Comparative Study of Seismic Performance of a Building with and without P-Delta Effect using Time History Analysis

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Abstract— The G+20 multi storey irregular building is taken for present study. This building is modeled and analyzed by using ETABS V9.7.4. Assuming the material property as linear and nonlinear. The performance of the building is studied by comparing the base shear, displacement, storey drift in time history analysis. Multi-storey buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load, even then their construction is still widespread in the developing nations. An investigation has been performed to study the behavior of the columns at ground level of multi-storey buildings with soft ground floor as satellite bus stop and moment transfer beams in all storey subjected to earthquake loading. The structural action of masonry infill panels of upper floors has also been taken into account by modeling them as diagonal struts. Shear wall is one of the most commonly used lateral load resisting in high rise building. In this study building is modeled with different shapes of shear wall with top and bottom soft storey.

Key words: Soft Storey, P-Delta Effect, Equivalent Diagonal Strut, Moment Transfer Beams, Shear Wall

I. INTRODUCTION

Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings. Objective of seismic analysis is stated as the structure should be able to endure minor shaking intensity without sustaining any damage, thus leaving the structure serviceable after the event. Lateral forces can produce the critical stresses in a structure and in addition cause lateral sway of the structure. Many buildings constructed in recent times have a special feature that the ground stories are left open for the purpose of parking, reception etc. Such buildings are often called open ground storey buildings or buildings on stilts. The strength demand on the column in the first storey for these building is large, upper stories move almost together as a single block and most of the horizontal displacement of the building occurs in the soft ground storey. Reinforced concrete building can adequately resist both horizontal and vertical load. Whenever there is requirement for a multistory building to resist higher value of seismic forces, lateral load resisting system such as shear wall should be introduced in a building. Vertical plate like RC wall introduced in building in addition to beam, column and slab are called shear wall. Shear walls are incorporated in building to resist lateral forces and support the gravity loads. RC shear wall has high in plane stiffness. Positioning of shear wall has influence on the overall behavior of the building. For effective and efficient performance of building it is essential to position shear wall in an ideal location. Many researchers have investigated on changing position of shear wall location to determine parameter like storey shear, time period, storey acceleration and displacement. This analysis is done by using ETABS 2015.

II. OBJECTIVES OF THE PRESENT WORK

- To study the effect of P-Delta in multistory buildings.
- To know proper modeling technique of masonry infill.
- To know the behavior of the building with ground and top soft-storey.
- To study the influence of moment transfer beams on structural behavior of multistory building.
- To study the parameters such as storey drift, storey displacement, story shear in multi-story building.
- To check the results with software ETABS, with different models, parameters.

III. MODEL DESCRIPTION

In the present study 9 different models of 21 storey which is having 4 bays of 10m in x- direction and 13 bays of 10 m in y direction with the plan dimension of 40m X 130m and a storey height of 10m, 2m and 3m of storey 1, storey 11 and 21 and remaining all storey respectively. Following type of structure such as bare frame, both ground and intermediate floor as soft storey are considered, L, Box, swastika and I pattern shear wall are provided at corner of the plan. Providing equivalent diagonal strut of 300 mm width in place of masonry infill panel. The building is considered in zone 5 and medium strength soil. Modulus of elasticity of brick masonry is $3500x10^3 kN/m^2$ density of brick masonry is $20kN/m^3$, grade of concrete(for beams and slabs) is 25 N/mm^2, grade of concrete(for columns and shear walls) is 30 N/mm^2, floor finishes is $1kN/m^2$, imposed loads is 3.5 KN/m^2, wall load of $12kN/m^2$. Slab thickness of 0.150m and thickness of slab of 200 beneath swimming pool exerting a pressure of 19.62 kN/m^2 on slab. Column size of 1.2mx1.5m, Moment Transfer beam of .4mx.6m in x –direction, beam at first storey of .6mx1.2m and rest of the beams as .4mx.6m.

IV. MODELS CONSIDERED FOR ANALYSIS

Following 9 models are analyzed by equivalent static method response spectrum method using ETABS software.

1) Model 1: Bare frame model, however masses of brick masonry infill walls (230mm thick) are included in the model.
2) Model 2: Building model is same as model 1 with L-type shear wall at corners.
3) Model 3: Building model is same as model 1 with Box-type shear at the corners.
4) Model 4: Building model is same as model 1 with Swastik-type shear wall at corners.
5) Model 5: Building model is same as model 1 with I-type shear wall at corners.

6) Model 6: Building model is same as model 2 with full diagonal strut.
7) Model 7: Building model is same as model 3 with full diagonal strut.
8) Model 8: Building model is same as model 4 with full diagonal strut.
9) Model 9: Building model is same as model 5 with full diagonal strut.

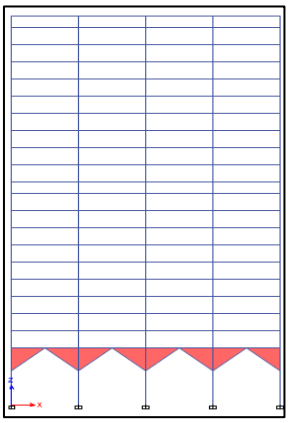
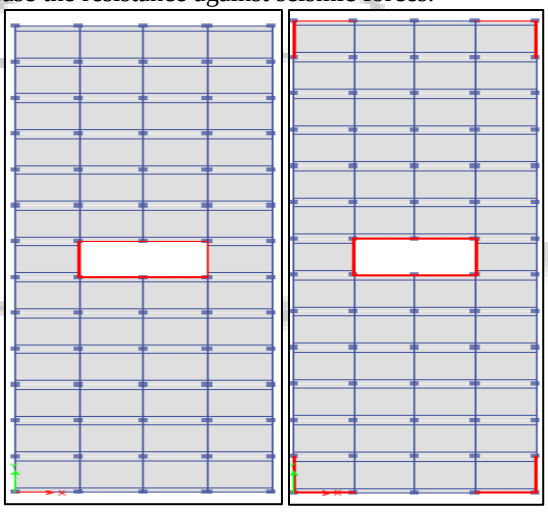
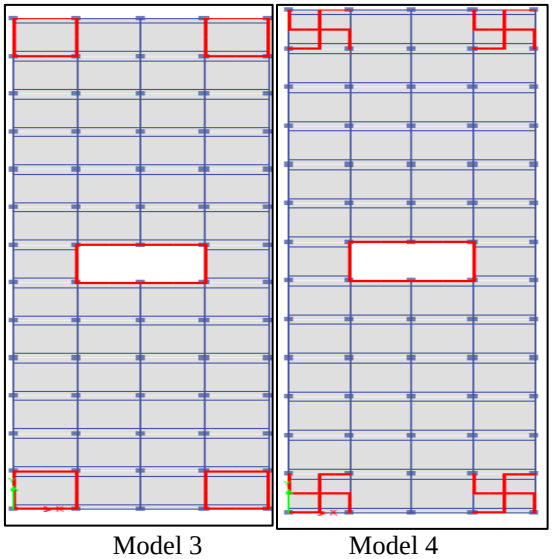


Fig. 1: Front view of building

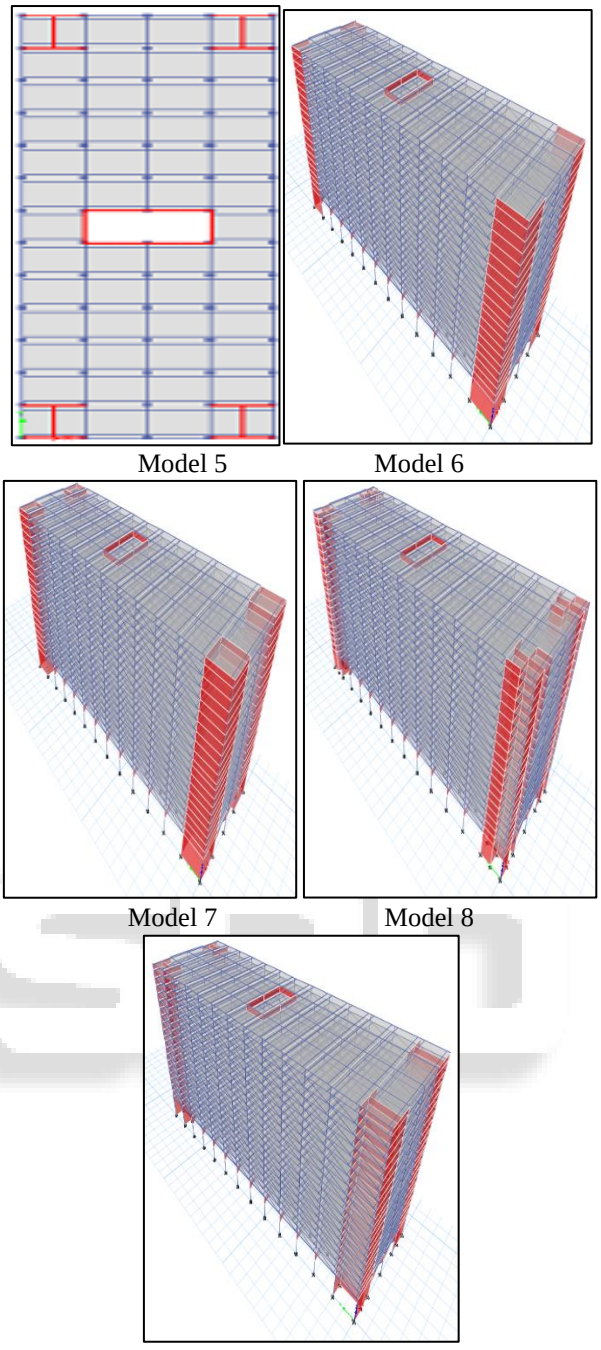
The above figure shows how beams and columns in the ground storey are connected by the use of a triangular reinforced concrete wall in order to provide extra stability and increase the resistance against seismic forces.



Model 1 Model 2



Model 3 Model 4



Model 5 Model 6 Model 7 Model 8 Model 9

Fig. 2: Models

V. RESULTS AND DISCUSSION

The results obtained from the ETABS analysis of G+20 model for time history analysis with and without p-delta effect are tabulated and discussed for the parameters such as base shear, storey drift and storey displacement.

A. 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

Base Shear (kN)		
Model No.	Without P-Delta	With P-Delta
1	24166.6505	27380.2288
2	61962.4054	58926.6708
3	72417.0422	70315.0696

4	64252.0447	64643.8459
5	53084.3917	51829.4338
6	78366.377	75392.1247
7	72622.3526	73921.1777
8	72437.2838	73602.5627
9	54683.4237	52585.2802

Table 1: Base Shear for Time History Anlysis with and without P-delta effect.

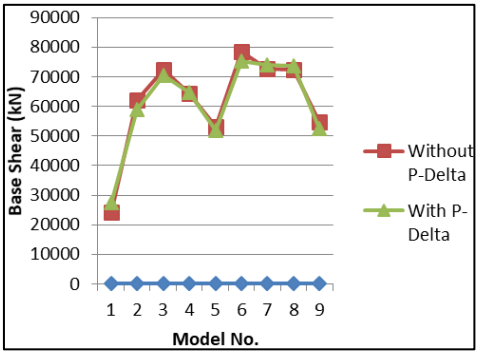


Fig. 3: Chart 1: Base Shear for THA with and without P-delta effect.

B. Storey Displacement

It is the important factor, when the structure is affected by seismic forces and wind force. It mainly depends on the height of the structure, tall structures are more flexible for lateral loads. Displacement values will be higher at the top storey and less at bottom storey.

The storey displacement time history analysis with and without P-delta methods are given in the Table 2 and the graphical representation is shown in Chart 2.

Storey Displacement (mm)		
Model No.	Without P-Delta	With P-Delta
1	379.3	308.3
2	135.5	136.4
3	96.5	96.9
4	109.8	112.8
5	96.6	95.4
6	114.4	108.3
7	100.8	100.3
8	103.8	104.3
9	95.9	95.4

Table 2: Storey Displacement for Time History Analysis with and without P-delta effect.

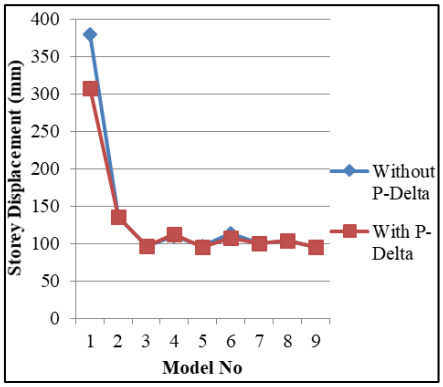


Fig. 4: Chart 2: Storey Displacement Vs Different Models

C. Storey Drift

It is nothing but the difference between storey displacements of one storey with respect to the other storey. As per codes its value should not exceed the limit of 0.004 of height of the storey. Its value is usually maximum at mid stories.

The storey drift for THA methods are given in the Table 3 and the graphical representation is shown in Chart 3

Storey Drift		
Model No.	Without P-Delta	With P-Delta
1	0.009052	0.007916
2	0.003651	0.003539
3	0.002407	0.002434
4	0.003036	0.003067
5	0.002356	0.002337
6	0.002948	0.002684
7	0.002389	0.002399
8	0.002796	0.002811
9	0.002304	0.002306

Table 3: Storey Drift for time history analysis with and without P-delta effect.

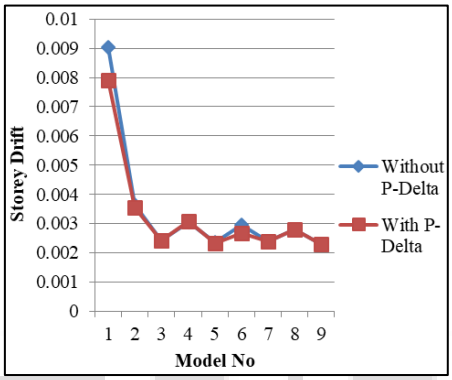


Fig. 5: Chart 3: Storey Drift Vs Different Models

VI. CONCLUSIONS

1) The storey drifts are found within the limit as specified by the code IS 1893(Part-1):2002.
2) Higher storey drift values are dangerous to the building in our study Model 9 has shown least drift by time history analysis.
3) Drift is almost same in with P-Delta and without P-delta and without P-delta effect.
4) Highest storey displacement is shown by bare frame Model 1.
5) Considerable amount of reduction in storey displacement observed by introduction of any type of shear wall.
6) Displacement is found to be minimum for Model 9 in case of THA method. Considerable amount of storey displacement is reduced using any type of shear wall.
7) The soft story effect is less at intermediate location of the building because of increased stiffness. A service storey of lesser height can be safer for building at higher level.
8) In case of base shear, Model 6 offers high base shear with L-type shear wall at corner.
9) All models with different type of shear wall and models with shear wall with diagonal strut are giving good results compared to bare frame model. So it is recommended to use any type of shear wall depending on the site condition and the convenience of designer.
10) By providing shear walls at corner p-delta effect can be minimized,
11) Seismic base shear is more in p-delta effect and less in without p-delta effect.
12) P-delta effect increases bending moment and forces.

13) P-delta effect increases joint displacement compared to without p-delta effect.
14) A secondary beam helps to reduce span of the large slab and keep check on slab depth. It avoids load concentration and helps in redistribution of bending moments from main beams.
15) By using secondary beams we can avoid floating columns.

REFERENCES

[1] IS 13920: 1993, Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces; Bureau of Indian Standards, New Delhi, India
[2] Mohammed Khaja Moinuddin, Vishwanath. B. Patil, (2014), 'Seismic Evaluation of R.C. Framed High Rise Structural System with the Effect of Ground and Intermediate Soft Storey', International Journal of Engineering Research & Technology, vol. 3, pp. 602 - 608.
[3] IS 456: 2000."Indian Standard Code of Practice for plain and reinforced Concrete", Bureau of Indian Standards, New Delhi. ETABS Non-linear 9.7 Computers and Structures Inc, Berkeley.
[4] IS 1893 (Part I): 2002, 6th Edition, Criteria for Earthquake Resistant Design of Structures; Bureau of Indian Standards, New Delhi, India
[5] Md Irfanullah, Vishwanath. B. Patil."Seismic Evaluation of RC Framed Buildings with Influence of Masonry Infill Panel".International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-2, Issue-4, September 2013.
[6] Syed Mohammad Zakir Ali M.Tech Student (Structural Engineering) & Amaresha"A Seismic Analysis of RC High Rise Structural Building with Multiple Soft Storey at Various Level using ETabs "(IJSRD) vol 3, issue 04,2015.
[7] IS 13920: 1993**.** "Indian Standard Code of the practice for the detailing of Reinforced Concrete Structures Subjected to Seismic Forces" Bureau of Indian Standards, New Delhi.
[8] IS 456: 2000. "Indian Standard Code of Practice for plain and reinforced Concrete", Bureau of Indian Standards, New Delhi.
[9] Dr. Vinod Hosur. "Earthquake resistant design of building structures" Wiley India Pvt Ltd. New Delhi 110002.

