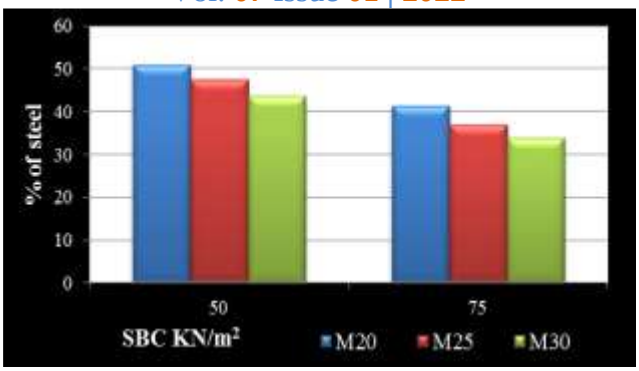


Fig. 7: Comparison of Pile & Raft foundation for 9th storey

IV. CONCLUSIONS

In present work attempt has been made to compare, design & analyse the pile and raft foundation for different SBC as per IS-2911 2010 for pile & IS-2950 1981 for raft foundation. While IS-456 2000 is used for design purpose. Based on the results derived some major conclusion are drawn which are presented below.

- From results avg. length of pile is same for SBC 50 KN/m2 is 13 m & for SBC 75 KN/m2 is 9 m. From these it is observed that as the values of coefficient of earth pressure (k) increases the length of pile goes on decreasing visa-versa.
- From the study it is observed that the length of pile for same SBC is approximately. It show that the length reduces for higher unit weight of soil or SBC.
- For different soil type and multi-storied building ranging from G+5 to G+9 raft foundation is considered uneconomically in reinforcement point of view.
- From results raft slab depth becomes almost same as that of primary and secondary beams of higher stores which means for higher stories over all raft is of same thickness.
- From study it is observed that raft foundation is gives more fixity to the structure as it covers more area than that of pile foundation.
- From study the construction of raft foundation is easier as that of pile foundation as it does not required special equipment for constructed and installation.
- From study raft foundation requires large cantilever slab for multi-stories structure.

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