A Study on High Rise Building of Different Slab Systems using Response Spectrum

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***Abstract* - A study on high rise building of different slab systems using response spectrum, carried out on a high-rise residential building G+23 in zone-II (Hyderabad) by considering gravity loads, design lateral forces, and secondary moments due to axial load i.e., P.Δ ANALYSIS. Flat slab system increases floor to floor height, architectural flexibility, easier form work and less construction time etc., The structure proposed is designed by limit state method according to IS: 456-2000, the dynamic wind load analysis according to IS: 875-2015 (part-3), seismic loads according to IS: 1893- 2016 (part–1), shear wall according to IS:13920-2016 and tall building analysis according to IS:16700-2017 in ETABS by response spectrum method.**

***Index Terms* - P.Δ Analysis, G+23**

1.INTRODUCTION

1.1. General

An earthquake is a sudden tremor movement of earth's crust, which originates naturally at or below the surface. The word natural is important here, since it excludes shock waves caused by nuclear tests, man-made explosions, etc. about 90% of all earthquakes result from tectonic events, primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or man- made activities. Tectonic earthquakes are triggered when the accumulated strain exceeds the shearing strength of rocks. Elastic rebound theory gives the physics behind the earthquake genesis.

People do not kill by the earthquakes, chances of losing their life due to improper designing of buildings. Seismologists are given this statement who trust that human construction is the cause of most deaths when buildings collapse during earthquake. Without considering seismic forces is the main reason of destruction and loss in India at rural and urban areas.

2. LITERATURE REVIEW

K Venkatesh, T. Venkatdas (January 2017): In this paper they were studied on the lateral behavior of structure of zone II and zone III with different storey heights of 6, 11, and 16. The lateral displacement of the structure is compared in OMRF & SMRF and the analysis was done in staad pro v8i and it was found that lateral displacement is less in SMRF compare with OMRF.

Israa H. Nayel, Shereen Q. Abdulridha, Zahraa M. Kadhum (july2018): They were study the structure with G+10 for different positions of the structural walls and also with floating column to study the effectiveness of the shear wall.

Pooja.M and Dr Karthiyani.S (April 2017): This study mainly deals with design and analysis of structures of length 80m, 138m and 180m with and without expansion joints. From the results it can be concluded that considering the temperature loads during design of flat slab structures the provision of expansion joints can be eliminated.

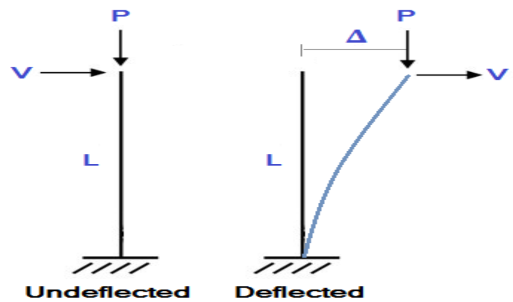
Anjana R K Unnithan, Dr. S. Karthiyaini April (2017): This paper described the analysis and design of high-rise buildings with Steel Plate Shear Wall (SPSW) for (G+9) stories. The design and analysis of the composite building with steel plate shear wall was carried out using software ETABS. The models were analyzed by Response Spectrum analysis as per IS 1893:2002.

Subhajit Sen and Yogendra Singh (June2016): In this paper, performance of flat slab buildings of various heights, designed for gravity load alone according to code, is evaluated under earthquake loading as per ASCE/SEI 41 methodology.

ZasiahTafheem, A.S.M RubaiatNahid, Tanzeelur Rahmanand Tariq Mohammad Shamim: They were studied on flat plate building with edge beam of 8 stories and flat plate building with shear wall 0f 8 story. The analysis and modeling of building is done by ETABS using Bangladesh national building code 2006 (BNBC).

3. P-DELTA ANALYSIS

P-Delta Analysis is a type of analysis that is particularly important for laterally displacing multi-story building structures experiencing a gravity load. Any structural model will deflect when it is loaded. A deflected structure may encounter significant secondary moments because the ends of the members have changed position. To illustrate this, consider the simple cantilevered column example shown below.



It is the secondary effect on shear forces and bending moments of lateral resisting elements generated under the action of the vertical loads, interacting with the lateral displacement of building resulting from seismic effects.

1. Non-iterative Based on Mass-In which load is automatically computed from the mass at each level. This is an approximate method which does not require an iterative solution, providing for faster computation. P-Delta is considered by treating the structure as a simplified stick model, a process which is most effective with a single rigid diaphragm at each level. Local bukleing is not captured as effectively. The benefit of this non-iterative method is that P-Delta may be considered in load cases which do not specify gravity load. When gravity load is specified, we generally recommend the Iterative Based on Load Cases method.
2. Iterative Based on Load Cases-In which load is computed from a specified combination of static load cases, then known as the P-Delta load combination. This is an iterative method which considers P-Delta on an element-by-element basis. Local buckling is captured more effectively. An example application may be when load includes the dead load case and a fraction of a live load case.

4. DYNAMIC EFFECTS OF WIND

Flexible slender structures and structural elements shall be investigated to ascertain the importance of wind induced oscillations or excitations in along wind and across wind directions.

In general, the following guidelines may be used for examining the problem of wind- induced oscillations.

Building and closed structures with a height to minimum lateral dimension ratio of more than about 5.0,

OR

b) Building and structures whose natural frequency in the first mode is less than 1.0 Hz Any building or structure which satisfies either of the above two criteria shall be examined for dynamic effects of wind as per the clause 9.1 in IS 875(part 3)2015 code.

5. DESIGN OF STRUCTURAL ELEMENTS

The structure chosen for a study is a G+23 storied Residential building. The building is situated in seismic zone II on medium stiff soil. Three dimensional mathematical models are generated in ETABS software. For structural elements, M40, M30 grade of concrete is used. The floor diaphragms are assumed to be rigid. Using ETABS a G+23 RC structure, Flat slab structure with shear walls at different locations are modeled and analyzed.

Model-1:
G+23 MOMENT FRAME building without shear wall in Zone II.

Model-2:
G+23 FLAT SLAB building without shear wall in Zone II.

Model-3:
G+23 MOMENT FRAME building with central shear wall in Zone II.

Model-4:
G+23 FLAT SLAB building with central shear wall in Zone II.

Model-5:
G+23 MOMENT FRAME building with corner shear wall in Zone II.

Model-6:

G+23 FLAT SLAB building with corner shear wall in Zone II.

Structural Detail of the models:

Table 1 Building Details

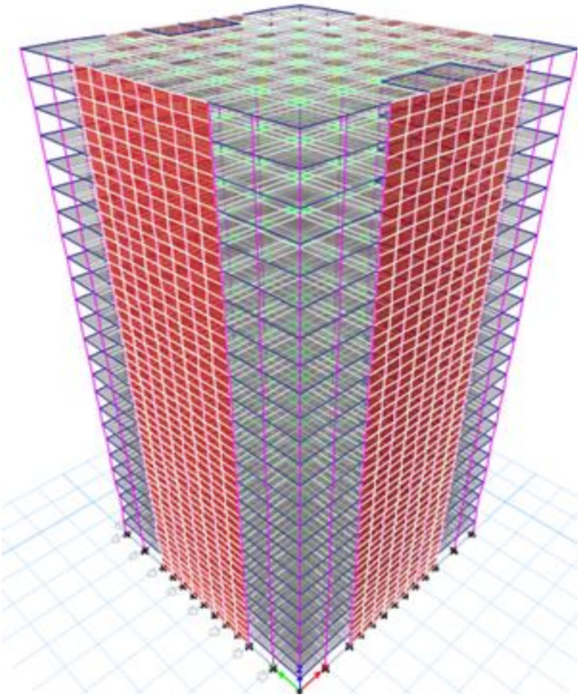
Plan dimension	40 X 40 m
Seismic zone	II
Zone factor, z	0.1
Wind Speed	44m/s
Number of storey	G+23
Floor height	3.2m
Depth of Slab	150 mm
Depth of FlatSlab	250 mm
Size of beam	230 x 700 mm
Size of column	600 x 600mm
Size of column	750 x 750mm
Thickness of shear wall	300mm
Thickness of Drop	500mm
Length of the drop	2m
width of the drop	2m
Materials	M 30, M 40 concrete and Fe 415 &500 steel
Thickness of external and internal walls	230mm
Type of soil	Medium soil
Importance Factor, I	1.2
Response spectrum analysis	Linear dynamic analysis
Damping of structure	5 percent
Response reduction factor for moment frame	5
Response reduction factor for flat slab	3
Wall load	12kN/m
Live load	2&3kN/m^2 (IS: 875 (Part 2))

6. ANALYTICAL INVESTIGATION

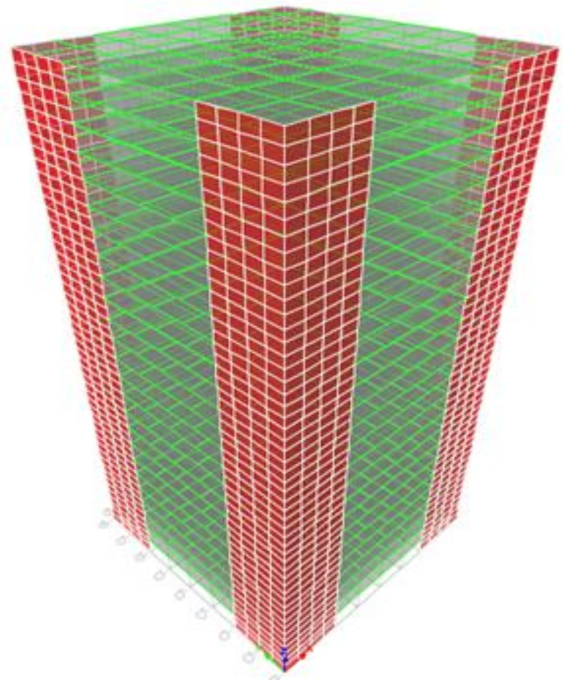
6.1. Model of the Study

Modeling of the building is done in ETABs software with the following steps:

- Selection of a grid pattern
- Defining beams, columns, slabs
- Modeling the structure
- Defining load and load combinations.

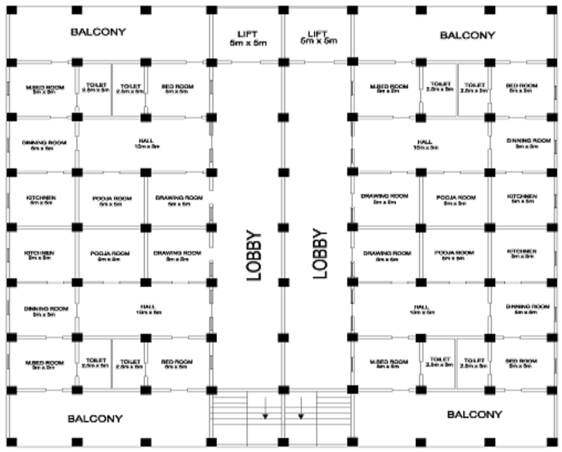


3D model-4 with shear wall at central external wall

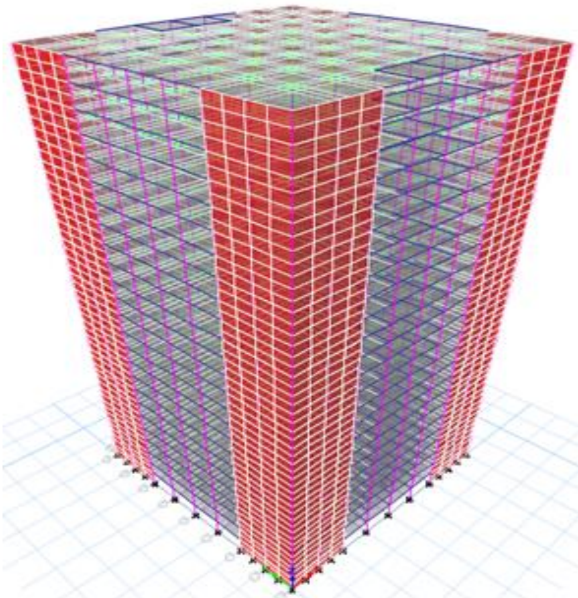


3D model-5 with shear wall at peripheral corners

- Assigning loads.



RESIDENTIAL BUILDING PLAN OF G+23



3D model-6 with shear wall at peripheral corners

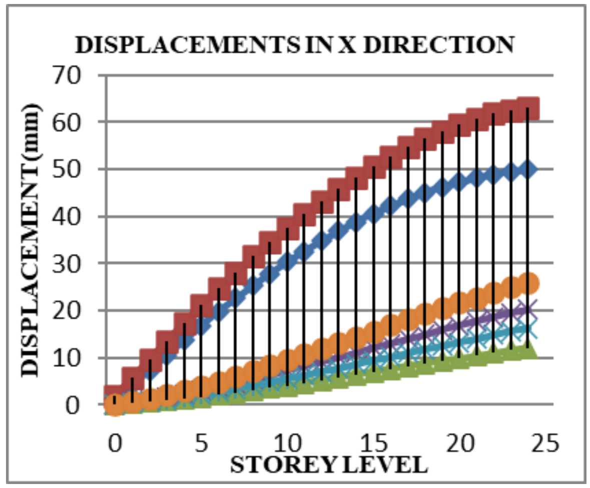
The model has been analyzed and designed using ETABS software. The results found to be are shown with the help of graph for the parameters base shear, displacements, time period, story drift, story shear, mass participation ratio and story stiffness.

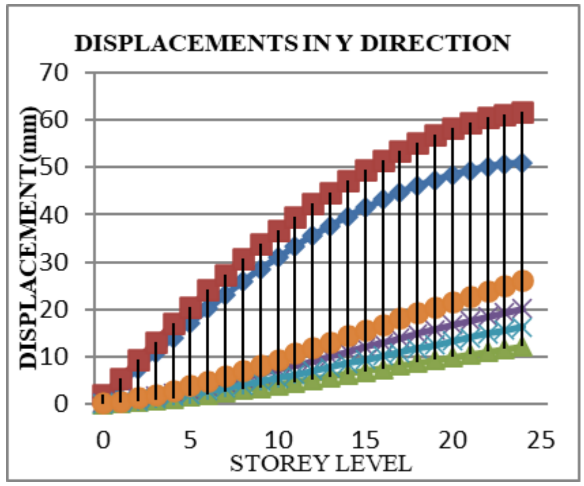
7. RESULTS AND DISCUSSION

7.1. Story Displacements

It is the displacement of a storey with respect to the base of the structure. Displacements under seismic loads should not exceed.

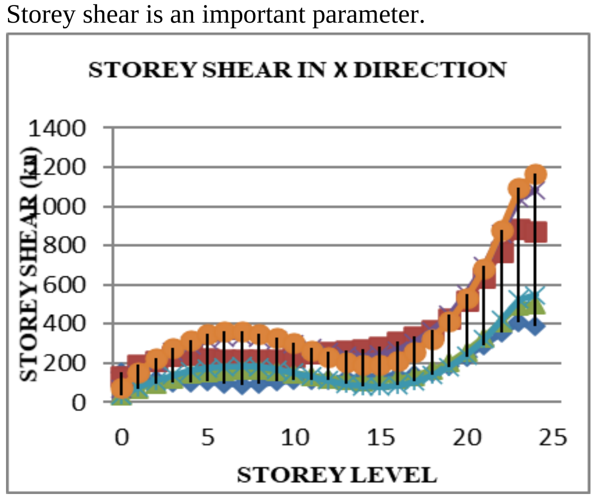
$$\frac{H}{250}=\frac{80000}{250}=320\text{mm}$$

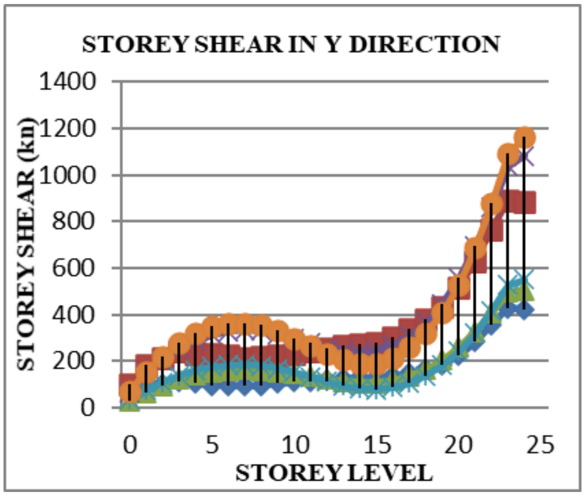




7.3 Storey Shear:

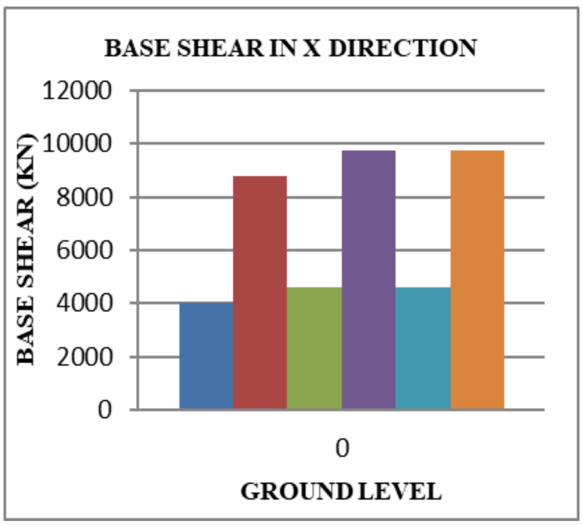
IS 1893-2016 code is used to calculate Storey shear, for all the models results are obtained and presented in Tables and Figures. by using linear dynamic analysis storey shear of models are compared and illustrated in table 5.3. for earthquake resistant design of buildings Storey shear is an important parameter.

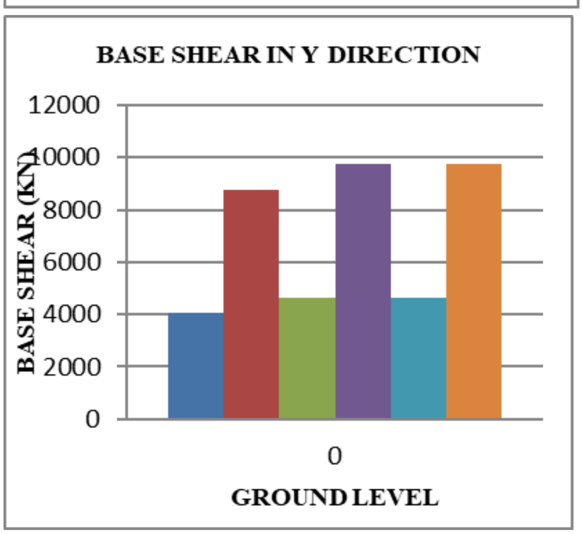




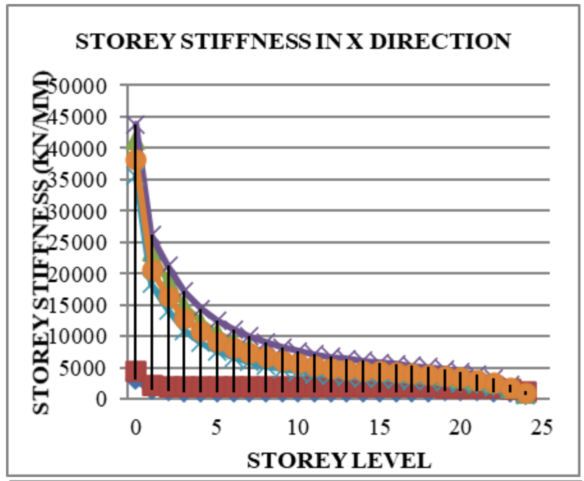
7.4 Base Shear:

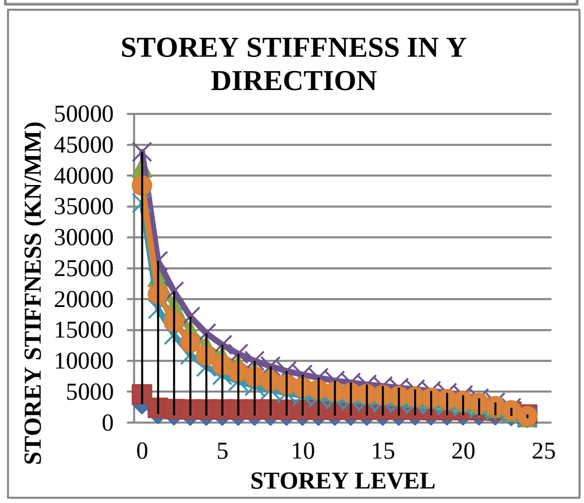
Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.





7.6 Storey stiffness:





8. CONCLUSION

1. For flat slab systems, location of shear walls is very important for resisting seismic forces in seismic prone areas.
2. Flat slabs are the most critical system in the seismic prone areas. To have a good control over the forces and displacements, it is preferable to locate the shear wall towards flat slab systems.
3. The presence of shear wall influences the overall behavior of structures when subjected to lateral forces. Lateral displacements and storey drifts are considerably reduced while contribution of the shear wall.
4. The storey drifts observed in all models are found to be within the limit as specified by code (IS: 1893-2016, part 1) by linear dynamic analysis.
5. As compared with moment frame and flat slab system, moment frame gives the better results.

Among the shear wall models the shear wall provided at external wall in plan given better results. After that shear walls provided at peripheral corners.

6. It is observed that the flat slab buildings are having relatively higher base shear and storey shear values than the other models. 7. It is observed that the buildings without shear wall in plan are having relatively less base shear and storey shear values than the other models.
7. It is observed that as the mode number increases fundamental time period of all the models decreases. As compared with moment frame system fundamental time period of flat slab system is reduced by 14.44%.
8. It is observed that Fundamental Time Period of the without shear wall model is very high values compare to remaining models.
9. Lateral translational stiffness of each storey is not less than 70 percent of that of the storey above. b) Lateral translational strength of each storey is not less than that of the storey above.
10. Storey stiffness of moment frame slab system is relatively small as compared the remaining models i.e flat slab, with and without shear walls provided symmetrically in plan and at peripheral corners in plan to the flat slab and moment frame.
11. Flat slab with central shear wall has more stiffness than all other models with and without shear walls. Models Without providing shear walls has less stiffness than models with shear walls.

Scope of future work:

1. The studies can be carried out for different slab systems for better understanding of the behavior of different slab systems with and without shear walls at different locations.
2. The present study is based on linear dynamic analysis using response spectrum. The results need to be verified with the non-linear dynamic analysis.
3. The study can be further extended to the buildings in seismic prone areas by incorporating voided slab system.

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