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"Seismic Behavior of Tall Building using Piled Raft Foundation"

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Abstract: *Foundation is the basic component of the structure and it plays very important role for the building to stand. The foundation of the building is defined as the substructure through which the loads of the whole structure are transferred to the soil safely and to ensure reliability and serviceability of the structure. India is the country where we find many types of soils, these different types of soil plays very important role in designing the structure. Depend on the type of the soil which type of foundation to be provided for the structure is decided. In this project, it includes analysis and design of tall building (25 stories) using piled raft foundation. Seismic analysis of the building is carried out in different zones and difference in results is studied .Also two models are made in which first model is with raft foundation only and the second model is with piled raft foundation. The difference in results between the two models is noted for different zones and comparative studied is carried out .The model is made with the help of ETABS software .ETABS can be easily handled ,also it can handle the largest and the most complex building model ,including a wide range of nonlinear behavior. Most of the structural engineers use this software as their tool for designing the structures and make their work easier. The comparative study of the parameters such as storey drift, storey displacement, base shear, modal shapes, modal period, modal frequencies are studied for different zones.*

Key words: *piled-raft foundation, storey displacement, storey drift, base shear, modal shapes.*

1. INTRODUCTION

Usually pile foundation is provided for tall buildings which are subjected to perpendicular, horizontal and toppling forces. Piled raft foundation is successfully preferred aimed at high structures meanwhile the raft remains capable towards afford a judicious quantity of together toughness and load opposition. A piled raft foundation is a grouping of a thin foundation and the bottomless foundation. Usually the foundation are provided to transfer the load from the superstructure to the soil safely and economically. Now the strategy of the piled raft foundation the load is shared among pile and the raft.

A piled raft foundation associations' binary foundation structure methods hooked on a mixture project fit aimed at particular circumstances. The raft, foundation extents the load of the structure through the crushed. Reason of the situation as a raft fluctuating happening the crushed secondary an assembly. Piles remain pillars ranging under the broken up shallow that join on the topmost of the construction. A piled raft foundation customs together approaches to sustenance the construction.

In situations where a raft foundation only fixes not satisfy the project supplies, it might be probable to recover the presentation of raft by the adding of piles. The usage of an insufficient amount of piles, purposely positioned, might recover together the final load ability and the settlement and variance settlement presentation of raft. The project procedure for a piled raft be able to be measured as a three stage procedure. The first is an initial phase trendy which the belongings of the quantity of piles on load ability and payment remain restrained through an estimated study. The second is an extra thorough check up to deliberate wherever piles remain obligatory and towards gain around suggestion of the support supplies. The third remains a complete strategy stage popular is an additional unconventional investigation remains working to settle the perfect amount and place of the piles, and to find important data for the physical enterprise of the groundwork scheme. The assortment of strategy geotechnical limits is an indispensable section of together project periods, and about of the events for guessing the important limitations are labelled. Approximately characteristic requests of piled ranges are labelled, counting judgements among intended and slow foundation behaviour.

Pile foundation stays a generous of profound foundation, stays basically a lean pillar or elongated distance chamber completed of possessions such as material or else toughen which provisions the erection, assignment the load at important penetration moreover through conclusion attitude, membrane abrasion.

Pile foundations are deep foundations. They are formed by long, slender, columnar elements which are naturally made from steel or reinforced concrete, or sometimes timber. A foundation is called as 'piled' when its depth is greater than three times its breadth.

Pile foundation remains normally recycled giant buildings trendy conditions wherever the earth on thin deepness remains not apposite towards attack payment, attack elevate etc.

Pile foundation is usually provided for the soil with the less safe bearing capacity and the soil in the loose condition. Pile foundation is the type of deep foundation. Compared to other type of foundation .this type foundation is expensive. The construction of pile foundation requires much time.

The material such as steel or concrete can be used for the construction of the pile foundation. The performance of the type of the foundation in loose soil condition is better than the isolated foundation.

2. METHODOLOGY

1. The models of the buildings are made using the software ETABS.
2. A symmetrical building is made with G+25 stories.
3. Two models are made i.e. first model with raft foundation only and second model with piled raft foundation.
4. The type earth considered for analysis is soft soil.
5. The building is analyzed for different zones (ZONE II, ZONE III, ZONE IV, and ZONE V) towards training the seismic performance construction.
6. The division dislocation improper clip will power benefit towards associate the presentation of representations and to recognize which construction consumes additional presentation in contradiction of quake.

3. LITERATURE REVIEW

❖ **A study on behavior of high rise building i.e,25 storey with piled raft foundation for given variable subsoils condition(Shukla S J, Feb 2013)**

The piled raft foundation remains an arrangement low foundation bottomless foundation through greatest features. The piled raft foundation stands a compound structure containing 3 basics, piles, raft and subsoils. Distinct old-style project foundation wherever load remains maintained moreover through the raft or by the piles, in the design of a piled raft foundation the load portion between the piles and the raft remains occupied for examination. Popular foundation the piles commonly stand essential towards confirm full reliability foundation but then again towards decline amount typical settlements, discrepancy settlements consequential sloping structure pledge acceptable concert foundation arrangement. The behavior of piled raft foundation in the course of earthquake is well-defined by compound soil-structure relationships .The modelling requires dependable influential examination tackles, such by way FEM method. The study of soil structure interface is very important in case of high rise structure, popular education a try stays finished towards learning performance of 25 storey building relaxing on dissimilar varieties of soil with piled raft foundation method through earthquake.

❖ **Simplified design procedure for the Piled raft Foundation, 2002.**

Raft foundation alone cannot satisfy the design necessities, the presentation the raft can be increased through the accumulation of the piles to it. The custom piles along with the raft helps to increase ultimate load capacity, regular settlement and the difference settlement. This study will help to select the easy method of analysis for the piled raft foundation. It includes two phases: 1) The approximation complete foundation functioning and 2) the approximation of the behaviour underneath specific column loads. In two cases, easy solution is found out to calculate foundation stiffness and ultimate load capacity. The choice of design geotechnical factors is a required factor of two design steps, and roughly calculation for valuing the essential factors are précised.

❖ **A study on eccentrically loaded raft with short piles**, by Mostafa EI Sawwaf

The impact of short piles on the behaviour eccentrically loaded raft resting on the sand is studied. The short piles placed beside the raft edge is found to be cost-effective in case of eccentrically loaded case. The pile arrangement has the effect on the settlement of the raft particularly at the lower loads .Hence the pile arrangement depends on the load configuration and the raft geometry. The performance of the raft improves when we introduces the pile sand it also depends on the number of the piles used. The behaviour of the raft depends on the density of the sand, denser the sand greater will be the improvement in the performance of the raft. The use of the connected and unconnected piles helps to reduce the average settlement and also the tilt of the raft to the acceptable limits which results in the economical design. The raft with the connected short piles have good behaviour than the unconnected piles.

❖ **Estimation of the plan Alternatives Piled raft Cases details, 2001.**

The study covers the idea for the design of piled raft foundation discovering the features that governs the event past wherever piled raft foundation is used. The study includes how focused column loads, and the normal "feast" piles, stayed measured I n the stability project. Primarily rear enquiry stands passed obtainable towards resistor the numerical program executed in the study. It is tracked through a parametric examination for the estimation of dissimilar

project substitutes. These substitutes applied characteristic pile parameter.

4. MODELLING AND ANAYSIS

The structure is modelled as shown below and design is carried out by considering the following details. Grade of concrete used is M40. The type of the rebar used for construction is Fe415. The building is constructed for G+25 storey, where the height of each storey is 3.2m. The slab is provided with 150mm thickness. And platform sunbeam is constructed at elevation 1.5 m after crushed external level. The column size of 600mmX600mm and the beam size of 300mmX600mm are being used. The building plan is considered to be proportioned. The foremost loads delivered construction remain living load and ground load, the living load delivered project is 3kN/m2 and ground load is 2.5kN/m2.

Table 1 Building details

Concrete grade used	M40
Steel grade used	Fe415
Height of each floor	3.2m
Height of plinth beyond the GL	1.5m
Thickness of slab	150mm
Size of column used	600mx600mm
Size of the beam used	300mmx 600mm
No of stories	G+25
Plan type	Symmetrical plan
Type of soil	Soft soil (Type –III)
Zone	II,III,IV,V
SBC of soil	10T/m^2
Software used	ETABS

Data considered:

- Live load =3KN/m^2 [as per IS CODE 875 Part 2]
- Floor finish=2.5KN/m^2 [as per the code IS CODE 875 part 1]
- Raft thickness=1m[as per the code IS CODE 2950.1.1981,clause 4.3]
- Standard allowable settlement=25mm
- Pile length=12m[as per IS 2911-12(2010)]
- Pile dia =600mm
- Spacing of the piles=2.5 times the dia of the pile[as per IS 2911-12(2010), clause 6.6.1]

MODELLING

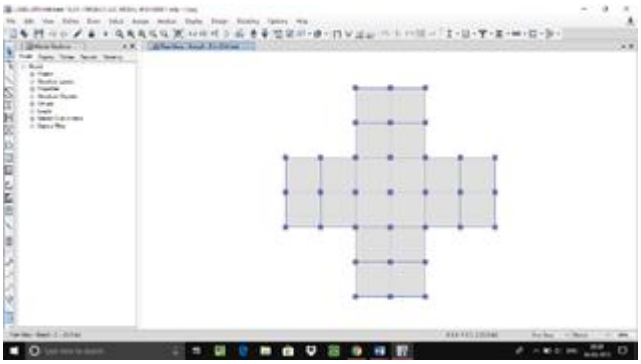


Fig.1 Plan of the building

For analysis we considered two models i.e first model with raft foundation only and the second model with the piled-raft foundation. Modelling is being done by using ETABS. Here we considered symmetric structure as shown in the plan. The first model made is provided with the raft foundation only, in order to check the deformation of the tall buildings. And also to compare the results with respect to the other model. According to the IS CODE 2950.1.1981, clause 4.3 the thickness of the raft to be considered is 1m.

The highlighted portion the building with the raft foundation only. We know that raft foundation is provided for the building which has the very less SBC i.e., for the loose soil condition. And also in the situation where the settlement is more.

Usually the standard allowable settlement considered will be 25mm.The thickness provided should be uniform throughout. Raft foundation helps to distribute the entire load after super building towards earth uniformly over area.

The edge raft foundation is restrained while modelling in order to prevent the structure from twisting or overturning. Here the provided depth raft foundation is sufficient. The raft prevents settlement building.

MODEL DETAILS:

Fig.2 model with raft foundation only

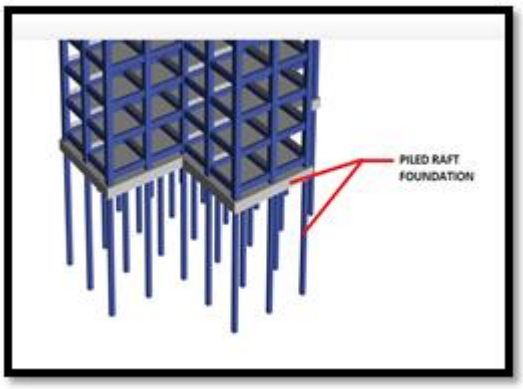


Fig.3 model with piled raft foundation

Analysis result:

1] Storey displacement

a] Model-1

Stories	Zone II (mm)	Zone III (mm)	Zone IV (mm)	Zone V (mm)
1	**216.2**	**345.9**	**518.9**	**778.4**
2	210.2	336.3	504.4	756.6
3	203.7	325.9	488.9	733.4
4	196.7	314.8	472.2	708.3
5	189.3	302.8	454.2	681.4
6	181.3	290.2	435.2	652.8
7	173	276.8	415.3	622.9
8	164.3	262.9	394.4	591.6
9	155.4	248.6	372.8	559.3
10	146.1	233.8	350.6	525.9
11	136.6	218.6	327.9	491.8
12	127	203.1	304.7	457
13	117.1	187.4	281.2	421.7
14	107.2	171.6	257.4	386.1
15	97.3	155.6	233.4	350.2
16	87.3	139.6	209.4	314.1
17	77.3	123.6	185.4	278.1
18	67.3	107.7	161.5	242.3
19	57.4	91.8	137.7	206.6
20	47.6	76.1	114.2	171.3
21	37.9	60.7	91	136.5
22	28.4	45.4	68.1	102.2
23	19.1	30.5	45.8	68.7
24	10.1	16.2	24.3	36.4
25	2.3	3.8	5.6	8.5
BASE	0.002119	0.00339	0.005084	0.007627

GRAPHICAL REPRESENTATION

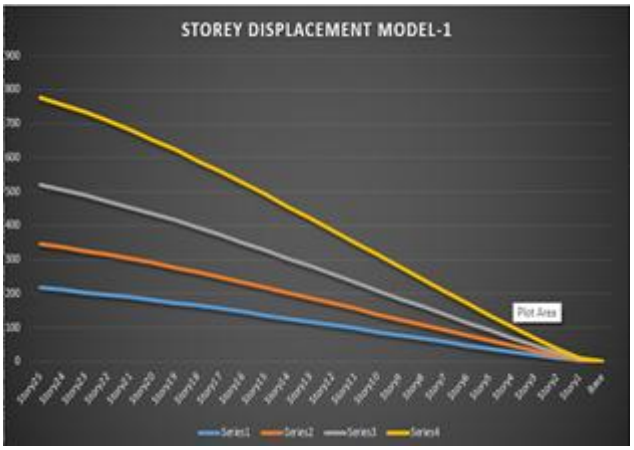


Fig.4 storey displacement of model-1

b] Model-2

Stories	Zone II (mm)	Zone III (mm)	Zone IV (mm)	Zone V (mm)
Story25	**147.1**	**235.4**	**353.2**	**529.7**
Story24	142.5	228	342	513
Story23	137.5	220	330	495
Story22	132.2	211.4	317.2	475.7
Story21	126.5	202.4	303.5	455.3
Story20	120.5	192.8	289.2	433.8
Story19	114.3	182.8	274.2	411.4
Story18	107.8	172.5	258.7	388.1
Story17	101.2	161.9	242.8	364.2
Story16	94.4	151	226.5	339.8
Story15	87.5	140	209.9	314.9
Story14	80.5	128.8	193.2	289.8
Story13	73.5	117.6	176.4	264.6
Story12	66.5	106.4	159.5	239.3
Story11	59.5	95.2	142.8	214.2
Story10	52.6	84.2	126.3	189.4
Story9	45.8	73.3	110	165
Story8	39.2	62.7	94.1	141.2
Story7	32.8	52.5	78.7	118
Story6	26.6	42.6	63.8	95.7
Story5	20.7	33.1	49.6	74.4
Story4	15.1	24.1	36.1	54.2
Story3	9.8	15.7	23.5	35.3
Story2	5	7.9	11.9	17.8
Story1	0.6	1	1.5	2.3
PILE	0	0	0	0
Base	0	0	0	0

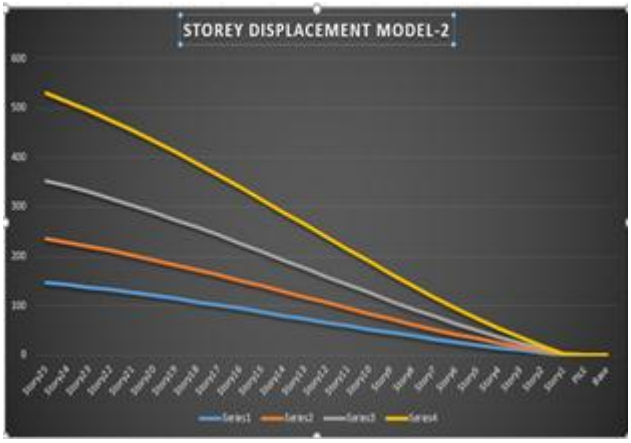


Fig.5 storey displacement of model-2

2] Storey drift

A] Model-1

Stories	Zone II (mm)	Zone III (mm)	Zone IV (mm)	Zone V (mm)
25	1.83	3.024	4.536	6.805
24	2.018	3.229	4.844	7.266
23	2.182	3.491	5.236	7.855
22	2.335	3.737	5.605	8.407
21	2.475	3.961	5.941	8.911
20	2.601	4.161	6.242	9.363
19	2.712	4.339	6.509	9.764
18	2.809	4.495	6.742	10.113
17	2.893	4.628	6.942	10.414
16	2.963	4.74	7.11	10.666
15	**3.127**	**5.003**	**7.504**	**11.256**
14	3.064	4.903	7.354	11.031
13	3.097	4.954	7.432	11.147
12	3.117	4.988	7.481	11.222
11	3.067	4.853	7.245	11.213
10	3.126	5.001	7.502	11.253
9	3.115	4.983	7.475	11.212
8	3.094	4.95	7.425	11.137
7	3.064	4.902	7.353	11.03
6	3.025	4.84	7.26	10.89
5	2.977	4.763	7.145	10.717
4	2.914	4.662	6.993	10.489
3	2.799	4.478	6.717	10.075
2	2.452	3.923	5.885	8.827
1	1.564	2.502	3.754	5.63
BASE	0	0	0	0

GRAPHICAL REPRESENTATION:

Fig.6 storey drift of model-1

B] Model-2

Stories	Zone II (mm)	Zone III (mm)	Zone IV (mm)	Zone V (mm)
25	1.451	2.322	3.483	5.224
24	1.563	2.501	3752	5.628
23	1.674	2.678	4.018	6.026
22	1.775	2.84	4.261	6.391
21	1.867	2.986	4.48	6.719
20	1.947	3.115	4.673	7.01
19	2.017	3.227	4.84	7.261
18	2.075	3.32	4.98	7.471
17	2.122	3.395	5.093	7.639
16	2.157	3.451	5.177	7.765
15	**2.192**	**3.507**	**5.266**	**7.895**
14	2.181	3.482	5.259	7.845
13	2.191	3.506	5.228	7.888
12	2.179	3.486	5.17	7.843
11	2.154	3.446	5.082	7.754
10	2.118	3.388	4.966	7.623
9	2.069	3.311	4.821	7.449
8	2.009	3.214	4.647	7.231
7	1.936	3.098	4.443	6.97
6	1.851	2.962	4.209	6.665
5	1.754	2.806	3.943	6.313
4	1.643	2.629	3.644	5.915
3	1.518	2.429	3.238	5.466
2	1.349	2.159	1.022	5.5
1	0.426	0.681	0	1.533
BASE	0	0		0

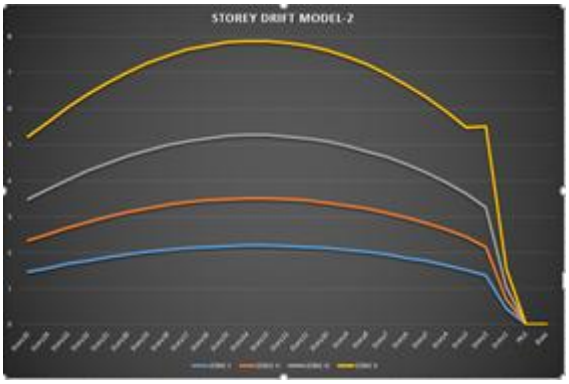
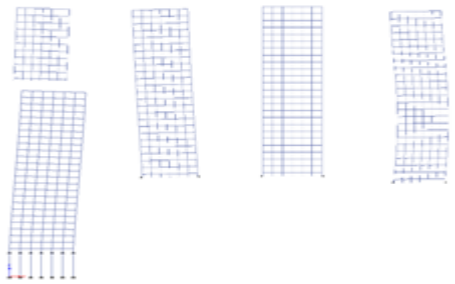


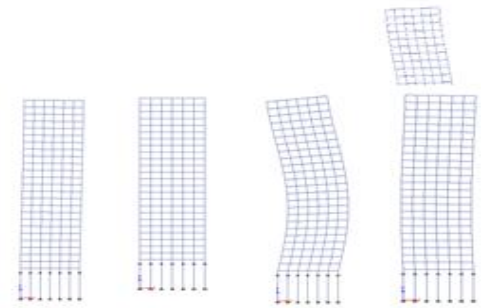
Fig.7 storey drift of model-2

3] Modal shapes:

Modal-1:



Modal-2



CONCLUSION

From the analysis result we found that the time period for all the zones of individual models are same for the soft soil condition. The base shear values of the models is less for the zone II and is higher for zone III, zone IV, zone V. The storey displacement of the building with piled raft foundation is less compared to that of building with raft foundation because the piles in piled raft foundation provides anchorage to the supports and holds the building firmly. In addition to this the raft will provide stiffness to the building and hence piled raft foundation is preferred over raft foundation. The graphs i.e, storey displacement graph and storey drift graph shows the difference between raft and the piled raft foundation. Also the amount piles will reduce when the raft is provided with piles that will help to reduce the construction time. Hence piled raft foundation is good for tall building with soft soil condition.

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