Performance of P-Delta Analysis of Flat Slab and R. C. Framed Buildings

Kanchan Gupta, Md. Tasleem

Abstract ***Two-way slab directly rests on column known as flat plates, in flat slab building formwork is simple as compare to normal slab (that means slab rest on beam column frame building) and reinforcement layout are also simple and storey height decreases. In flat slab building check second order effect (second order effect known as p-delta effect). P-delta analysis means laterally displacing structures (for high rise building) with gravity loads will deflect. In P-delta analysis when lateral force act on member then it will deflect at delta distance and create secondary moments. For stability design of a building P-delta analysis is required. In the present work seismic analysis (consider zone V & soft soil) of a multi storey flat slab building with and without P-delta effects is analysed by using ETAB software. The seismic zone factor of 0.36 is considered. From the analysis check displacement and drift of flat slab building at different storey (G+9, G+19, and G+ 29) of flat slab building.***

Keywords : ***delta analysis (second order effect), flat slab, drop, seismic zone (V), zone factor 0.36, soil type (soft).***

I .INTRODUCTION

It is the slab that directly rest on columns, sometimes drop panel and column capital or combination may also be used to prevent punching failure. Its behavior is as two-way slab and thickness is inveriavely higher than thickness of slab of beam slab system. For better aesthetic view we can provide flat slab. flat slab also provided for better light dispersion. In flat slab building AC ducts, firefighting and electric ducts easily provided. Storey Hight is lesser in flat slab buildings. According to IS456 minimum thickness should not be less than 125mm.longer span should be used in the slab in the calculation of the span /depth ratio according to IS456 and critical failure is punching shear failure or two-way shear failure. Critical section for punching shear is at a distance d/2 from face of column, d/2 from face of drop panel and also from column capital. Reducing negative moment reinforcement over a column or reducing the shear force around the column supports provided drop panel. Wajdi J. Baniya[1] (2020/333-347)doing work on Behavior Of Composite Pre-Flat Slabs In Resisting Punching Shear Forces he was concluded that For All Composite Pre-Flat Slabs Referring To Numerical And Experimental Results, The Relative Deflection Index Was Calculated By Failure Load Over The Deflection For Each Experimental And Numerical Specimen. The Numerical Maximum Deflection Was 19% Higher Over The Experimental. Bent Bar Vertical Shear Reinforcement Indicated Higher Resistance Of Punching Shear Compared Of Those Have Closed Stirrups. Epoxy Bonding Materials Increases The Slab Resistance To Vertical Deflection. Ala Torabian[2](2019/109-327)Work On Behavior Of Thin Lightly Reinforced Flat Slabs Under Concentric Loading And Concluded That The Current Research Aim To Study The Behavior Of Thin Reinforced Concrete (RC) Slabs Under Concentrated Loads As Well As To Investigate The Application Of Critical Shear Crack Theory (CSCT) To Such Slabs. He Check Punching Shear According To ACI 318 And Euro Code 2 And Find The Punching Failure Through Shear Reinforcement.

Marcos Honorato Oliveira[3](2019/109-311) Work Based On Tests On The Punching Resistance Of Flat Slabs With Unbalanced Moments He Was Concluded That The Work Examines The Experimental Tests On The Punching Resistance Of Flat Slabs With Unbalanced Moment. He Did Eight Tests On Slab Column Connection With Concentric And Eccentric Loading And Found That Slab Without Shear Reinforcement, The Transference Of Unbalanced Moments Significantly Affected The Cracking Pattern And Failure Occur In Unbalanced Moments.

M. Deepthi[4](2019) Her Work Based On Behavior Of P-Delta Effect In High- Rise Buildings With And Without Shear Wall She Was Concluded That The Work Deals With Behavior Of P-Delta Effect In High Rise Buildings With And Without Shear Wall. Displacements Of Conventional Building Models Without P-Delta Is Less When Compare To Building With P-Delta And Storey Drift Also Max. In Case Of P-Delta Effects. And Shear Wall Placed At Centre Of Frame Shown More Effectiveness When Comparing With Shear Wall Placed At Corner And Without Shear Wall Of The Structure.

Ahmed Sada Dheeb [5](2019/129-135) His Work Based On Deterministic Wind Load Dynamic Analysis Of High Rise Steel Buildings Including P-Delta Effects And Concluded That Objective Of This Work Determine The Deterministic Wind Load Dynamic Analysis Of High Rise Steel Building Including P-Delta Effects. Results Show That The Effects Of P-Delta On The Dynamic Response Of Tall Buildings With 20 Storey Heights Or More Must Be Added Dynamic Analysis.

II .OBJECTIVE OF STUDY

The Main Objectives Of The Proposed Research Study Are Summarized As Follows:

(A).To Perform P-Delta Analysis on Conventional R.C. Building & Flat Slab R.C. Building Using Etab Software.

(B).To Study the Effect of Both Earthquake Load on Conventional R.C. Building & Flat Slab R.C. Building Using Etab Software.

(C).Study The Result Of Displacement On Conventional R.C. Building & Flat Slab

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Building By Considering P- Delta Effect And Without P-Delta Effect.
(D).Study The Result Of Storey Drift On Conventional R.C. Building & Flat Slab Building By Considering P- Delta Effect And Without P-Delta Effect.

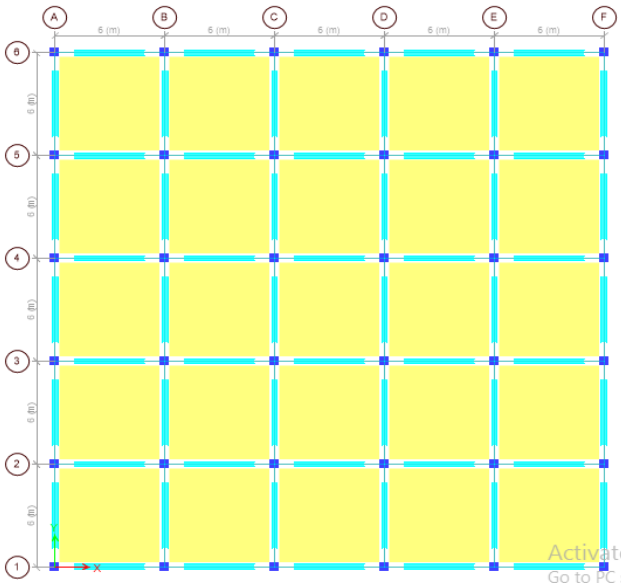
III DETAILS OF THEBUILDING

It Is Proposed To Design And Analysis Of G+9, G+19,G+29 Storied Building By Finite Element Method And Compares Their Design Results. The Nature Of The Building Is Of Commercial Building. The Building Is Located In Seismic Zone V On A Site With Soft Soil.

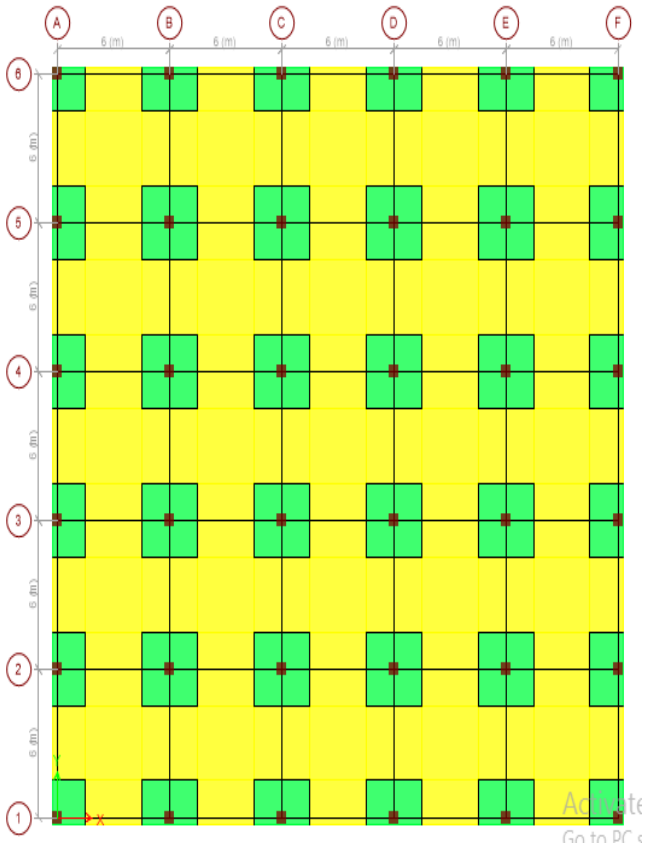
For study purpose, the layout of the plan has 5 X 5 bays of equal length of 6m.

Building parameters are as follows –

- Type of building: Commercial building
- Numbers of Storey: G+9, G+19,G+29
- Seismic zone: V
- Floor height: 3m
- Grade of concrete: M30
- Grade of steel: Fe415
- Beam dimension: 350 x 300mm
- Column dimension: 500 x 500mm
- Conventional Slab Depth: 125mm
- Flat Slab Depth: 210mm
- Importance factor: 1
- Response reduction factor®: 5
- Site type: III
- Imposed Load : 3kn/M2
- Floor Finish : 1.5kn/M2
- Density Of Masonry Wall : 20kn/M2



- **FIG 1: PLAN VIEW OF R C FRAMED BUILDINGS**



- **FIG 2: PLAN VIEW OF FLAT SLAB BUILDINGS**

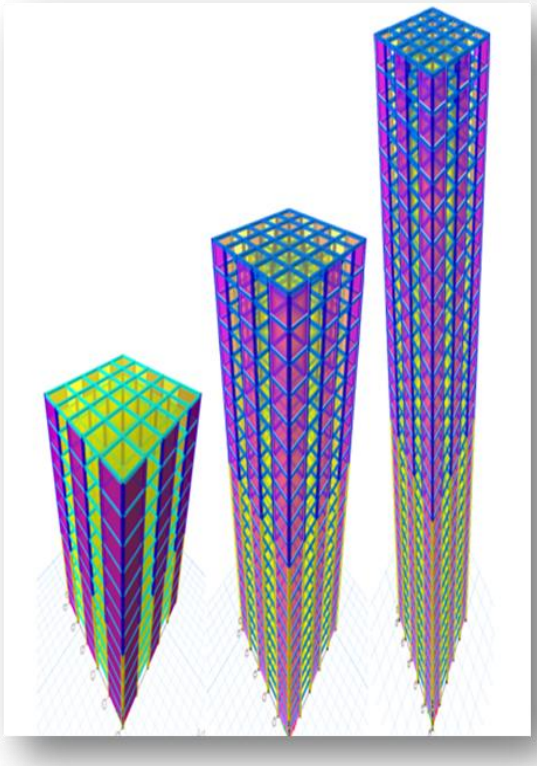


FIG 3: ISOMETRIC VIEWS OF R.C .FRAMED BUILDING (G+10, G+20, G+ 30)

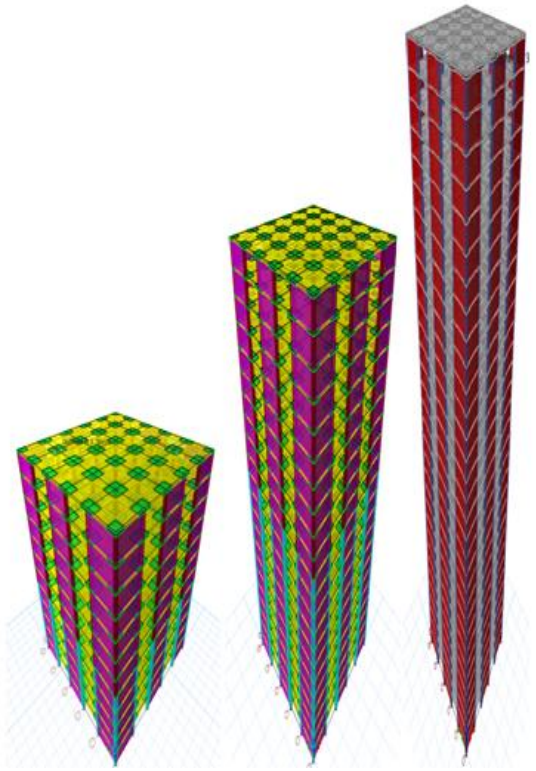


FIG 4: ISOMETRIC VIEWS OF FLAT SLAB BUILDINGS (G+10, G+20, G+30)

IV.RESULTS (GRAPHS)

(1).STOREY DRIFTS

Storey Drift Can Be Defined As The Lateral Displacement Of One Level Relative To The Level Above Are Below It: As Per Clause No. 7.11.1 Of Is 1893 (Part-1): 2002, The Storey Drift In Any Storey Due To Specified Design Lateral Force With Partial Load Factor Of 1.0, Shall Not Exceed 0.004 Times The Storey Height.

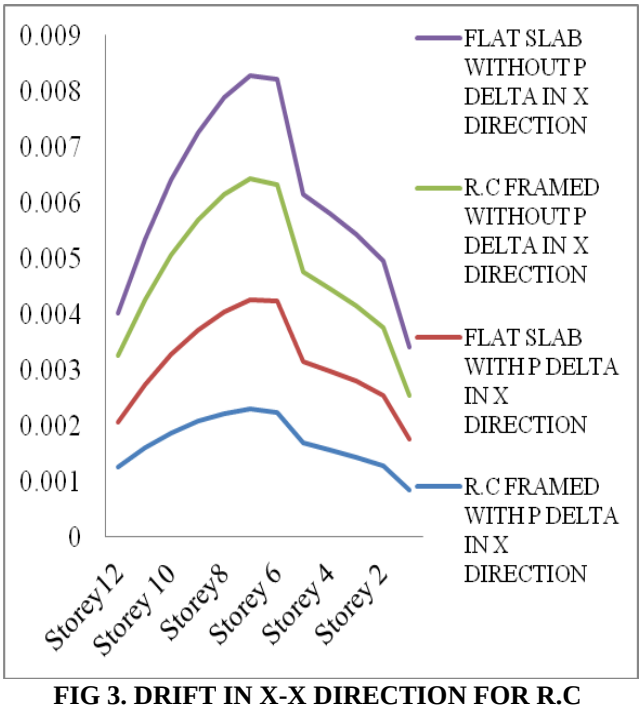


FIG 3. DRIFT IN X-X DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS IN CASE OF (G+9)

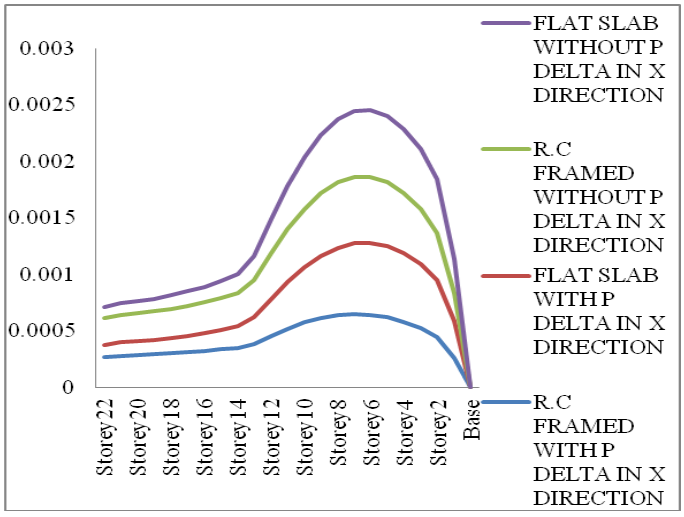


FIG4. DRIFT IN X-X DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS IN CASE OF (G+19)

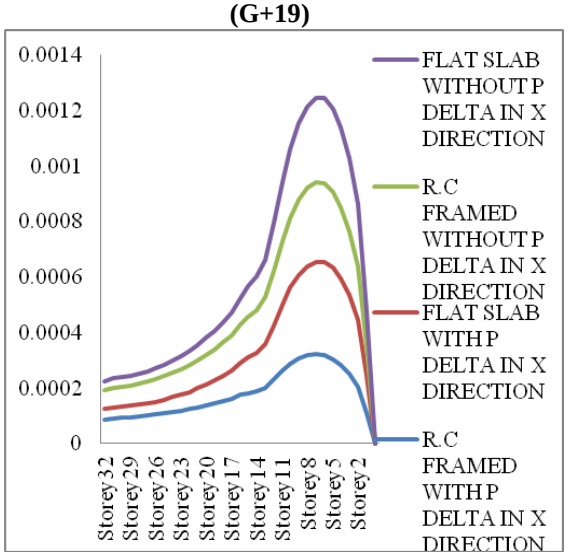


FIG 5. DRIFT IN X-X DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS IN CASE OF (G+29)

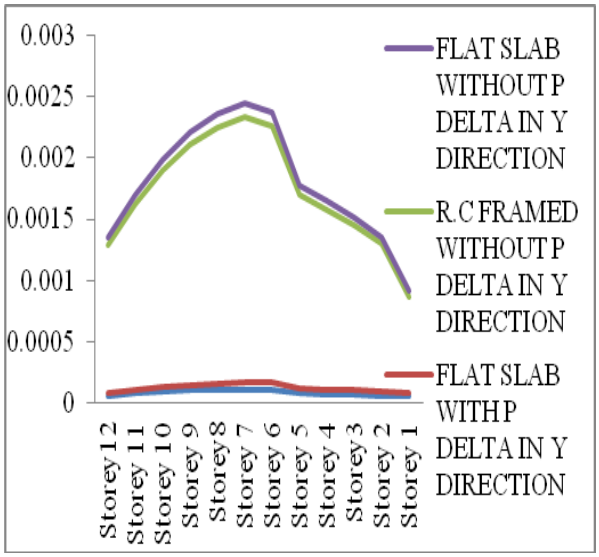


FIG6. DRIFT IN Y-Y DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS G+9

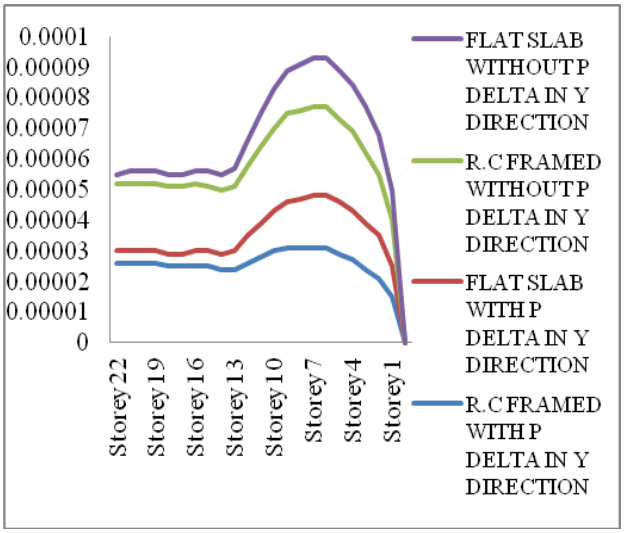


FIG7. DRIFT IN Y-Y DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS G+19

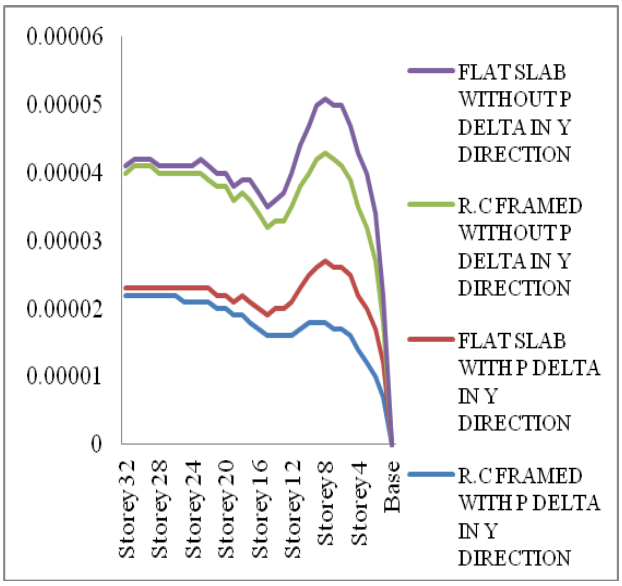


FIG 8. DRIFT IN Y-Y DIRECTION FOR R.C FRAMED AND FLAT SLAB BUILDINGS G+29

RESULT DISCUSSION FOR DRIFT VALUE

The Value Of Storey Drift In X Direction. It Can Be Seen Drift Of The Storey' S Of Building Is Maximum In R.C Framed Building. R.C Framed Building Is 46.82% More Than Flat Slab Building In Case Of P Delta Effect. And 45% Maximum In Case Of Without P Delta Affect. When Only R.C Framed Building Compare With P Delta Affect And Without P Delta Affect Than Due To P Delta Affects Building Drift Increase 4.44% And In Case Of Flat Slab Due To P Delta Affect Drift Increases 0.54%.

(2).DISPLACEMENT

Storey Displacement Is An Important Criterion When Structures Are Subjected To Lateral Loads Like Earthquake And Wind Load. Height Of Structure And Slenderness Of Structure Are Important Factors For Determining Storey Displacement Because Structure Are More Vulnerable As Height Of Building Increases By Becoming More Flexible To Lateral Loads. The Displacement Is Maximum At Top and Minimum at Base of Structure. According To Is1893:2002 Maximum Allowable Deflection Is Calculated As H/250, Where H Is Height Of Storey From The Ground Level. The Displacement Of All Models Has Been Compared For Flat Slab And R C Framed Building Analysis. All Displacement Of All Models Are Tabulated In Form Of Graph For Different Stories For Both X And Y Direction.

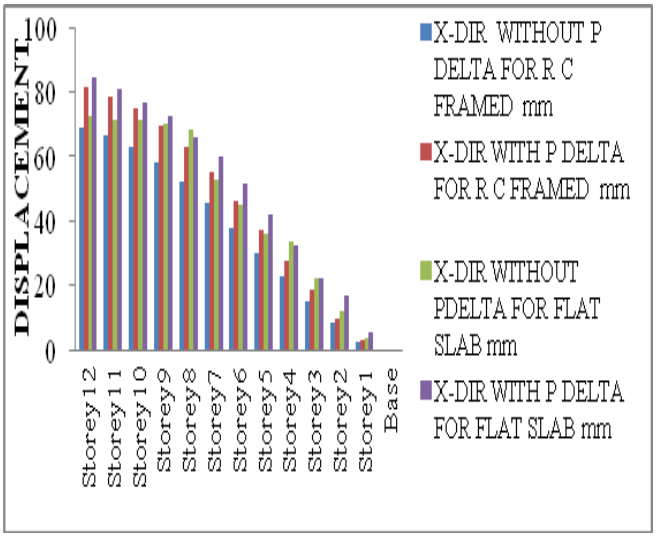


FIG 9: DISPLACEMENT IN X-X DIRECTION FOR G+9 FOR R.C FRAMED AND FLAT SLAB BUILDING

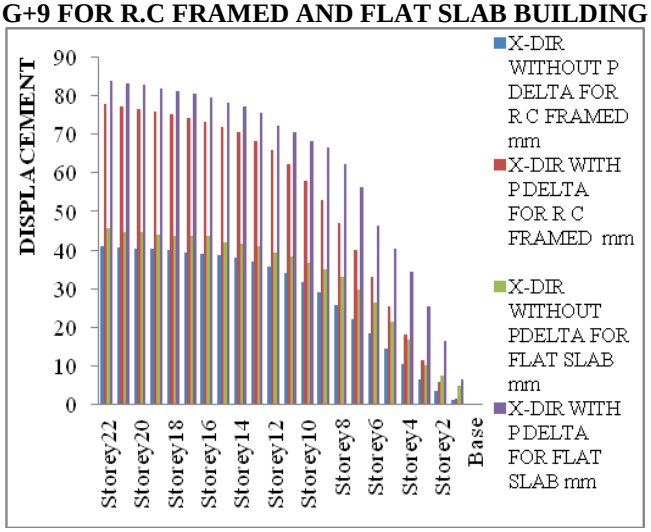


FIG 10: DISPLACEMENT IN X-X DIRECTION FOR G+19 FOR R.C FRAMED AND FLAT SLAB BUILDING

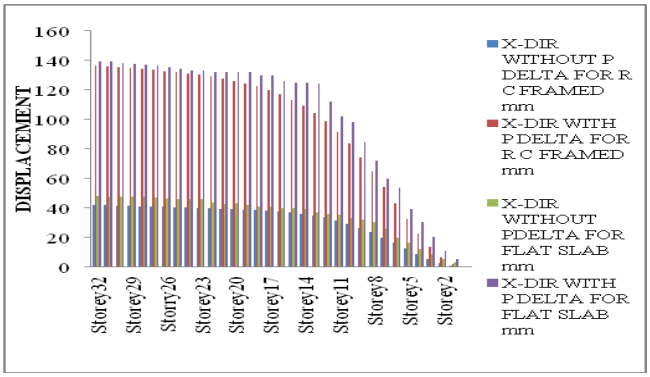


FIG 11: DISPLACEMENT IN X-X DIRECTION FOR G+29 FOR R.C FRAMED AND FLAT SLAB BUILDING

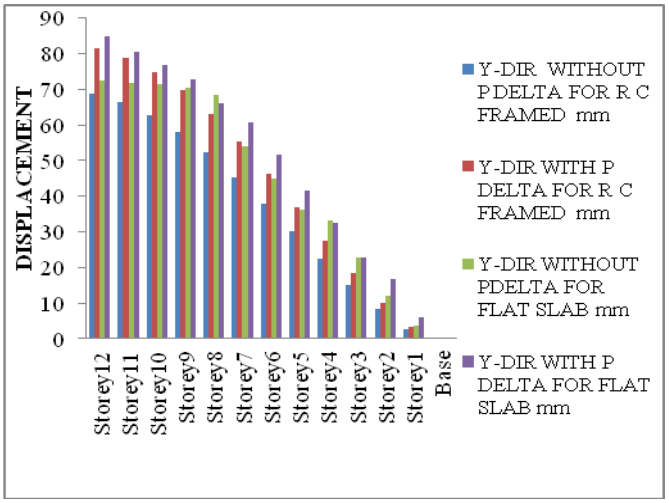


FIG 12: DISPLACEMENT IN Y-Y DIRECTION FOR G+9 FOR R.C FRAMED AND FLAT SLAB BUILDING

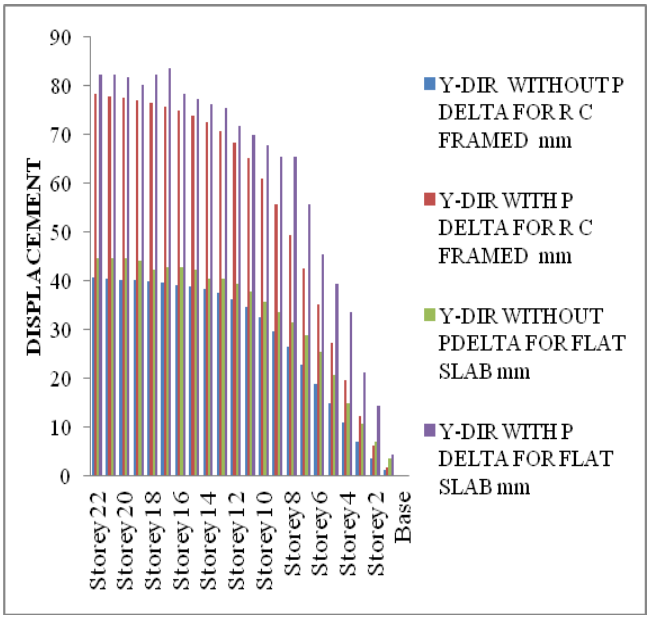


FIG 13: DISPLACEMENT IN Y-Y DIRECTION FOR**G+19 FOR R.C FRAMED AND FLAT SLAB BUILDINS**

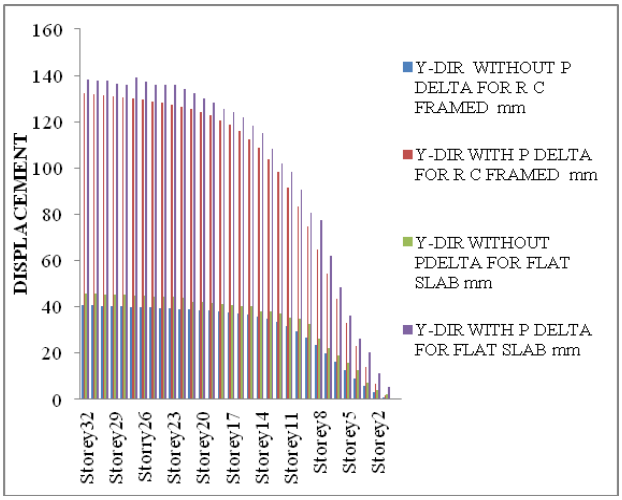


FIG 14: DISPLACEMENT IN Y-Y DIRECTION FOR G+29 FOR R.C FRAMED AND FLAT SLAB BUILDING

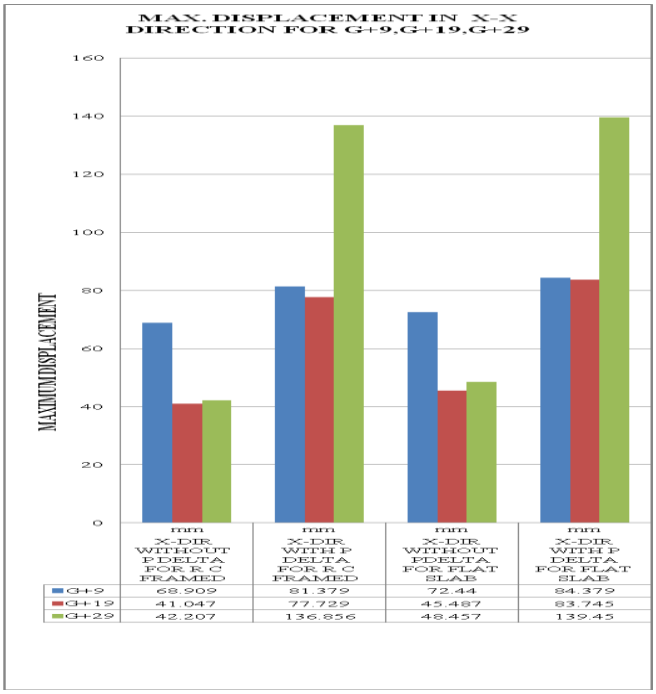


FIG 15: MAX. DISPLACEMENT IN X-X DIRECTION FOR G+9, G+19, G+29

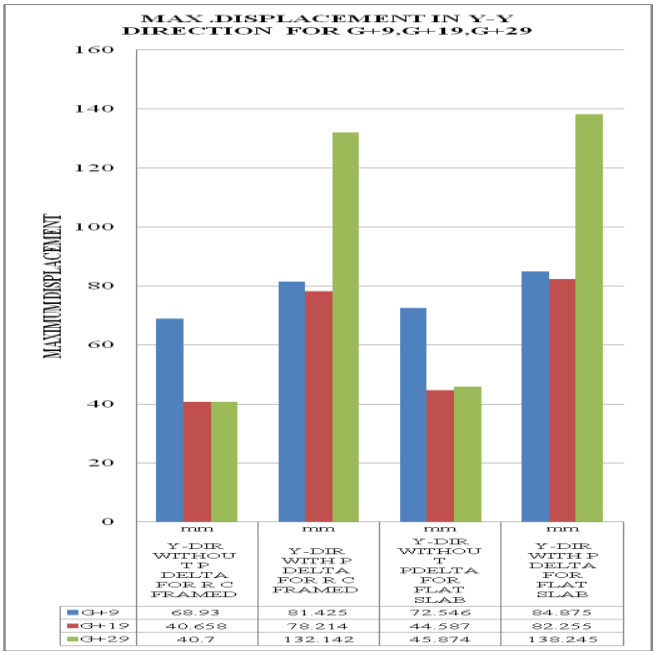


FIG 16: MAX. DISPLACEMENT IN Y-Y DIRECTION FOR G+9, G+19, G+29

V. RESULTS (TABLES)

TABLE I DISPLACEMENT IN X-X DIRECTION FOR G+9 FOR R.CFRAMEDAND FLAT SLAB BUILDING

STOREY	X-DIR WITHOUT P DELTA FOR R C FRAMED	X-DIR WITH P DELTA FOR R C FRAMED	X-DIR WITHOUT PDELTA FOR FLAT SLAB	X-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey12	68.909	81.379	72.44	84.379
Storey11	66.469	78.776	71.415	80.776
Storey10	62.871	74.891	71.385	76.891
Storey9	58.066	69.6	70.345	72.6
Storey8	52.19	62.982	68.253	65.982
Storey7	45.439	55.192	52.919	60.192
Storey6	38.026	46.426	44.828	51.426
Storey5	30.183	36.946	35.965	41.946
Storey4	22.548	27.592	33.824	32.592
Storey3	15.081	18.386	22.412	22.386
Storey2	8.204	9.912	11.89	16.912
Storey1	2.69	3.197	3.541	5.197
Base	0	0	0	0

TABLE II DISPLACEMENT IN Y-Y DIRECTION FOR G+9 FOR R.C FRAMED AND FLAT SLAB BUILDING

STOREY	Y-DIR WITHOUT P DELTA FOR R C FRAMED	Y-DIR WITH P DELTA FOR R C FRAMED	Y-DIR WITHOUT PDELTA FOR FLAT SLAB	Y-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey12	68.93	81.425	72.546	84.875
Storey11	66.489	78.82	71.952	80.669
Storey10	62.889	74.93	71.485	76.992
Storey9	58.08	69.634	70.545	72.865
Storey8	52.201	63.01	68.557	66.21
Storey7	45.448	55.214	53.919	60.685
Storey6	38.032	46.442	44.938	51.56
Storey5	30.187	36.958	36.354	41.566
Storey4	22.551	27.6	33.254	32.689
Storey3	15.083	18.391	22.812	22.786
Storey2	8.204	9.915	11.999	16.922
Storey1	2.691	3.198	3.654	5.877
Base	0	0	0	0

TABLE III DISPLACEMENT IN X-X DIRECTION FOR G+19 FOR R.C FRAMED AND FLAT SLAB BUILDING

STOREY	X-DIR WITHOUT P DELTA FOR R C FRAMED	X-DIR WITH P DELTA FOR R C FRAMED	X-DIR WITHOUT PDELTA FOR FLAT SLAB	X-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey22	41.047	77.729	45.487	83.745

Storey21	40.772	77.135	44.756	83.122
Storey20	40.489	76.51	44.687	82.641
Storey19	40.19	75.832	44.125	81.785
Storey18	39.865	75.076	43.698	81.124
Storey17	39.501	74.207	43.765	80.354
Storey16	39.074	73.178	43.553	79.587
Storey15	38.552	71.923	42.145	78.125
Storey14	37.885	70.355	41.785	77.147
Storey13	36.997	68.351	40.857	75.475
Storey12	35.774	65.747	39.475	72.154
Storey11	34.073	62.349	38.187	70.465
Storey10	31.834	58.057	36.542	68.145
Storey9	29.068	52.867	34.875	66.451
Storey8	25.835	46.849	33.059	62.154
Storey7	22.228	40.142	29.748	56.254
Storey6	18.358	32.946	26.345	46.452
Storey5	14.362	25.53	21.456	40.254
Storey4	10.401	18.231	16.951	34.245
Storey3	6.675	11.47	10.158	25.254
Storey2	3.441	5.756	7.347	16.45
Storey1	1.052	1.697	4.854	6.541
Base	0	0	0	0

TABLE IV DISPLACEMENT IN Y-Y DIRECTION FOR G+19 FOR R.C FRAMED AND FLAT SLAB BUILDING

STOREY	Y-DIR WITHOUT P DELTA FOR R C FRAMED	Y-DIR WITH P DELTA FOR R C FRAMED	Y-DIR WITHOUT PDELTA FOR FLAT SLAB	Y-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey22	40.658	78.214	44.587	82.255
Storey21	40.466	77.816	44.656	82.352
Storey20	40.266	77.392	44.587	81.741
Storey19	40.053	76.921	44.025	8085
Storey18	39.817	76.378	42.198	82.224
Storey17	39.543	75.729	42.785	83.554
Storey16	39.211	74.926	42.653	78.287
Storey15	38.788	73.902	42.165	77.278
Storey14	38.222	72.56	40.485	76.257
Storey13	37.435	70.769	40.357	75.455
Storey12	36.304	68.346	39.245	71.784
Storey11	34.674	65.074	37.787	69.965
Storey10	32.479	60.835	35.642	67.785
Storey9	29.731	55.614	33.575	65.451
Storey8	26.491	49.476	31.459	65.354
Storey7	22.853	42.558	28.688	55.564
Storey6	18.93	35.066	25.455	45.362
Storey5	14.86	27.278	20.656	39.454
Storey4	10.803	19.555	14.751	33.455

Storey3	6.964	12.35	10.788	21.254
Storey2	3.61	6.22	6.987	14.452
Storey1	1.111	1.84	3.424	4.4541
Base	0	0	0	0

TABLE V DISPLACEMENT IN X-X DIRECTION FOR G+29 FOR R.C FRAMED AND FLAT SLAB BUILDING

STOREY	X-DIR WITHOUT P DELTA FOR R C FRAMED	X-DIR WITH P DELTA FOR R C FRAMED	X-DIR WITHOUT PDELTA FOR FLAT SLAB	X-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey32	42.207	136.856	48.457	139.45
Storey31	41.994	136.289	47.854	139.334
Storey30	41.781	135.706	47.785	138.425
Storey29	41.567	135.1	47.685	138.025
Storey28	41.351	134.461	47.582	137.485
Storey27	41.133	133.778	47.421	136.487
Storry26	40.911	133.04	46.425	135.487
Storey25	40.685	132.231	46.215	134.465
Storey24	40.452	131.335	46.112	133.452
Storey23	40.21	130.329	46.012	133.124
Storey22	39.955	129.187	44.125	132.487
Storey21	39.681	127.877	43.0147	132.241
Storey20	39.383	126.358	43.085	132.475
Storey19	39.05	124.581	42.451	132.014
Storey18	38.669	122.49	41.245	130.245
Storey17	38.223	120.015	41.147	130.147
Storey16	37.685	117.076	40.225	126.241
Storey15	37.023	113.58	40.014	125.142
Storey14	36.187	109.419	39.147	125.012
Storey13	35.114	104.471	37.452	124.247
Storey12	33.715	98.602	36.145	112.247
Storey11	31.884	91.682	35.487	102.245
Storey10	29.579	83.676	33.245	98.251
Storey9	26.816	74.652	32.254	85.241
Storey8	23.653	64.773	30.568	72.124
Storey7	20.178	54.287	26.254	60.245
Storey6	16.503	43.524	20.145	54.124
Storey5	12.763	32.891	16.784	39.245
Storey4	9.117	22.86	12.458	30.254
Storey3	5.756	13.967	8.785	20.245
Storey2	2.911	6.788	5.345	11.254
Storey1	0.87	1.931	3.254	5.245
base	0	0	0	0

TABLE VII:DISPLACEMENT IN Y-Y DIRECTION FOR G+29 FOR R.C FRAMED AND FLAT SLAB BUILDING

STOREY	Y-DIR WITHOUT P DELTA FOR R C FRAMED	Y-DIR WITH P DELTA FOR R C FRAMED	Y-DIR WITHOUT PDELTA FOR FLAT SLAB	Y-DIR WITH P DELTA FOR FLAT SLAB
	mm	mm	mm	Mm
Storey32	40.7	132.142	45.874	138.245
Storey31	40.55	131.761	45.675	137.785
Storey30	40.4	131.368	45.354	137.542
Storey29	40.249	130.954	45.245	136.245
Storey28	40.096	130.511	45.125	136.124
Storey27	39.941	130.029	44.754	139.078
Storry26	39.782	129.496	44.662	137.245
Storey25	39.619	128.897	44.552	136.124
Storey24	39.448	128.216	44.321	136.087
Storey23	39.268	127.431	44.214	135.754
Storey22	39.074	126.514	44.142	134.254
Storey21	38.861	125.433	42.124	132.241
Storey20	38.623	124.146	41.895	130.245
Storey19	38.349	122.604	41.557	128.451
Storey18	38.027	120.749	41.225	125.425
Storey17	37.638	118.508	40.654	124.125
Storey16	37.157	115.799	40.254	121.875
Storey15	36.549	112.526	40.078	118.124
Storey14	35.766	108.578	38.145	115.243
Storey13	34.744	103.83	38.0147	108.425
Storey12	33.393	98.142	37.245	102.125
Storey11	31.609	91.382	35.247	98.452
Storey10	29.348	83.511	34.784	90.784
Storey9	26.626	74.595	32.745	80.451
Storey8	23.501	64.794	26.451	77.245
Storey7	20.059	54.358	22.178	62.245
Storey6	16.414	43.619	18.981	48.365
Storey5	12.701	32.986	15.754	36.245
Storey4	9.077	22.941	12.451	26.354
Storey3	5.733	14.022	7.412	20.128
Storey2	2.9	6.817	4.125	11.274
Storey1	0.867	1.939	2.125	5.241
Base	0	0	0	0

VI. RESULT AND DISCUSSION

In the present study of the R.C framed building and flat slab building for G+9, G+19, G+29 was modeled and analyzed for without p-delta effect(linear static analysis) and with p-delta effect(non linear analysis) by Etabs. The structure was analyzed for seismic zone V for soft soil type.

(A) For G+9 Maximum Displacement Value In X Direction Increased By 1.18 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 1.16 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab).

(B) For G+19 Maximum Displacement Value In X Direction Increased By 1.89 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 1.84 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab).

(C) For G+29 Maximum Displacement Value In X Direction Increased By 3.24 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 2.88 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab).
(D)Thus Maximum value of displacement in x direction is observed for G+29 in both cases (R.C. Framed Building & Flat Slab Building for with and without P-Delta Analysis).
(E) For G+9 Maximum Displacement Value In Y Direction Increased By 1.181 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 1.17 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab).
(F) For G+19 Maximum Displacement Value In Y Direction Increased By 1.92 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 1.844 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab)
(G) For G+29 Maximum Displacement Value In Y Direction Increased By 3.24 TIMES For analysis with P-Delta as compared to without P-Delta analysis (R.C. Framed Building), were as value increased by 3.01 times for analysis with P-Delta as compared to analysis without P-Delta (Flat Slab).
(H) Thus Maximum value of displacement in y direction is observed for G+29 in both cases (R.C. Framed Building & Flat Slab Building for with and without P-Delta Analysis).

VII.CONCLUSION

Thus, value of maximum displacement observed for G+29 Building with flat slab case for both X & Y Direction .and The Value of Storey Drift in X Direction. It Can Be Seen Drift Of The Storey' S Of Building Is Maximum In R.C Framed Building. R.C Framed Building Is 46.82% More Than Flat Slab Building In Case Of P Delta Effect. And 45% Maximum In Case Of Without P Delta Affect. When Only R.C Framed Building Compare With P Delta Affect And Without P Delta Affect Than Due To P Delta Affects Building Drift Increase 4.44% And In Case Of Flat Slab Due To P Delta Affect Drift Increases 0.54%.

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