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Stability Analysis of Multi-Story Building with Underneath Satellite Bus Stand having Top Soft-story and Floating columns using P-Delta Analysis.

Syed Gousepak[1], Prof. Vishwanath. B. Patil[2]
[1]MTech Structural Engg. Student, [2]Associate Professor
[1,2] Department of Civil Engineering
Poojya Doddappa Appa College of Engineering Kalaburagi-585102

Abstract—*The masonry infill walls are considered as non-structural element and their stiffness contribution are ignored in the analysis when building is subjected to seismic loads, but it is considered while we studying stability analysis. RC frame building with open ground storey, and similar soft storey effect can be observed when soft storey at different levels of structure are constructed. The method used for stability analysis of columns, shear walls, coupled and coupled components, cores, single storey and multi storey structures are studying. Buildings and structures are considering stable with lateral supports by using either bracing systems or shear system or both such as wall to ensure the stability of the building. One of the problems is affected from wind load. The calculation methods are computer assisted through the use of the software, ETAB. Comparisons of results are made between the methodologies, and different models with different parameters. This is how the soft storey effects are managed to overcome the future damages of the storied structures.*

Key words: **Satellite Bus Stop, Soft-Storey, Non-Linear Time History Analysis, P-Delta, Floating Columns.**

1. INTRODUCTION

Satellite bus stop is the new term that has come in the recent years in cities like Bengaluru because, due to increasing population and the land value since the past few years' bus stands in populated cities is a matter of major problem. So that constructions of multi-storeyed buildings with open first storey. Hence it has been utilizing for the moment of the buses and people can use this as bus terminals. These type of buildings having no infill walls in ground storey, but all upper storeys infilled with masonry walls. Soft storeys at different levels of structure are constructed for other purposes like lobbies conference halls and for the service storeys. This storey is known as weak storey because storey stiffness is lower compare to above storeys. So, importance to be given for the earthquake resistant design. Consideration of infill and shear walls and correct shape can improve the performance of the building in analysis.

2. DESCRIPTION OF STRUCTURAL MODEL

2.1 Geometry

Grade of concrete	Member	Size in mm	Storey
M35	Column	900x1000	1st & 2nd
M35	Column	700x900	3 to 9
M35	Column	500x700	10 to 12
M35	Floating column	300x500	2 to 12
M35	Beam	900x1000	1st
M35	Beam	300x500	2 to 11
M35	Beam	300x400	12th
M25	Slab	150 mm thick	All storey

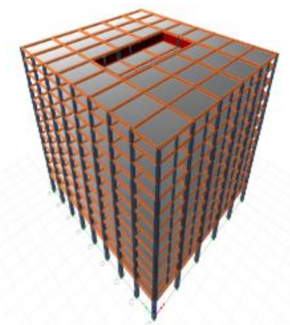
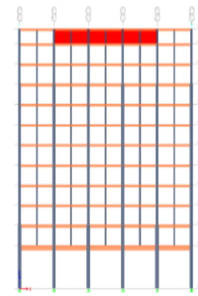
The plan layout for all the building models is same as shown below. Study has been done on ten different models of a twelve storey building. Out of them one is bare frame model, and fully infilled frame in the form of diagonal strut with bottom and top soft storey and other three models with different shapes of shear wall. The member size at respective floors with grade of concrete is shown in below table.

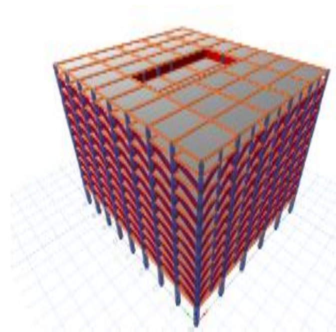
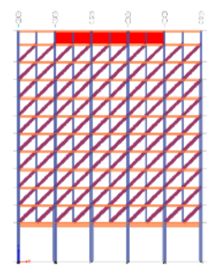
In the top soft storey Swimming pool is modeled with member properties as L = 30m, B = 14m, H= 2.7m, h = 2.3m. Thickness of wall (t_w) = 0.3m, thickness of slab (t_s) = 0.3m. following data is used in the analysis of the RC frame building models. Density of Reinforced Concrete 25kN/m^3 , Modulus of elasticity of brick masonry 4.33x10^3 KN/m², Density of brick masonry 20kN/m³, Poisson's Ratio of concrete 0.2, Floor finishes 1.0kN/m^2, Imposed loads 4KN/ m^2, Roof live 1.5 KN/ m^2 , Thickness of wall 0.3m, Zone –V, Zone factor, Z (Table2 of IS 1893-2002) – 0.33, Importance factor, I (Table 3 of IS 1893-2002) – 1.5, Response reduction factor, R (Table 7 of IS 1893-2002) – 5.00, Soil type (figure 2 of IS 1893-2002) – Type II (Medium soil),Storey heights: Bottom storey = 8m, 2 to 11th storey = 3.7mTop storey =2.7m

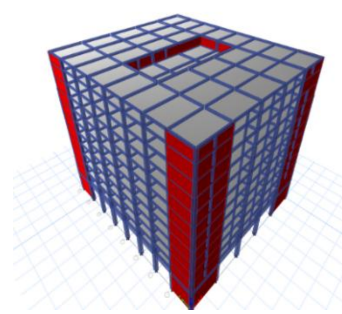
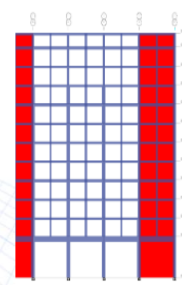
2.2 Models Considered for Analysis

Following ten models are analyzed in ETABS 2015 as special moment resisting frame using with and without P-Delta option for equivalent static method, response spectrum method and Time history nonlinear analysis.

- **Model 1**: Bare frame model with floating columns and swimming pool (at top storey), however masses of brick masonry infill walls (300 mm) thick are included in the model with and without P-delta.
- **Model 2**: Building model same as model 1and has full brick masonry infill in the form of diagonal strut but excluding top storey and bottom double height storey, with and without P-delta.
- **Model 3**: Building model is same as model 1, further L shape shear wall is provided at corners, with and without P-delta.
- **Model 4**: Building model is same as model 1, further C shape shear wall is provided at corners, with and without P-delta.
- **Model 5**: Building model is same as model 1, further + shape shear wall is provided at the corners, with and without P-delta.

3.RESULTS AND DISCUSSIONS

3.1 INTRODUCTION

Most of the past studies on different buildings such symmetrical and unsymmetrical have adopted idealized structural systems without considering the effect of masonry infill and concrete shear and core walls. Although these systems are sufficient to understand the general behaviour and dynamic characteristics, it would be interesting to know how real building will respond to earthquake forces. For this reason, a hypothetical building, located on a plane ground having similar ground floor plan have been taken as structural systems for the study.In this chapter, the results of natural period of vibration, base shear, lateral displacements, storey drifts of different building models are presented and compared. An effort has been made to study the effect of shear wall both at corners on exterior side in longitudinal & transverse direction respectively.

3.2 FUNADAMENTAL NATURAL TIME PERIOD AND FREQUENCY

All objects (including buildings and the ground) have a “natural period,” or the time it takes to swing back and forth. If you pushed the flag pole it would sway at its natural period. As seismic waves move through the ground, the ground also moves at its natural period. This can become a problem if the period of the ground is the same as that of a building on the ground. When a building and the ground sway or vibrate at the same rate, they are said to resonate. When a building and the ground resonate it can mean disaster. One of the most important factors affecting the period is height. A taller building will swing back and forth more slowly (or for a longer period) than a shorter one. Building height can have dramatic effects on a structure’s performance in an earthquake.

	PERIOD IN SEC		FREQUENCY IN CYC/SEC	
MODEL	**Without P-Delta**	**With P-Delta**	**Without P-Delta**	**With P-Delta**
1	3.833	4.204	0.259	0.238
2	0.843	0.843	1.203	1.183
3	1.855	1.855	0.539	0.531
4	1.495	01.51	0.339	0.332
5	2.727	2.827	0.337	0.354

Table 3.1: Fundamental natural time period and Frequency.

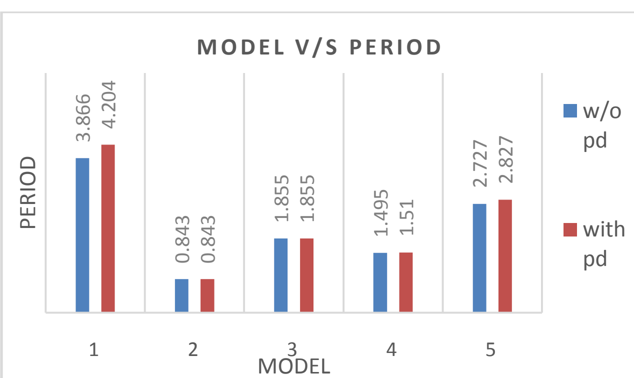


Chart 3.1.1: Model Vs Time period for Different models

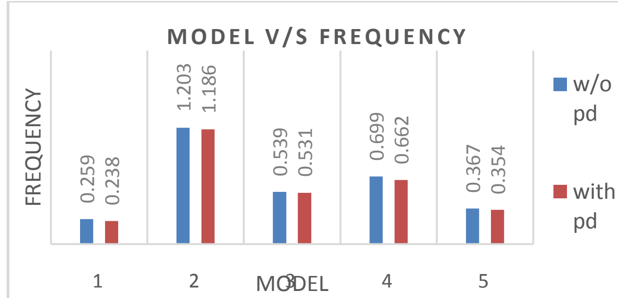
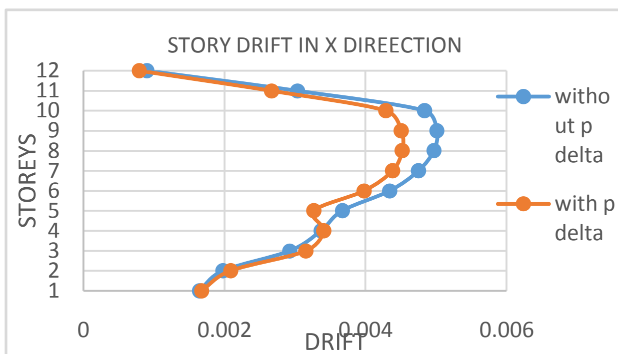


Chart 3.1.2: Model Vs Frequency for Different models

Table 3.1 shows the time period and frequency obtained by ETABS without P-delta options for analysis, time period and frequency for model 2 reduces by 31.51% as compared to bare frame model 1. For models with shear walls i.e. model 3,4 and 5-time period reduced by 49.33%, 52.94%, and 54.53% respectively as compared with model 1.

Table 3.1 shows the time period and frequency obtained by ETABS analysis, time period and frequency for model-1 with P-Delta increases by 5.17% as compared to model 1 without P-delta. For model-2 with P-Delta increases by 2.41% as compared to model 1 without P-delta. Similarly, for models with shear walls i.e. model 3,4 and 5-time period increases by 1.02%, 0.71%, and 0.87% respectively as compared with P-delta.



From chart 3.1-time period by ETABS analysis values are differing for different models. Thus it can be clearly understanding that from table 3.1 and chart 3.1, presence of brick infill and concrete walls considerably reduces the time period of building as shown in chart 3.1 and P-Delta increases the Time period and frequency of the structure.

3.3 STOREY DRIFTS

The permissible storey drift according to IS1893(part1)-2002 is limited to 0.004 times the storey height, so that minimum damage would take place during earthquake and pose less psychological fear in the minds of people. The maximum storey drifts for various building models along longitudinal and transverse direction obtained from Non-linear time history analysis from ETABS are shown in tables below.

From the table 3.3.1 to 3.3.5 and chart 3.3.1 to 3.3.10, shows the comparison of the drift values of all the model in x-direction and y-direction of all storeys by Non-Linear THA with and without P-Delta. from that it can be seen that the storey drift in all storey for models (with shear wall) has lower values as compare to that for models (without shear wall). It can be seen that the model-2 yields higher drifts values as compared with the other models. The drift values gradually decrease from storey 1 to 15th storey in longitudinal direction. Also the drift in both the directions satisfy the permissible drift limit i.e. 0.004*h = 0.004*3.5 = 0.014m.

Story	Drift w/o p d	Drift with p d	Drift w/o p d	Drift with p d
Story12	0.000895	0.000783	0.000744	0.000323
Story11	0.003033	0.002339	0.00333	0.003383
Story10	0.004837	0.004289	0.005133	0.004304
Story9	0.005008	0.004503	0.005157	0.004747
Story8	0.004933	0.00452	0.005138	0.004901
Story7	0.004751	0.004383	0.004808	0.004712
Story3	0.004343	0.00398	0.004813	0.004419
Story5	0.003338	0.003237	0.00448	0.004454
Story4	0.003334	0.003408	0.004357	0.004305
Story3	0.00292	0.003153	0.003283	0.003798
Story2	0.001979	0.002085	0.001371	0.001929
Story1	0.00134	0.001372	0.001443	0.001311

Table 3.3.1: Comparison of Storey Drifts for with and without P-Delta Non-Linear Time History analysis of Model-1 in x and y-direction.

Chart 3.3.1: Storey drift Vs Storey for model-1

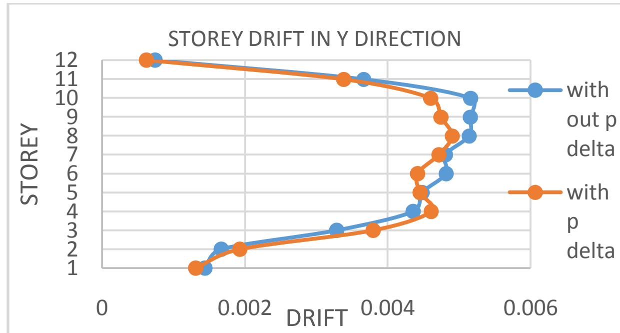


Chart 3.3.2: Storey drift Vs Storey for model-1 along Y-direction by THNA with and w/o P-d

Story	Drift pd	Drift	Drift pd	Drift
Story12	0.000377	0.000378	0.000338	0.000339
Story11	0.000143	0.000145	0.000152	0.000153
Story10	0.000135	0.000137	0.000135	0.000133
Story9	0.000133	0.000134	0.000131	0.000132
Story8	0.000134	0.000133	0.000133	0.000133
Story7	0.000133	0.000135	0.000133	0.000133
Story3	0.000137	0.000139	0.00013	0.00013
Story5	0.000139	0.000137	0.000155	0.000155
Story4	0.000159	0.00013	0.000159	0.000159
Story3	0.00013	0.000158	0.000177	0.000175
Story2	0.000233	0.000257	0.000288	0.000284
Story1	0.00427	0.004233	0.005335	0.005193

Table 3.3.2: Comparison of Storey Drifts for with and without P-Delta Non-Linear Time History analysis of Model-2 in x and y-direction.

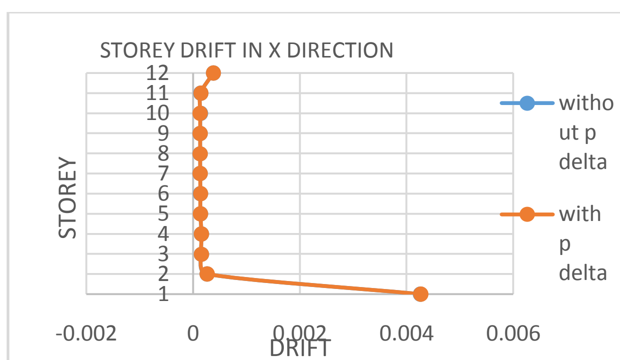


Chart 3.3.3: Storey drift Vs Storey for model-2 along X-direction by THNA with and w/o P-d.

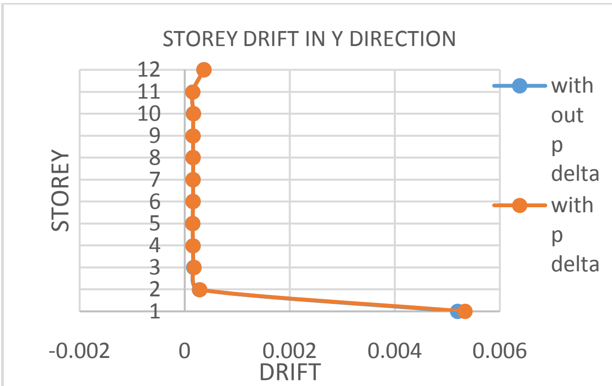


Chart 3.3.4: Storey drift Vs Storey for model-2 along Y-direction by THNA with and without P-delta.

Story	Drift	Drift PD	Drift	Drift PD
Story12	0.002101	0.002048	0.00254	0.002525
Story11	0.002311	0.002257	0.00303	0.003015
Story10	0.002503	0.002448	0.003051	0.003037
Story9	0.002341	0.002284	0.002818	0.002803
Story8	0.002333	0.002304	0.002809	0.002797
Story7	0.002315	0.002254	0.002725	0.002715
Story3	0.002207	0.002145	0.002551	0.00254
Story5	0.002058	0.002	0.002293	0.002282
Story4	0.001887	0.001835	0.001999	0.001978
Story3	0.00131	0.00153	0.001533	0.001575
Story2	0.001188	0.001175	0.001095	0.001121
Story1	0.00079	0.000793	0.00032	0.000328

Table 3.3.3: Comparison of Storey Drifts for with and without P-D NTHA of Model-3 in x and y

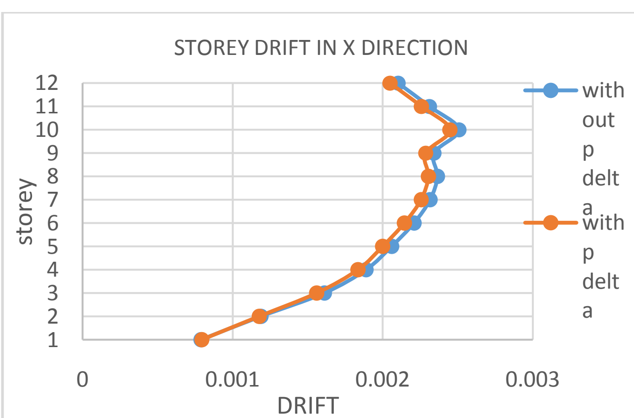


Chart 3.3.5: Storey drift Vs Storey for model-3 along X-direction by THNA with and without P-delta.

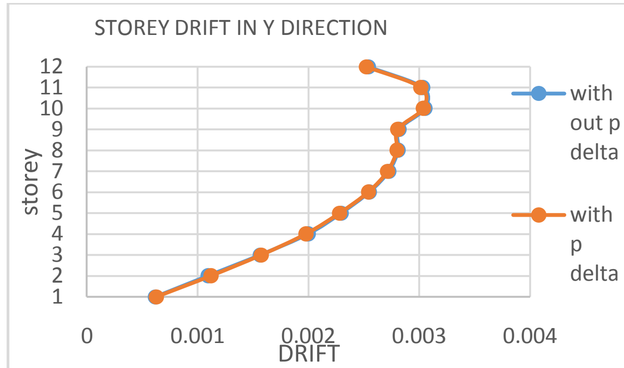


Chart 3.3.3: Storey drift Vs Storey for model-3 along Y-direction by THNA with and w/o P-d.

Story	Drift	Drift PD	Drift	Drift PD
Story12	0.002182	0.002204	0.001502	0.001527
Story11	0.002301	0.002339	0.001883	0.001913
Story10	0.002538	0.002302	0.00193	0.00193
Story9	0.002308	0.002329	0.001829	0.001858
Story8	0.00229	0.002303	0.001873	0.001904
Story7	0.002197	0.002211	0.001823	0.001858
Story3	0.002034	0.002121	0.001714	0.001742
Story5	0.001937	0.001992	0.001583	0.001303
Story4	0.001791	0.001839	0.001538	0.001501
Story3	0.001581	0.001321	0.001448	0.00141
Story2	0.001194	0.001222	0.001025	0.000992
Story1	0.000711	0.000725	0.000324	0.000305

Table 3.3.4: Comparison of Storey Drifts for with and w/o P-D NTHA of Model-4 in x and y-dir.

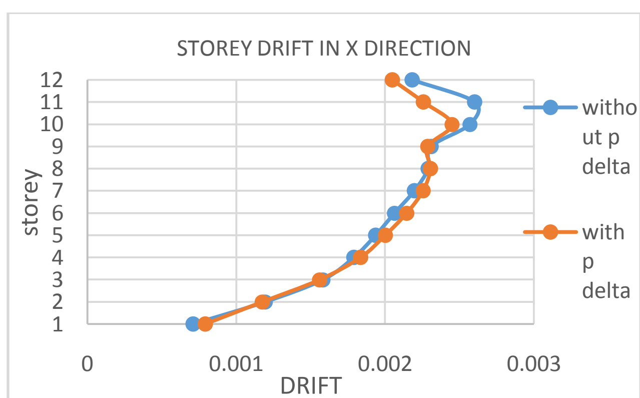


Chart 3.3.7: Storey drift Vs Storey for model-4 along X-direction by THNA with and w/o P-d

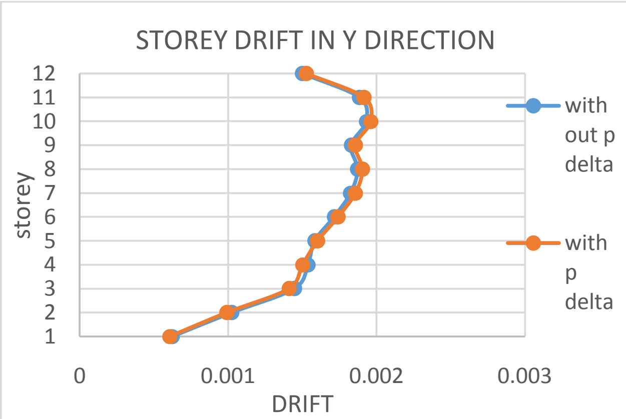


Chart 3.3.8: Storey drift Vs Storey for model-4 along Y-direction by THNA with and without P-delta.

Story	Drift	Drift PD	Drift	Drift PD
Story12	0.00023	0.00023	0.000235	0.000233
Story11	0.000134	0.000134	0.000119	0.000118
Story10	0.00014	0.00014	0.000123	0.000123
Story9	0.000144	0.000143	0.000133	0.000132
Story8	0.000144	0.000144	0.000137	0.000133
Story7	0.000147	0.000147	0.000138	0.000137
Story3	0.000143	0.000143	0.000141	0.00014
Story5	0.000149	0.000149	0.000143	0.000142
Story4	0.000173	0.000173	0.000145	0.000144
Story3	0.00024	0.00024	0.000207	0.000203
Story2	0.000332	0.000332	0.000352	0.000351
Story1	0.00081	0.00081	0.000824	0.000822

Table 3.3.5: Comparison of Storey Drifts for with and without P-D NTHA of Model-5 in x and y-dir.

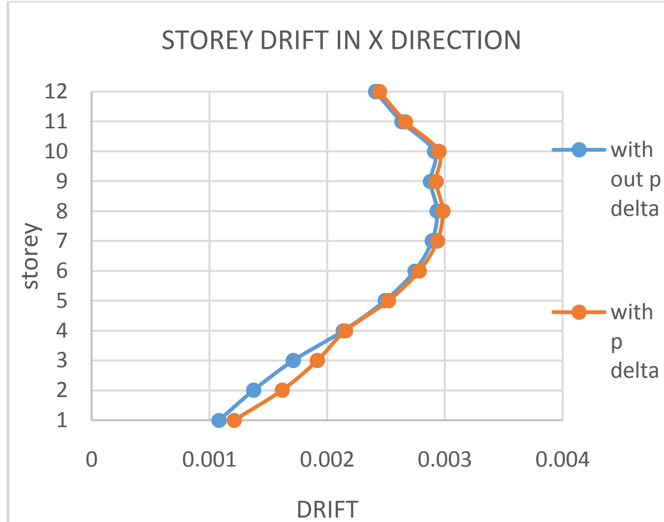


Chart 3.3.9: Storey drift Vs Storey for model-5 along X-direction by THNA with and without P-delta.

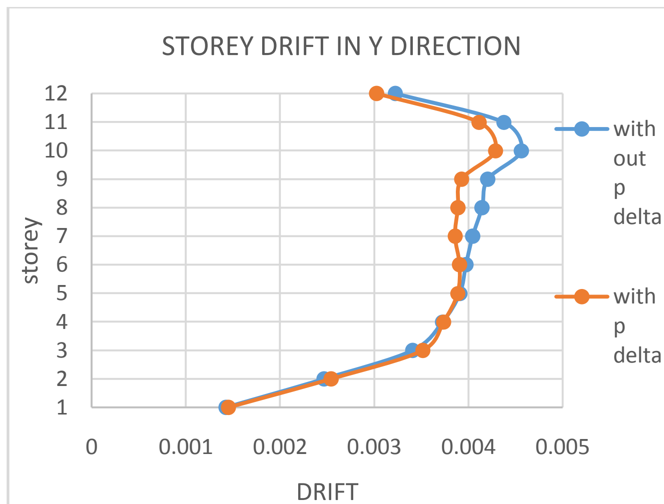


Chart 3.3.10: Storey drift Vs Storey for model-5 along Y-direction by THNA with and without P-

3.4 STOREY DISPLACEMENTS

The maximum displacement at each storey with respective to ground level are presented in tables obtained from Non-Linear Time history analysis for different models. To understand in a better way, the displacements for each model along the longitudinal direction and transverse direction are plotted in charts below.

Story	UX	UY	UX PD	UY PD
Story12	217.034	219.913	213.932	227.934
Story11	213.978	219.85	214.572	223.745
Story10	213.722	219.284	212.944	213.395
Story9	213.257	218.193	212.587	215.353
Story8	215.384	213.932	212.193	214.118
Story7	215.015	215.323	211.803	212.353
Story3	214.243	214.423	211.391	210.927
Story5	213.37	213.15	210.951	208.948
Story4	212.415	212.043	210.503	209.209
Story3	211.434	211.027	210.07	209.289
Story2	210.537	210.21	209.729	209.273
Story1	210.003	209.795	209.523	209.239

Table 3.4.1: Comparison of Storey Displacement for with and without P-Delta NTHA of Model-1 in x and y-direction.

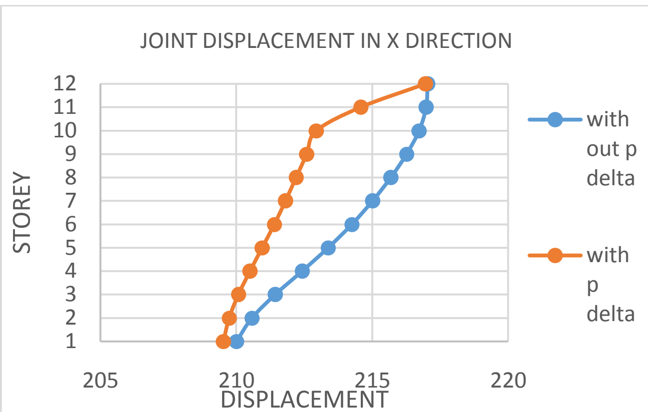


Chart 3.4.1: Storey Displacement Vs Storey for model-1 along X-direction by THNA with and without-delta.

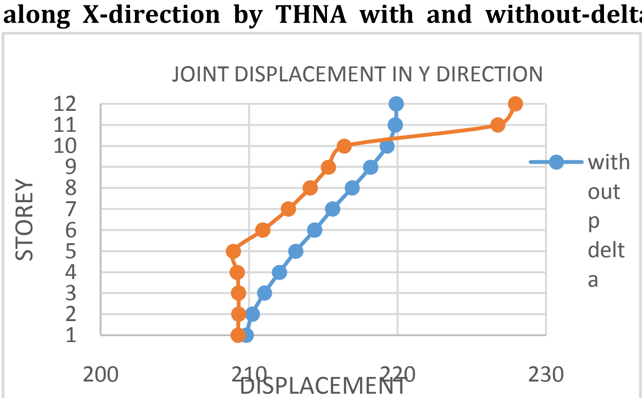


Chart 3.4.2: Storey Displacement Vs Storey for model-1 along Y-direction by THNA with and without P-delta.

Story	UX	UY	UX PD	UY PD
Story12	209.307	209.384	209.234	209.378
Story11	209.304	209.381	209.231	209.375
Story10	209.302	209.379	209.259	209.373
Story9	209.3	209.373	209.257	209.37
Story8	209.298	209.374	209.255	209.337
Story7	209.293	209.371	209.253	209.335
Story3	209.294	209.339	209.251	209.332
Story5	209.292	209.333	209.249	209.359
Story4	209.291	209.333	209.247	209.357
Story3	209.289	209.331	209.245	209.354
Story2	209.287	209.358	209.244	209.351
Story1	209.284	209.355	209.241	209.348

Table 3.4.2: Comparison of Storey Displacement

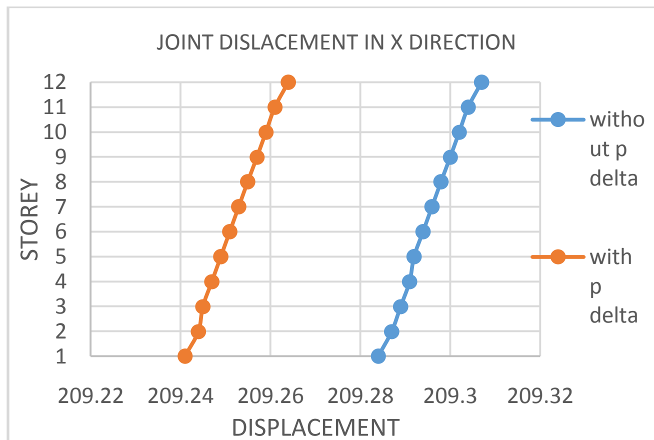
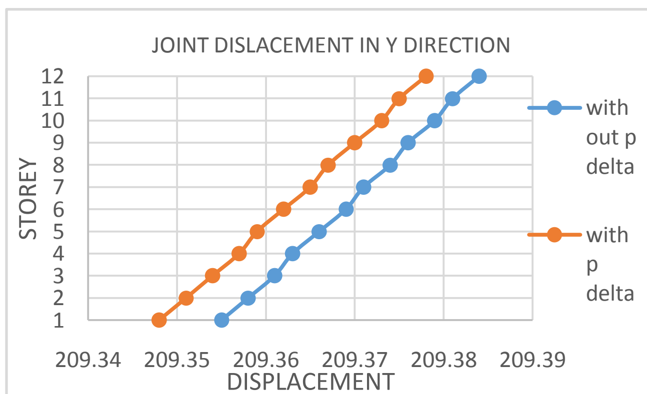


Chart 3.4.3:Storey Displacement Vs Storey



Story	UX	UY	UX PD	UY PD
Story12	211.839	215.721	211.99	213.435
Story11	211.379	215.184	211.797	215.904

Story10	211.423	214.435	211.534	215.109
Story9	211.135	213.355	211.235	214.27
Story8	210.907	212.857	210.993	213.407
Story7	210.351	212.048	210.724	212.533
Story3	210.404	211.234	210.432	211.33
Story5	210.133	210.434	210.211	210.81
Story4	209.942	209.373	209.974	210.131
Story3	209.738	209.233	209.759	209.811
Story2	209.558	209.134	209.57	209.523
Story1	209.403	209.112	209.411	209.307
Base	209.208	209.208	209.208	209.208

Table 3.4.3: Comparison of Storey Displacement for with and without P-Delta Non-Linear Time History analysis of Model-3 in x and y-direction.

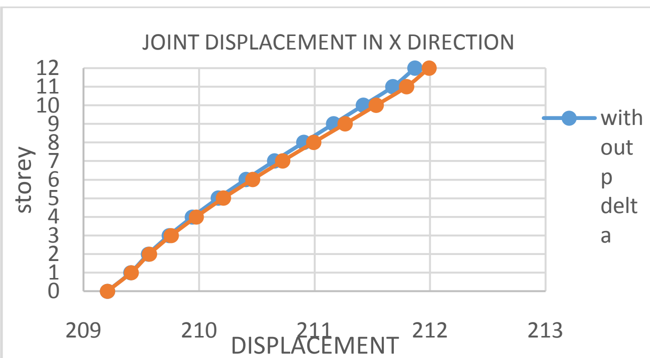


Chart 3.4.5: Storey Displacement Vs Storey for model-3 along X-direction by THNA with and without P-delta.

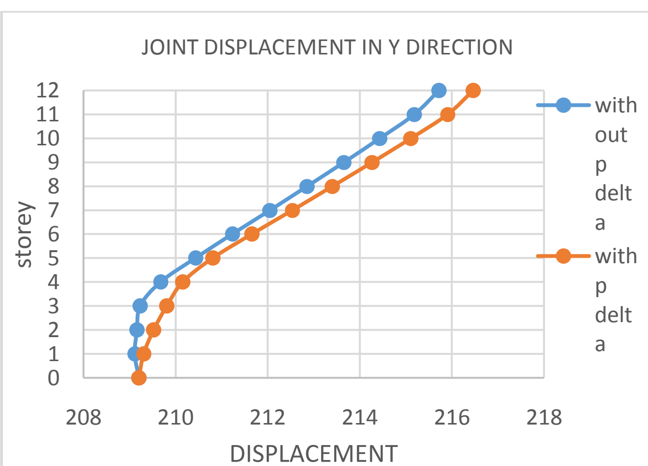


Chart 3.4.3: Storey Displacement Vs Storey for model-3 along Y-direction by THNA with and without P-delta.

Story	**UX**	**UY**	**UX PD**	**UY PD**
Story12	210.283	212.01	210.251	211.382
Story11	210.198	211.822	210.138	211.511
Story10	210.081	211.545	210.054	211.259
Story9	209.932	211.248	209.937	210.989
Story8	209.842	210.943	209.821	210.714
Story7	209.723	210.35	209.707	210.443
Story3	209.313	210.373	209.598	210.193
Story5	209.52	210.133	209.502	209.993
Story4	209.439	209.921	209.424	209.814
Story3	209.339	209.723	209.359	209.349
Story2	209.31	209.547	209.303	209.499
Story1	209.233	209.402	209.23	209.375
Base	209.208	209.208	209.208	209.208

Table 3.4.4: Comparison of Storey Displacement for with and without P-Delta Non-Linear Time History analysis of Model-4 in x and y-direction.

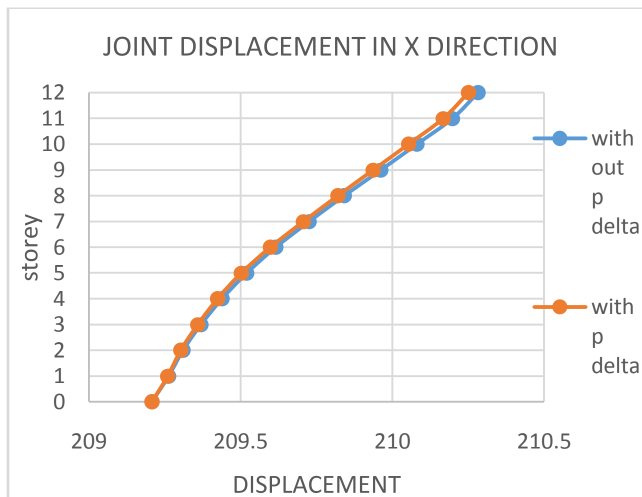


Chart 3.4.7: Storey Displacement Vs Storey for model-4 along X-direction by THNA with and with

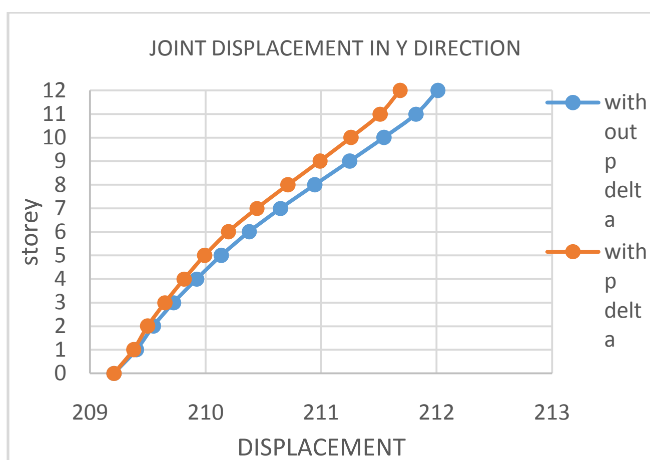


Chart 3.4.8: Storey Displacement Vs Storey for model-4 along Y-direction by THNA with and without P-delta.

Story	UX	UY	UX PD	UY PD
Story12	219.033	220.718	218.584	213.249
Story11	218.524	213.759	218.129	215.908
Story10	217.731	213.085	217.421	215.331
Story9	213.841	215.35	213.328	214.399
Story8	215.884	214.579	215.771	214.033
Story7	214.875	213.773	214.831	213.323
Story3	213.833	212.948	213.915	212.589
Story5	212.801	212.121	212.953	211.838
Story4	211.812	211.315	212.013	211.097
Story3	210.923	210.553	211.123	210.393
Story2	210.194	209.923	210.347	209.779
Story1	209.38	209.574	209.784	209.472
Base	209.208	209.208	209.208	209.208

Table 3.4.5: Comparison of Storey Displacement for with and without P-Delta Non-Linear Time History analysis of Model-5 in x and y-direction.

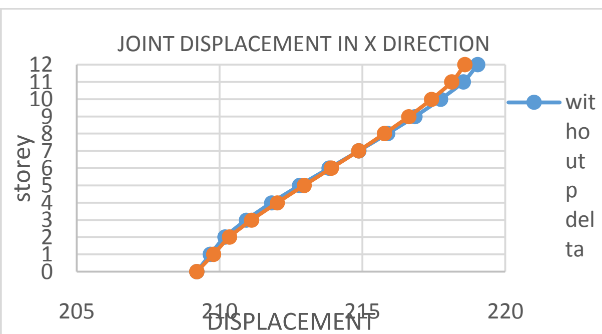


Chart 3.4.9: Storey Displacement Vs Storey for model-5 along X-direction by THNA with and without P-delta.

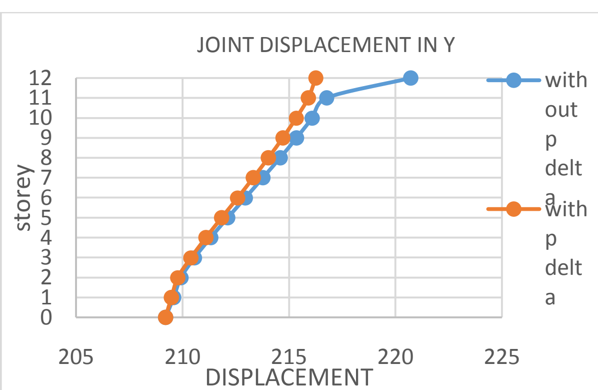


Chart 3.4.10: Storey Displacement Vs Storey for model-5 along Y-direction by THNA with and without P-delta.

Table 3.4.1 to 3.4.5 and chart 3.4.1 to 3.4.10 shows all Model storey displacements. The bare frame has highest storey displacement values as compared to all other models. The effect of p-delta will reduce the displacement values of all models in both x and y direction. model 2 (full brick infill) shows considerable reduction in storey displacement with a reduction compared with model-1,3,4 and mode-5(refer tables and charts). Thus it can be concluded that addition of infill and concrete shear wall act as drift and displacement controlled elements in RC buildings. Therefore, it can be concluded that as far as tall buildings are concerned, different types of Shear walls and brick masonry infill panel can be a good solution to minimize the effect of drift and displacement.

3.5 SEISMIC BASE SHEAR: Table 3.5.1 and 3.5.2 shows comparison of highest values of seismic base shear of different models by equivalent static analysis and Non-linear time history analysis. Therefore, it has been found that calculation of earthquake forces by considering building by ordinary frame will leads to underestimation of base shear.

MODEL No	Without P-Delta along X	With P-Delta along X	Without P-Delta along Y	With P-Delta along Y
1	25525.75	24791.8	17342.83	14893.33
2	84329.18	83271.35	91740.73	92490.27
3	43321.02	39833.39	33549.82	3.395.25
4	79814.75	80541.89	38940.83	39095.92
5	29023.4	27807.04	30920.11	27722.39

Table 3.5.1: Seismic Base shear by Non-linear Time-History analysis

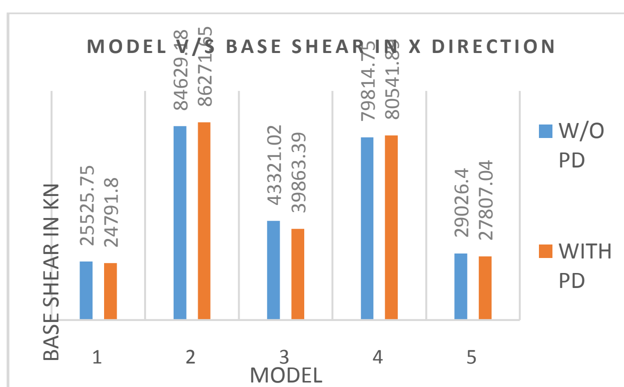


Chart 3.5.1: Model Vs Base shear for different models along x-direction.

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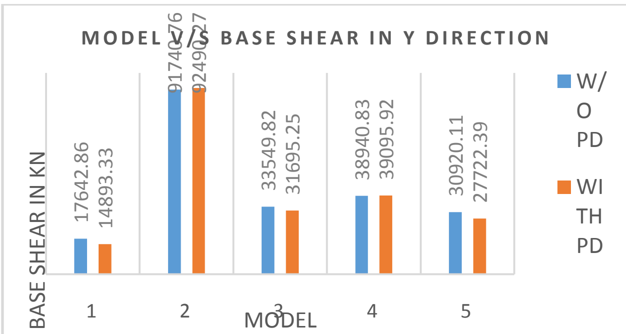

Chart 3.5.1: Model Vs Base shear for different models along y-direction.

3.3 STOREY ACCELERATION

The maximum acceleration at each floor level with respect to ground are presented in tables from 3.3.1 to 3.3.5 obtained from Non-Linear Time History Analysis along x-direction and y-direction

Table 3.3.1 to 3.3.5 shows the comparison of the storey acceleration values, the acceleration value is lower for the bare frame model as compare to the other models. When masonry infill stiffness taken into consideration, Model-2 (full brick infill) shows considerable increase in storey acceleration than model-1,4 and 5. It is observed that, the model with shear wall yields comparatively greater storey acceleration which is represented in chart 3.3.1 to 3.3.10. Hence it can be concluded that by providing shear walls at corners in X and Y direction significantly increases the storey acceleration in the storeys. 'L' type shear wall reduces the storey acceleration compared to all other models. And consideration of P-delta will reduce the acceleration values in all the models.

Story	UX	UY	UX PD	UY PD
Story12	1125.33	1247.43	1215.54	989.43
Story11	1040.34	1152.75	1124.79	930.82
Story10	850.23	337.39	712.35	300.5
Story9	888.38	734.4	850.24	822.98
Story8	970.81	835.7	942.75	910.03
Story7	935.12	912.98	979.21	983.58
Story3	1039.22	1131.15	1035.3	1093.17
Story5	1240.51	1349.3	1225.39	1130.48
Story4	1032.51	1184.93	1033.18	1043.58
Story3	1079.53	1028.38	1025.08	935.21
Story2	1101.75	788.13	1028.03	800.93
Story1	1103	720.23	937.75	773.33
Base	884	884	884	884

Table 3.3.1: Comparison of Storey Acceleration for with and without P-Delta Non-Linear Time History analysis of Model-1 in x and y-direction.

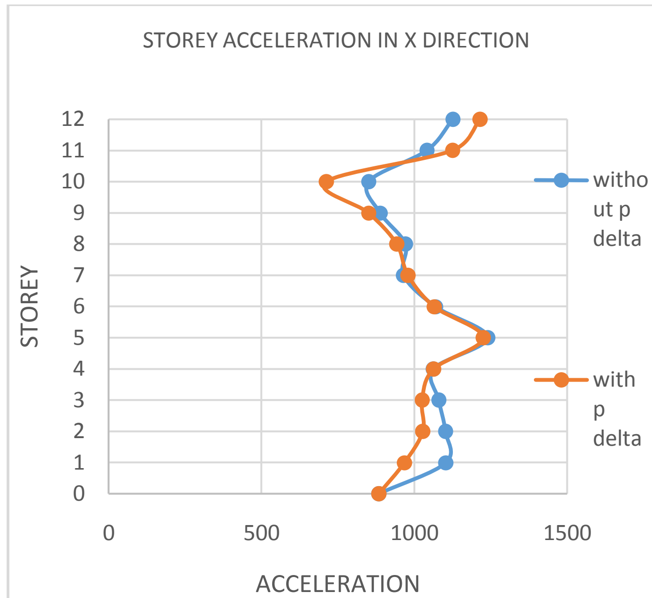

Chart 3.3.1: Storey Acceleration V Storey model-1

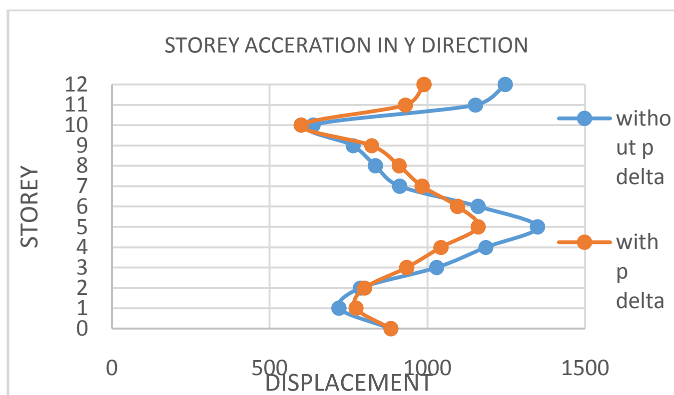

Chart 3.3.2: Storey Acceleration Vs Storey for model-1

Story	UX	UY	UX PD	UY PD
Story12	2327.1	2790.38	2329.97	2824.27
Story11	2591.55	2772.35	2312.58	2805.47
Story10	2533.33	2753.48	2590.03	2783.89
Story9	2533.74	2734.34	2537.37	2732.34
Story8	2510.73	2714.33	2544.55	2740.85
Story7	2485.37	2394.33	2521.38	2718.75
Story3	2431.24	2373.94	2498.92	2393.39
Story5	2437.78	2352.87	2473.57	2374.5

Story4	2415.43	2331.29	2455.04	2351.89
Story3	2394.98	2309.43	2434.95	2329.1
Story2	2373.38	2587.11	2413.31	2303.1
Story1	2349.43	2559.24	2389.2	2577.13
Base	884	884	884	884

Table 3.3.2: Comparison of Storey Acceleration for with and without P-Delta Non-Linear Time History analysis of Model-2 in x and y-direction.

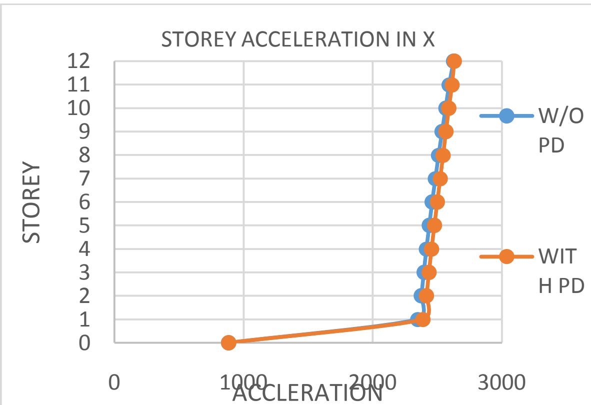

Chart 3.3.3: Storey Acceleration Vs Storey for model-2 along X-direction by THNA with and without P-delta.

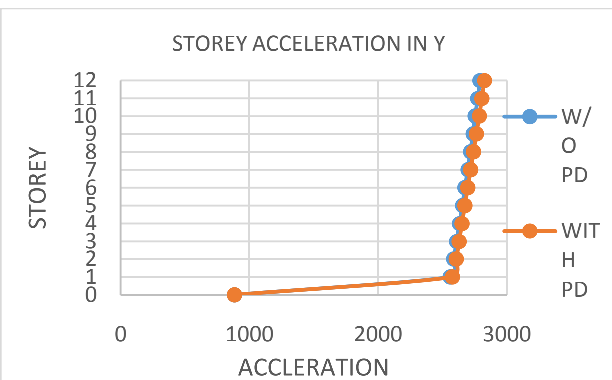

Chart 3.3.4: Storey Acceleration Vs Storey for model-2 along Y-direction by THNA with and without P-delta.

Story	UX	UY	UX PD	UY PD
Story12	2197.87	1331.78	2115.51	1351.48
Story11	2149.73	1434.48	2038.97	1459.13
Story10	1793.91	933.34	1712.29	879.75
Story9	1404.53	991.53	1324.13	1022.71
Story8	1277.72	1138.09	1207.77	1131.38
Story7	1214.27	1270.07	1199.34	1295.28
Story3	1483.38	1305.98	1500.82	1283.14

Story5	1721.94	1357.14	1725.03	1324.89
Story4	1713.78	1273.15	1711.93	1241.55
Story3	1453.05	1325.49	1439.08	1342.22
Story2	1233.13	1353.99	1221.07	1354.19
Story1	1133.43	1218.15	1133.3	1218.87
Base	884	884	884	884

Table 3.3.3: Comparison of Storey Acceleration for with and without P-Delta Non-Linear Time History analysis of Model-3 in x and y-direction.

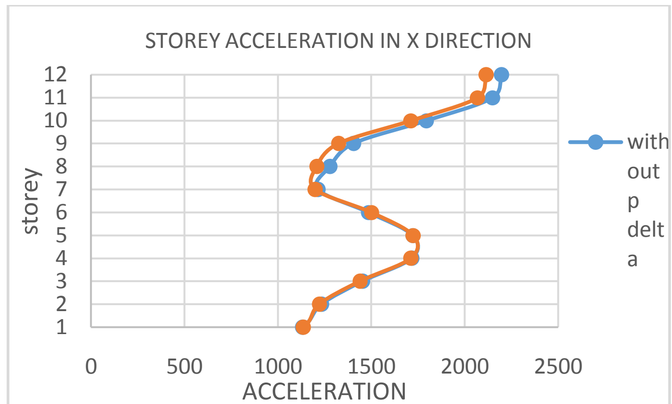

Chart 3.3.5: Storey Acceleration Vs Storey for model-3 along X-direction by THNA with and without P-delta.

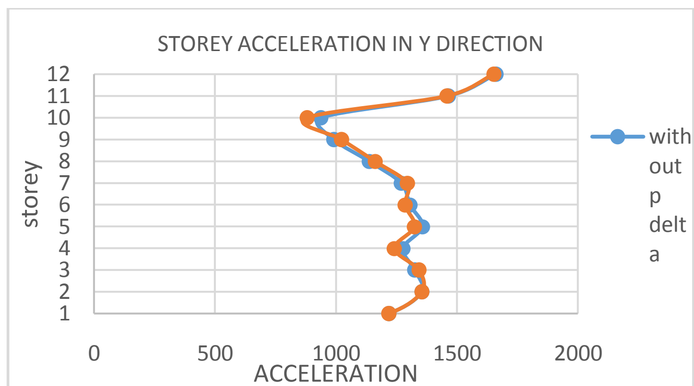

Chart 3.3.3: Storey Acceleration Vs Storey for model-3 along Y-direction by THNA with and without P-delta.

Story	UX	UY	UX PD	UY PD
Story12	3783.34	1490.14	3735.17	1489.74
Story11	3340.87	1384.55	3599.91	1384.3
Story10	2737.32	1113.2	2718.53	1112.35
Story9	2158.33	907.21	2195.93	933.03
Story8	1893.41	1083.85	1905.24	1099.53
Story7	2287.93	1178.34	2335.05	1179.11
Story3	2537.27	1223.41	2309.37	1214.94

Story5	2322.79	1449.59	2337.9	1455.3
Story4	2353.45	1443.93	2375.09	1433.85
Story3	2425.3	1242.18	2390.79	1220.98
Story2	1949.55	1204.55	1874.7	1213.09
Story1	1534.31	1158.27	1314.33	1133.31
Base	884	884	884	884

Table 3.3.4: Comparison of Storey Acceleration for with and without P-Delta Non-Linear Time History analysis of Model-4 in x and y-direction.

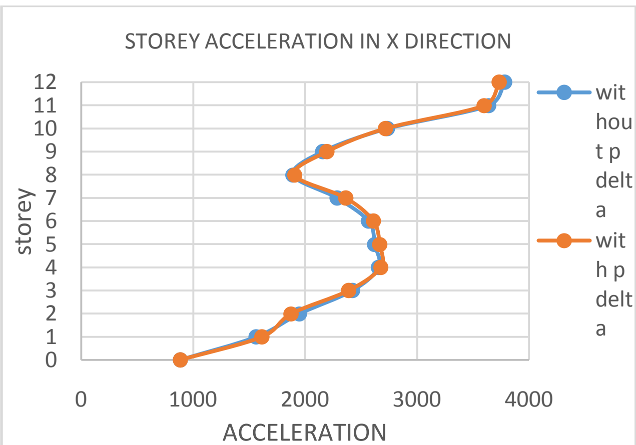

Chart 3.3.7: Storey Acceleration Vs Storey for model-4 along X-direction by THNA with and without P-delta.

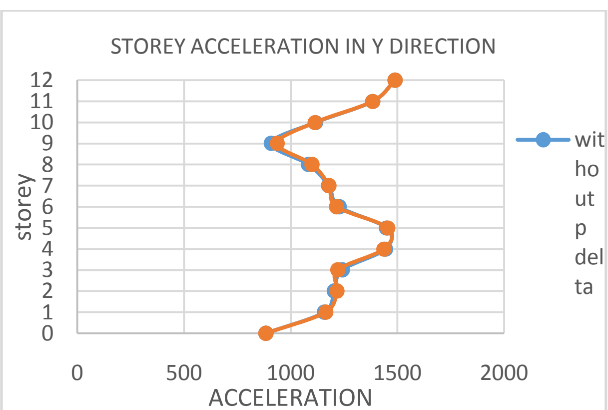

Chart 3.3.8: Storey Acceleration Vs Storey for model-4 along Y-direction by THNA with and without P-delta.

Story	UX	UY	UX PD	UY PD
Story12	1707.97	1395.83	1387.38	1339.39
Story11	1337.08	1441.8	1347.33	1417.79
Story10	1102.39	943.94	1092.7	907.91
Story9	1185.81	1288.84	1191.94	1114.33
Story8	1475.53	1314.14	1431.73	1531.37
Story7	1878.93	1374.93	1829.9	1809.75
Story3	1814.49	1439.44	1755.81	1317.13
Story5	1509.13	1435.15	1480.32	1510.13
Story4	1398.93	1723.25	1354.38	1732.97
Story3	1388.99	1801.75	1335.31	1713.39
Story2	1401.49	1330.34	1401.28	1535.81
Story1	1230.74	1321.34	1240.93	1352.31
Base	884	884	884	884

Table 3.3.5: Comparison of Storey Acceleration for with and without P-Delta Non-Linear Time History analysis of Model-5 in x and y-direction.

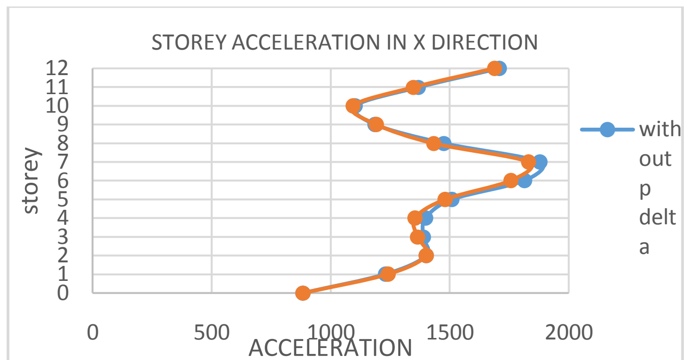

Chart 3.3.9: Storey Acceleration Vs Storey for model-5 along X-direction by THNA with and without P-delta.

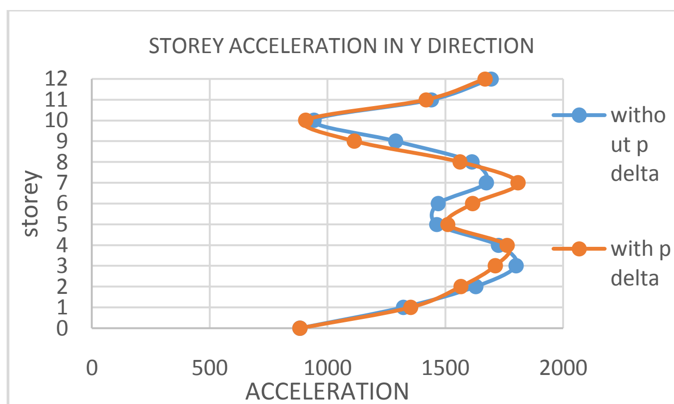

Chart 3.3.10: Storey Acceleration Vs Storey for model-5 along Y-direction by THNA with and without P-delta.

4. CONCLUSIONS

1. Fundamental time period decreases when the effect of masonry infill wall and concrete shear wall is considered.

2. The RC frame model 1(bare frame) having highest value of time period compared to masonry infill with soft storey.
3. As the number of soft stories increases, the fundamental time period of the structure also increases.
4. Fundamental time period decreases when the stiffness of masonry infill and concrete shear wall is considered.
5. C shaped shear wall shows considerably lesser storey drift by THA method of analysis when considered.
6. The second order analysis will not much effective in the time period and frequency as compared with NTHA.
7. The presence of masonry infill and shear wall in the structure are reduces the storey drifts.
8. Storey displacements are more for the bare frame model and the inclusion of shear wall reduces the displacements.
9. C shaped shear wall shows considerably lesser storey displacement.
10. Second order analysis is reducing the storey displacement in the building.
11. The base shear is more for infilled structure (model 2), the p delta effect is effective in this parameter for the reduction of values.
12. The acceleration increases when effect of infill wall and shear walls are considered.
13. Providing shear wall at all end corners of the building in X and Y direction significantly improves all parameters in the analysis.
14. Seismic base shear is considerably more for masonry infill and shear wall models as compared with bare frame model.
15. Consideration of stiffness of masonry infill and shear wall, greatly influences the overall structure.
16. For masonry infill and concrete shear wall models IS-1893 2002 gives same fundamental time period, therefore software like ETABS must be used to calculate the time period of the structure.
17. As the contribution of masonry infill and shear wall taken into the consideration the storey drifts and storey displacements considerably reduces, therefore presence of masonry infill and shear wall influence the overall behavior of the structure when subjected to lateral seismic loading.
18. As we add shear wall of C and L shaped at the corners of building in x and y direction, the effect of soft ground and soft intermediate storey got reduced. Hence shear wall in the form of C and L shape can be good solution to minimize the effect of soft storeys.
19. The storey drifts are found within the limit as specified by the code IS 1893 (Part 1):2002.
20. The use of P-delta can be included in the building for the analysis and design purposes.

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BIOGRAPHIES

SYED GOUSEPAK*S/O* ***SYED NABIASOOL.***
Student of M-Tech (structural Engg).
Poojya Doddappa Appa College of Engineering Kalaburagi-585102

2nd Author

Prof. VISHWANATH.B. PATIL
Associate Professor
Department of Civil Engineering
Poojya Doddappa Appa College of Engineering Kalaburagi-585102