P-DELTA ANALYSIS OF MULTI STORY RC BUILDING

Rajath R T[1], M Ramegowda[2]

[1]P.G. Student, Department of Civil Engineering, AIT, Chikmagalur, Karnataka, India
[2]Professor and Head, Department of Civil Engineering, AIT, Chikmagalur, Karnataka, India

Abstract

In first order analysis of a structure both kinematic as well as equilibrium relationships are taken with respect to un-deformed shape of the structure. But this does not consider the load which caused due to deflection of the structure. For stability design of a structure second order analysis is required which counteracts equilibrium and kinematic relationship of a structure. In a deformed structure in addition to the applied loads many additional loads due to deformation which develops second order or P-delta effects in the structure. In the present study seismic analysis and wind load analysis of a multi -storey RC building with and without P-Delta effects is analysed by using ETABS structural analysis software. The seismic zone factor of 0.36 is considered which falls under Zone-V. From the analysis, both the displacement and drifts with respect to earthquake loads are minimum when compared with earthquake load with P-delta effects.

Keywords: *P-delta, displacement, drifts and lateral load.*

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1. INTRODUCTION

When the structural elements are subjected to axial load, P-Delta effects occur in the structure. It is one of the second order effects which corresponds to the load imposed on the structure with respect to deformation. It is a second order effect which is related with the displacement and the axial load amount applied. P-Delta is a non-linear effect that occurs in every structure where elements are subject to axial load. P-Delta is actually only one of many second-order effects. It is a genuine "effect" that is associated with the magnitude of the applied axial load (P) and a displacement (delta).

2. P- Δ EFFECT

In structure P-Δ effect generally arises due to the direct action of lateral loads where the deformed structure shape is a dominating factor in the structure at state of equilibrium. In second order analysis this kind of effects are taken care when the elements are in damaged condition. Vertical loads in high rise buildings on their way through along the elements of the structure produces additional loads at deformed parts. This additional load is not taken into consideration for the analysis of the structure. Accurate mathematical model of the structure is considered for analysis in order to study effects of P-Delta.

Second-order analysis when accounting for P-Delta combines two effects to reach a solution:-

(i) **Theory of large displacement**: - In this theory both forces and moments due to deformed shape of structure and also members are considered.
(ii) **Stress stiffening**: - In this the effect of axial load on structure stiffness is seen. Normally tensile loads straighten the geometry of an element this increases the stiffness whereas compressive loads accentuate deformation which in turn reduces the stiffness of the structure.

3. LITERATURE REVIEW

Farzad Naeim et al., (2001), reported the difficulties due to drift and lateral solidity of a structure. At the early stages of design development itself the drift and lateral stability plays an important role in the designing of the structure. In tall buildings torsion is the main contributor for the structural response with respect to different load combinations. [7]

Mallikarjuna B.N et al., (2014), presented P-Delta analysis is compared with linear static analysis. In this study, a 18 steel storey has been selected. The mathematical model is analysed by structural analysis software STAAD Pro 2007 with P-Delta effect consideration. [1]

Anuj Man Shakya., (2011), carried out the effects of P-delta on steel moment frames with decreased beam section connection. Dog bone connection is called reduced beam section. [5]

Yousuf Dinar et al., (2013), focused on six different types of structures for the analysis with different number of stories. Non-linear method of P-delta analysis is used and it is carried out by P-delta analysis both P|-delta analysis and linear static analysis are important for RC buildings. [6]

Rafael Shehu et al., (2014), focused to make submission to the P-delta problem and ductility in seismic design ductility is important parameter. For safe design seismicity remains fundamental premise. Design is based on the recognition of the structure deformation shape. [2]

Table-1 Details about the building

Sl no	Structure details	
1	Number of stories	13
2	Ground floor height	5m
3	Floor to floor height	3m
4	Beams	RC 0.3m*0.6m,

		0.3*0.23m
5	Column	RC 0.3m*0.6m, 0.6*0.23m
6	Slab thickness	0.125m
7	Live load	5kN/m^2
8	Live load after applying reduction factor for earthquake case	5 X 0.25 = 1.25 kN/m^2
9	Roof live load	2kN/m^2
10	Seismic zones	V
11	Zone factor	0.36
12	Importance factor	1
13	Soil type	Medium (II)
14	Response reduction factor	5 (special moment resisting frame, SMRF)
15	Material used	M20, Fe 415
16	Damping	5%

4. DETAILS ABOUT THE STRUCTURE

The plan of the proposed building is shown in Fig-1 and elevation is shown in Fig-2

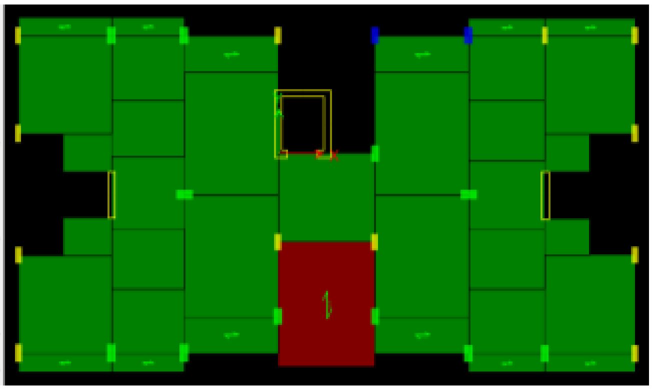

Fig-1: Building Plan

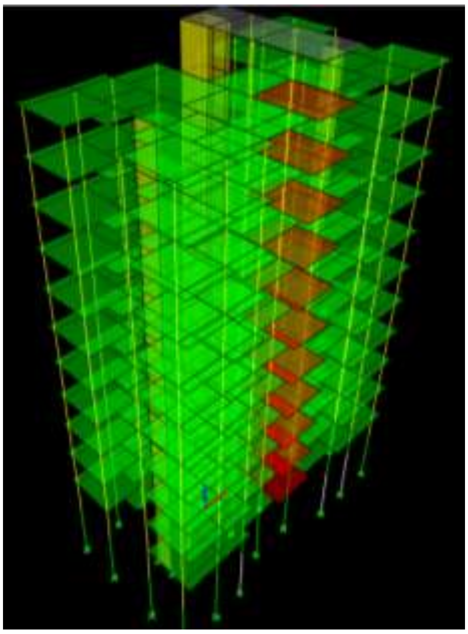

Fig-2: Building Elevation

5. RESULTS AND DISCUSSION

Along the height of the building auto lateral load for the earth quake load is shown in fig-3 Storey height is plotted in Y-axis and lateral force is plotted in X-axis

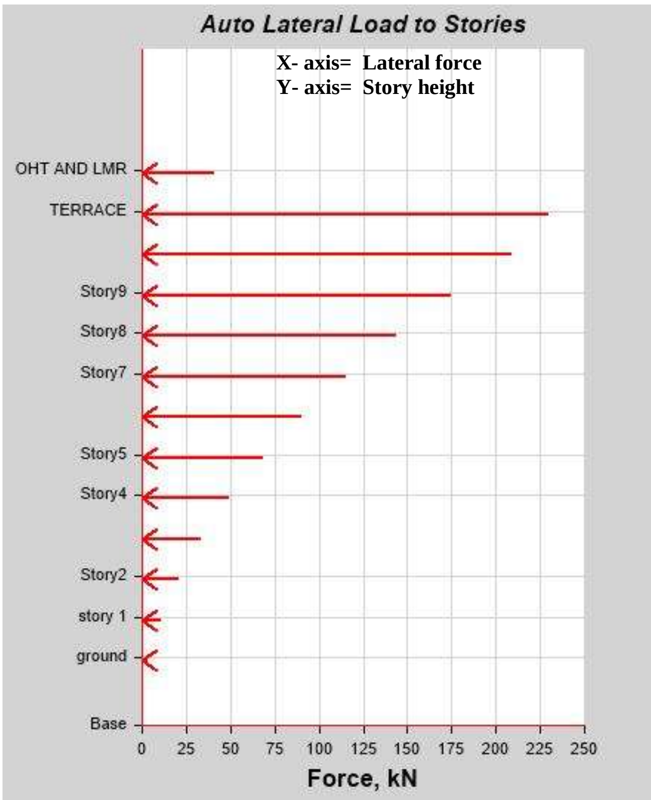

Fig-3: Auto lateral load verses storey height due to earth quake load in general

For earth quake load case the value of axial force are tabulated in table 1. Maximum axial force is seen in the terrace and minimum lateral force is seen at ground floor.

Table-1: Auto lateral load for earth quake

Story	Elevation (m)	Lateral load (kN)
Oht and lmr	41	40.6999
Terrace	38	230.2786
Story 10	35	209.4379
Story 9	32	175.073
Story 8	29	143.488
Story 7	26	115.4204
Story 6	23	90.327
Story 5	20	68.2961
Story 4	17	49.3469
Story 3	14	33.4928
Story 2	11	20.7709
Story 1	8	11.1086
Ground	5	3.2841

Storey displacement with respect to earth quake load without P-delta is shown in fig-4. Storey height is plotted in Y-axis and storey displacement is plotted in X-axis.

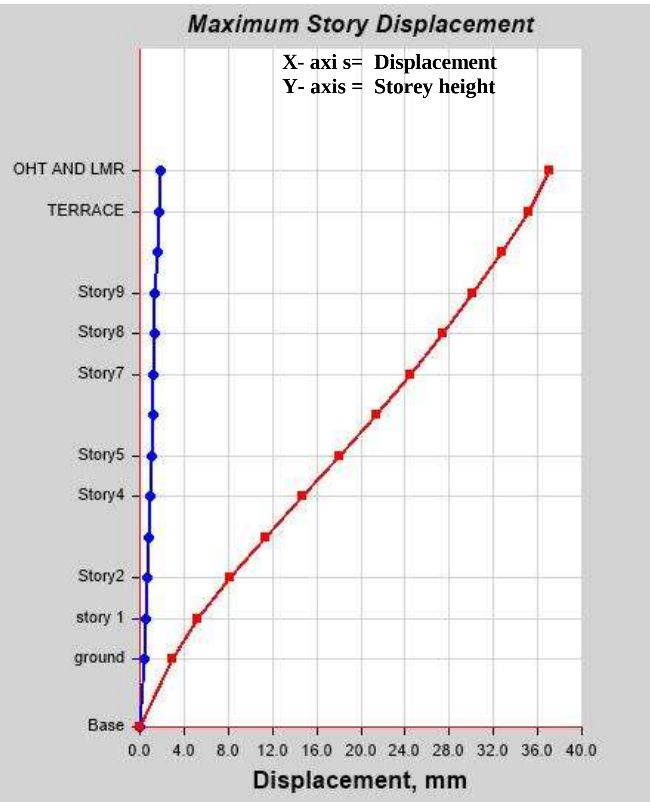

Fig-4: Displacement verses storey height due to earth quake load without P-delta effects

At the overhead tank and lift machine room the maximum storey displacement is seen and at ground floor minimum displacement is seen as shown in table-2.

Table-2 Storey displacements

Story level	**Height (m)**	**X direction (mm)**	**Y direction (mm)**
Oht and lmr	41	1.8	37.1
Terrace	38	1.7	35.1
Story10	35	1.6	32.7
Story 9	32	1.4	30.1
Story 8	29	1.3	27.4
Story 7	26	1.2	24.5
Story 6	23	1.1	21.4
Story 5	20	1.1	18.1
Story 4	17	0.9	14.8
Story 3	14	0.8	11.4
Story 2	11	0.7	8.2
Story 1	8	0.6	5.2
ground	5	0.4	2.9

For the eart quake load storey displacement with P-delta effects along the height of the building is shown in figure-5. The storey height is plotted in Y-axis and storet displacement is plotted in X-axis.

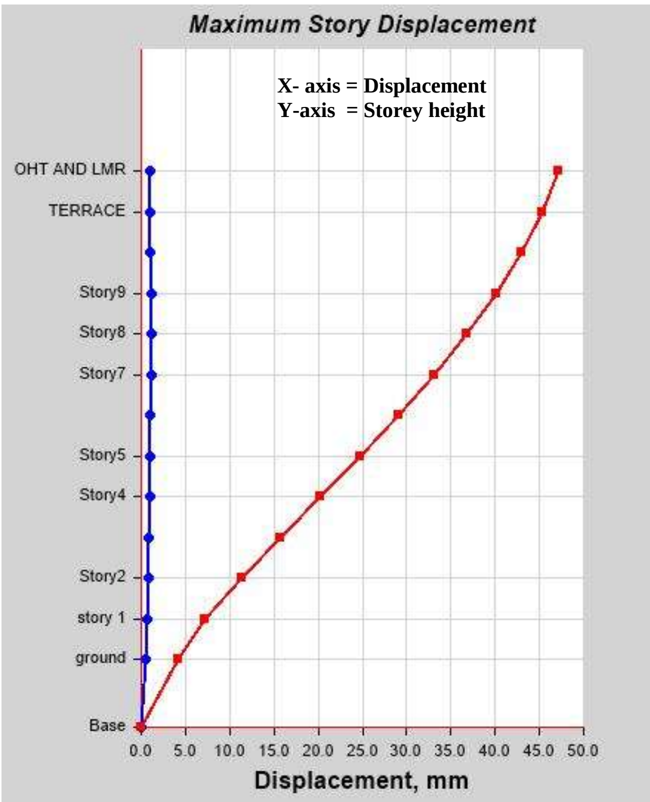

Fig-5: Displacement verses storey height due to earth quake load with P-delta effects

At the over head tank and left machine room maximum storey displacement is seen and the minimum storey displacement is seen at ground floor as shown in table-3.

Table-3: Storey displacements

Story level	Height (m)	X direction (mm)	Y direction (mm)
Oht and lmr	41	0.9	47.1
Terrace	38	1.1	45.4
Story 10	35	1.1	43
Story9	32	1.1	40.1
Story8	29	1.1	36.8
Story7	26	1.1	33.1
Story6	23	1.1	29.1
Story5	20	1	24.7
Story4	17	1	20.3
Story3	14	0.9	15.8
Story2	11	0.8	11.4
Story 1	8	0.7	7.2
Ground	5	0.5	4.2

Displacements are maximum in earth quake load with P-delta effects and displacements are minimum in earth quake load without P-delta effects as shown in chart-1.

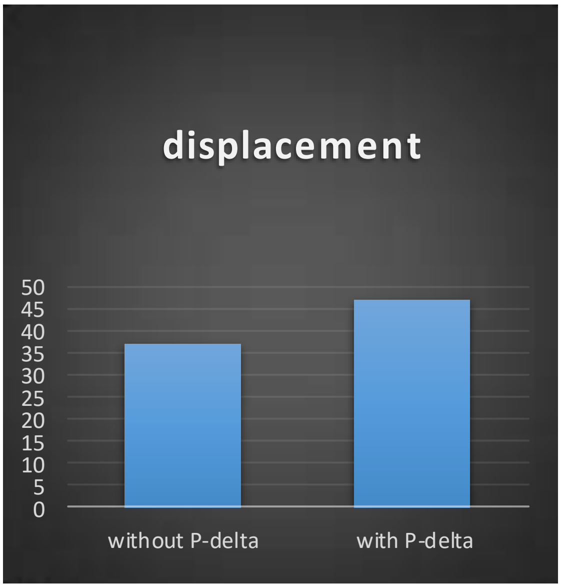

Chart-1: Comparison of roof displacements between the results.

6. CONCLUSION

P-delta investigations and linear static analysis are carried out for 13 storey RC framed structure using ETABS. On the basis of results obtained, following conclusions are drawn.

- Displacements with respect to earthquake load with P-delta effects are maximum when compared with earthquake load. This concludes P-delta effects have more effect in designing of a structure rather than first order effect.
- We can minimize pounding action of two tall buildings with roof displacements.
- Storey displacement values for all the load cases are within the permissible limit.

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