International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Behavior of P-Delta Effect in High- Rise Buildings With and Without Shear Wall

PhaniKumar.V, M.Deepthi, Saikiran K, R.B.N. Santhosh

***Abstract:** The high rise structures are proposed for residential and commercial purposes. They may easily effect by seismic as well as wind loads, so the buildings get deformed and collapsed easily. To avoid these problems we consider p-delta effect in designing. As the number of stories increases p-delta effect becomes very important. The P-Δ effect is relevant in structural engineering problems, especially in civil engineering, where we're dealing with large structures with proportionally decreasing small moments of inertia as they continue to be extended in absolute height. When designing structures, we may consider that they're immune to lateral deformation, and may therefore not account for their behaviour when sudden buckling or beam-column-like behaviour is introduced. In this study p-delta (P-Δ) effect on high-rise building studied for the analysis of G+29 RCC framed building and models were done by ETABS2016. Seismic and wind loads are applied to model as per IS-1893 (2002) and IS-875 (PART-III). The displacements, storey drifts, Bending Moments and Shear Forces are compared to the different models by considering with and without P-delta effect and by providing shearwalls at different locations.*

***Keywords:** p-delta effect (P-Δ), displacement, shear wall, ETABS.*

I. INTRODUCTION

National Building Code (NBC) defines all buildings which are 15 m or above in height are considered as high-rise buildings. But many development authorities define a high-rise building or a multi-Storied building as a building of a height of 24 metres or above.

When a slender structure is exposed to lateral loads

i.e. wind or seismic loads it experiences sway or lateral displacement. Whenever this lateral displacement is increased to peak then gravity loads start to act with an eccentricity. This is equal to the magnitude of elastic deflection causing an additional overturning moment. Due to which, a second order deflection is developed in the structure.

Revised Manuscript Received on 30 July 2019.

* Correspondence Author

Phani Kumar V,M.Tech,* (Ph.D.) (Geotechnical Engineering), Sr. Gr. Assistant Professor, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India.

M.Deepthi, (M.Tech),(Structural Engineering), Post Graduate Student, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India. +919059883009

Saikiran K, (Structural Engineering), Assistant professor, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India. +918464867499 (e-

R.B.N.Santhosh, (Structural Engineering), Assistant professor, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru, Andhra Pradesh, India.

This second order effect caused in the structure is known as P-Delta effect. Where "P" is the gravity load and "Δ" is the displacement experienced through first order or elastic analysis for lateral forces. The P-Delta effect is shown in the Figure 1. Where the Δ_2 is second order deflection caused due to P-delta effect.

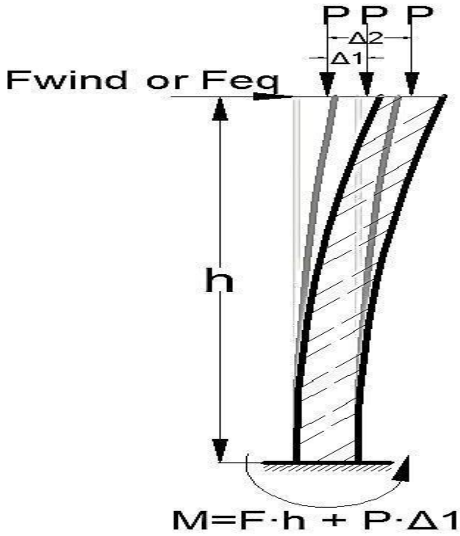


Figure.1: P-Delta Effects on a Simple Cantilever Column The P-Δeffect is experienced in all structures when

they were subjected to an axial load in combination with lateral displacement. The major effect is observed due to deflection of the structure as a whole and also termed as P-delta (P-Δ). However, this research is done on the P-delta effect observed through structural instability (P- Δ). Tall structures and buildings with more number of stories will undergoes large P-delta effect. They are to be designed with Proper recommended considerations. The importance of P-Delta non-linear analysis is continually increasing in high rise buildings are getting very popular and playing a key role.

II. OBJECTIVE OF WORK

✓ To perform linear static analysis of the tall structure by using E-TABS2016 by providing shear-wall. And to study the P-DELTA (non-linear) effect on tall structure by using ETABS and to study the effect of axial loading on the structure.

✓ To study the results of the structure, i.e. deflections and forces by considering with and without P-DELTA effect by providing shear-wall.

✓ To compare the results with P-delta effect and without P-delta effect in structure.

III. ANALYSING OF BUILDING AND MODELLING IN EATBS

A G+29 storey building with plan of 35x40m each storey height of 3m was analysed in ETABS by considering p-delta effect and without p-delta effect and the models were analysed by providing shear wall at different locations in the plan of the building.

Modelled steps in ETABS:

1. Preparing grid for layout
2. Assigning member properties of beams, columns, and slab and wall panels.
3. Preparing load cases like Dead, live, earthquake and wind loads.
4. Make load combinations and modal mass of the structure.
5. Assigning P-delta loads and the structure
6. Run the analysis
7. Note down the results and comparing the models with the same procedure.

The materials used for the analysis are M-25 for slabs and M-30 grade reinforced concrete for beams and columns and Fe-500 grade steel for the entire structure.

A. *Geometry of model:*

The analysis is carried out for G+29 storey building with reinforced concrete properties as specified above.

The model details are given below:

- Number of stories = G+ 29
- no. of Bays in x-direction= 9
- no. of Bays in y-direction= 11
- Height of each storey= 3m
- Slab depth= 125mm
- Size of the transverse beams= 230x450mm
- Size of longitudinal beams= 230x600mm
- Size of the columns (ground to 15th floor)= 900x900mm.
- Size of the column (16 to 30 floor)= 600x600mm.
- zone= III
- Response reduction factor considered = 3
- Importance factor considered= 1.5

B. *Load Proportions*

i. Dead load (DL):

The dead load is considered as per IS code book i.e. IS 875-1987 part-I .

- Unit weight of concrete = 25KN/m^3
- Floor finish =1KN/m^3
- Roof finish = 1KN/m^3

ii. Imposed load (LL):

Imposed load is also known as live load, it is considered as per IS code book i.e. IS 875-1987 part-II.

- Live load of slab = 4KN/m^3
- Live load on roof = 3 KN/m^3

iii. Earthquake load:

The earthquake load is considered as per IS code book i.e. IS-1893-2002 PART-I and the factors considered are

- Response reduction factor considered = 3.0
- Zone factor considered= 0.16
- Importance factor considered= 1.5
- Damping = 5%
- Soil condition = medium.

C. *linear static analysis and non-linear static analysis (p-delta):*

The linear static & non-linear is carried out for G+29 storey building with P-delta(P-Δ)and without considering P-delta(P-Δ) effect and providing shear wall in ETABS .from the analysis results, story drifts, displacements, BM and SF are obtained and these are compared.

IV. MODELS CONSIDER FOR ANALYSIS

A. *Model 1A*

G+29 building model, considering p-delta effect. Figure – 2 shows the plan and 3d model.

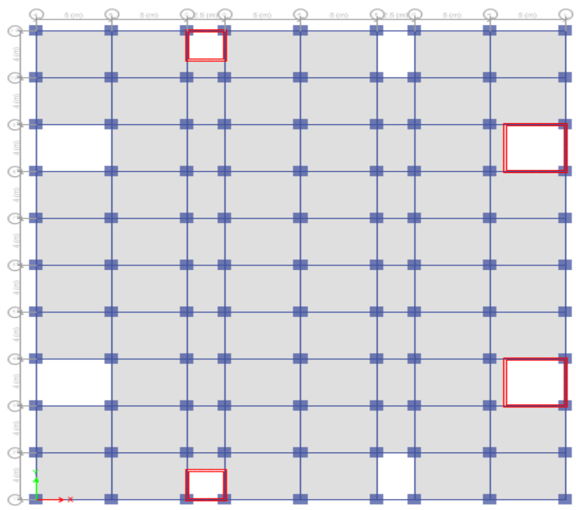


Figure.2a: Model 1A_Plan

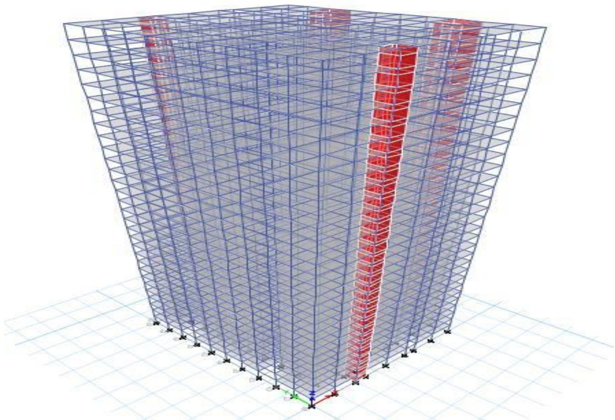


Figure.2b: Model1A_3D Model

B. Model2A

G+29 building model with p-delta effect and shearwall provided at the centre of the walls in the direction of X&Y axis. Figure – 3 shows the plan and 3d model, location of shear walls at centre of the bays.

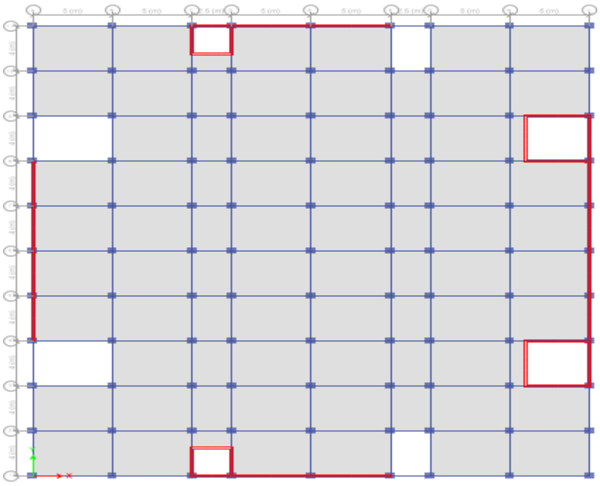


Figure.3a:Model2A_Plan

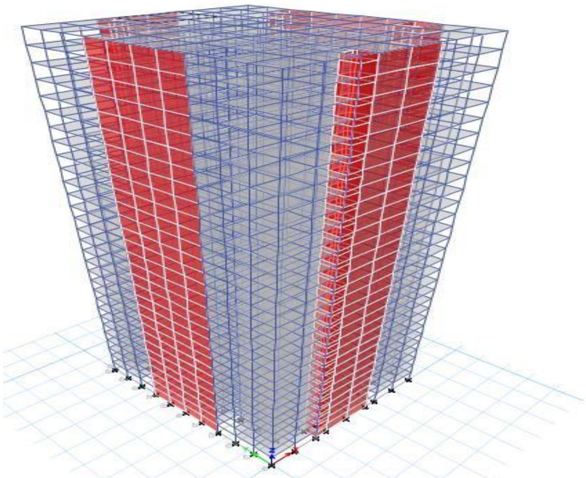


Figure.3b: Model 2A_3D Model

C. Model3A.

G+29 building model with p-delta effect and shearwall provided in all four corners of the structure. Figure – 4 shows the plan and 3d model, location of shear walls at corners of the structure.

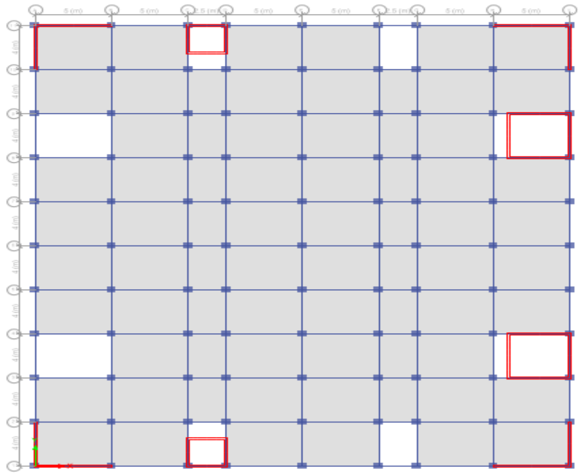


Figure.4a: Model3A_Plan

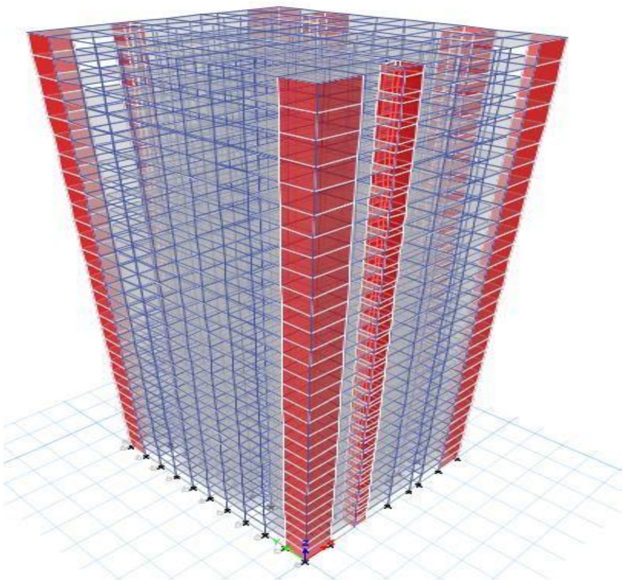


Figure.4b: Model 3A_3D Model

D. Model 1B

Consideration no p-delta effect in this model. Figure – 5 shows the plan and 3d model.

Retrieval Number: B2282078219/19©BEIESP
DOI: 10.35940/ijrte.B2282.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

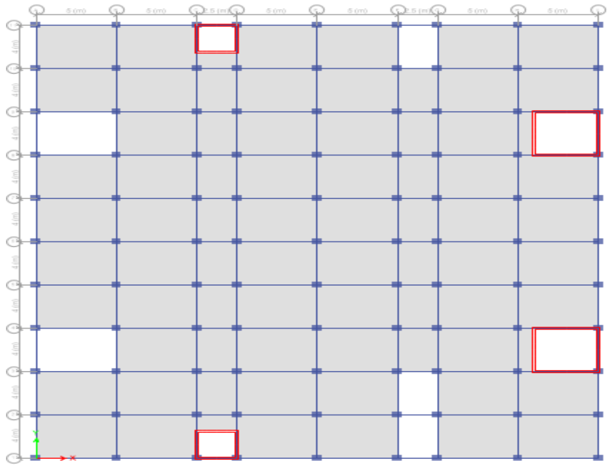


Figure.5a: Model 1B_Plan

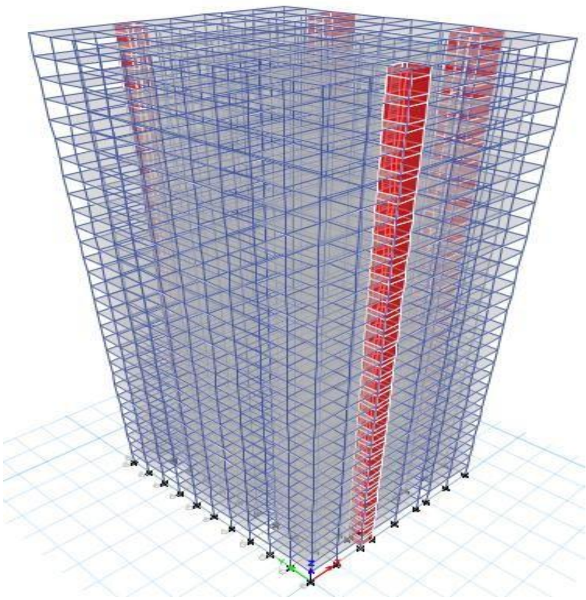


Figure.5b: Model 1B_3D Model

E. Model 2B

In this model: the structure without p-delta effect and shearwall provided along X&Y axis at the centre. Figure – 6 shows the plan and 3d model, location of shear walls at centre of the bays.

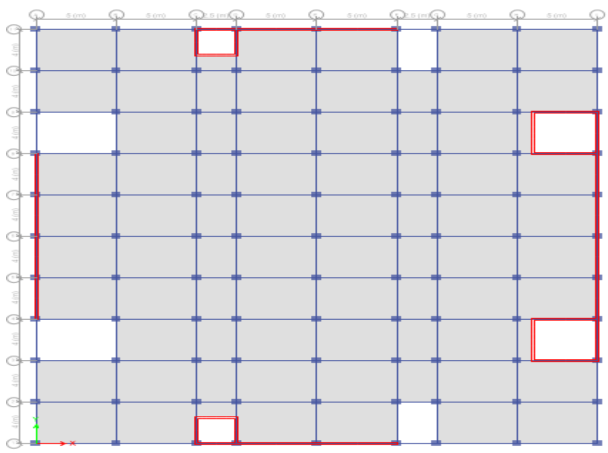


Figure.6a: Model 2B_Plan

V. RESULTS

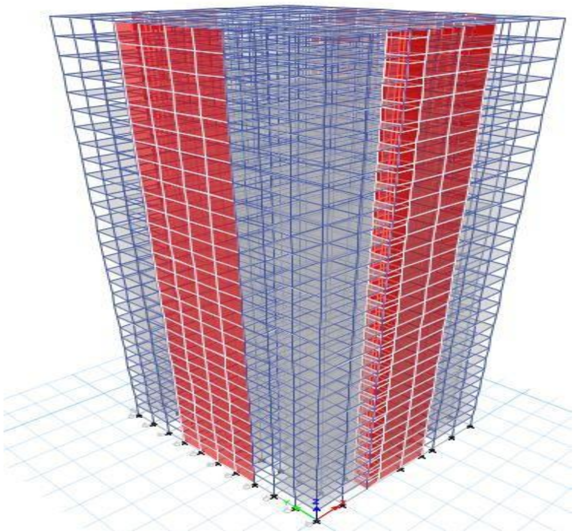


Figure.6b: Model 2B_3D Model

F. Model 3B

In this model, the structure with no p-delta effect and shear wall provided in all corners. Figure – 7 shows the plan and 3d model, location of shear walls, at corners of the structure.

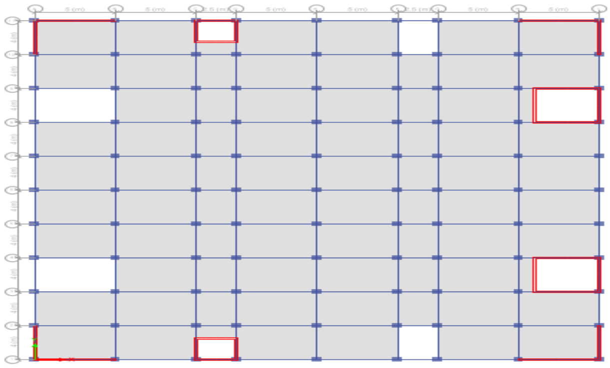


Figure.7a: Model3B_Plan

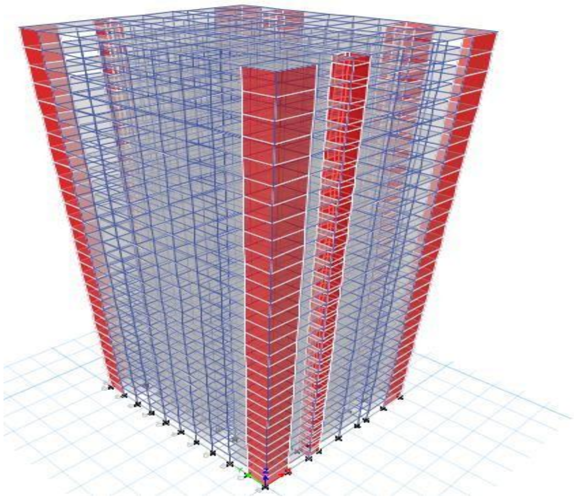


Figure.7b: Model 3B_3D Model

A. Maximum displacements and storey drifts

Table no.1

Storey no.	Max.displacements(mm)		Max.storey drifts(mm)	
	P-delta (P-Δ)1A	Without p-delta (P-Δ) 1B	P-delta (P-Δ) 1A	Without p-delta (P-Δ)1B
5	9.459	5.352	971x10^{-6}	594x10^{-6}
7	16.214	9.181	1170x10^{-6}	719x10^{-6}
9	23.884	13.533	1310x10^{-6}	803x10^{-6}
11	32.158	18.230	1390x10^{-6}	856x10^{-6}
13	40.791	23.130	1450x10^{-6}	886x10^{-6}
15	49.556	28.109	1470x10^{-6}	892x10-6
17	58.537	33.191	1489x10^{-6}	907x10^{-6}
19	67.305	38.164	1490x10^{-6}	883x10^{-6}
21	75.690	42.918	1370x10^{-6}	835x10^{-6}
23	83.523	47.356	1280x10^{-6}	776x10^{-6}
25	90.695	51.410	1166x10^{-6}	703x10^{-6}
27	97.167	55.056	1050x10^{-6}	628x10^{-6}
30	105.581	59.841	929x10-^{6}	532x10^{-6}

Table no.2

Storey no.	Max.displacements(mm)		Max.storey drifts(mm)	
	P-Δwith SW @ center 2A	Without P-Δ&with SW@center 2B	P-Δ with SW @ center 2A	Without P- Δ& with SW@ center 2B
5	4.602	5.674	463x10^{-6}	448x10^{-6}
7	7.865	8.475	570x10^{-6}	497x10^{-6}
9	11.683	11.521	657x10^{-6}	536x10^{-6}
11	15.931	14.754	724x10^{-6}	567x10^{-6}
13	20.503	18.124	773x10^{-6}	589x10^{-6}
15	25.269	21.573	805x10^{-6}	594x10 -6
17	30.296	25.121	841x10^{-6}	616x10^{-6}
19	35.407	28.684	855x10^{-6}	617x10^{-6}
21	40.52	32.208	851x10^{-6}	608x10^{-6}
23	45.544	35.646	833x10^{-6}	591x10^{-6}
25	50.413	38.936	803x10^{-6}	569x10^{-6}
27	55.083	42.136	770x10^{-6}	544x10^{-6}
30	61.615	46.623	729x10-6	504x10^{-6}

Table no.3

Storey no.	Max.displacements(mm)		Max.storey drifts(mm)	
	P-Δwith SW @ corner 3A	Without P-Δ&with SW@ corner 3B	P-Δ with SW @ corner 3A	Without P-Δ& with SW@ corner 3B
5	9.832	4.956	927x10^{-6}	689x10^{-6}
7	15.809	8.646	1080x10^{-6}	791x10^{-6}
9	22.523	12.955	1200x10^{-6}	863x10^{-6}
11	29.765	22.767	1290x10^{-6}	911x10^{-6}
13	37.361	27.992	1350x10^{-6}	933x10^{-6}
15	45.148	33.389	1370x10^{-6}	900x10-6
17	53.115	38.775	1400x10^{-6}	962x10^{-6}
19	61.033	41.028	1390x10^{-6}	955x10^{-6}
21	68.758	45.044	1350x10^{-6}	927x10^{-6}
23	76.168	48.755	1290x10^{-6}	881x10^{-6}
25	83.187	55.987	1260x10^{-6}	824x10^{-6}
27	89.787	58.137	1140x10^{-6}	766x10^{-6}
30	98.996	64.157	996x10-^{6}	689x10^{-6}

B. Lateral Displacements:

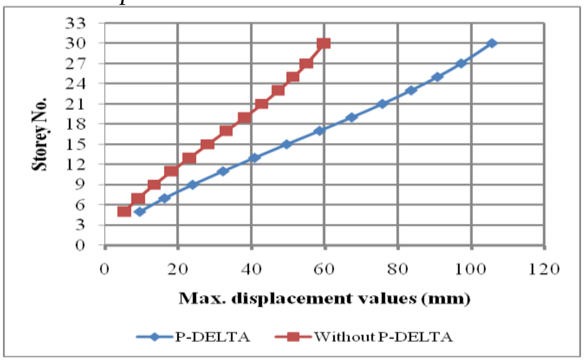


Figure.8a: Max. Displacement of storeys with and without P-Delta.

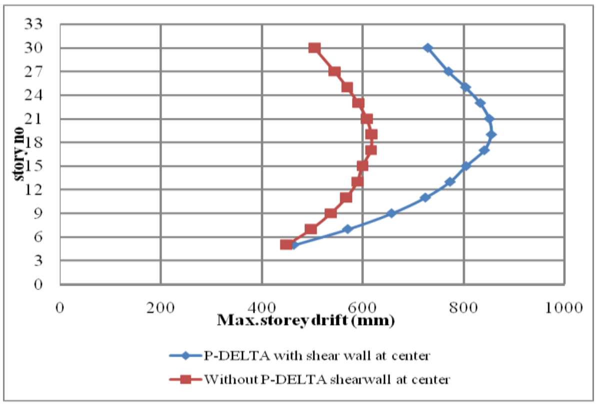


Figure.8b: Max. displacement of storeys with and without P-Delta considering shear wall at center

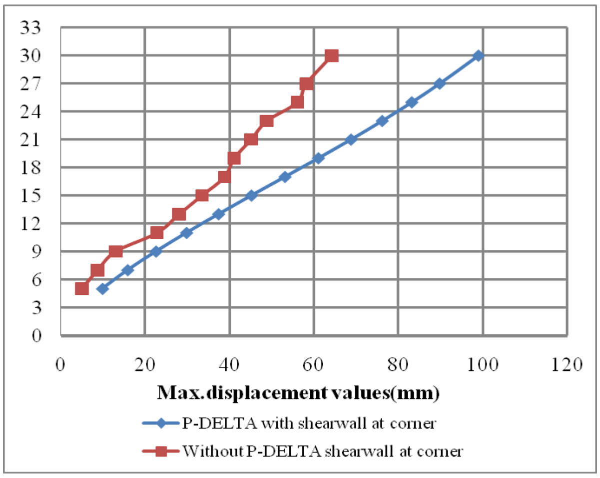


Figure.8c: Max. Displacements of storeys with and without P-Delta considering shear wall at corner.

C. Storey drifts:

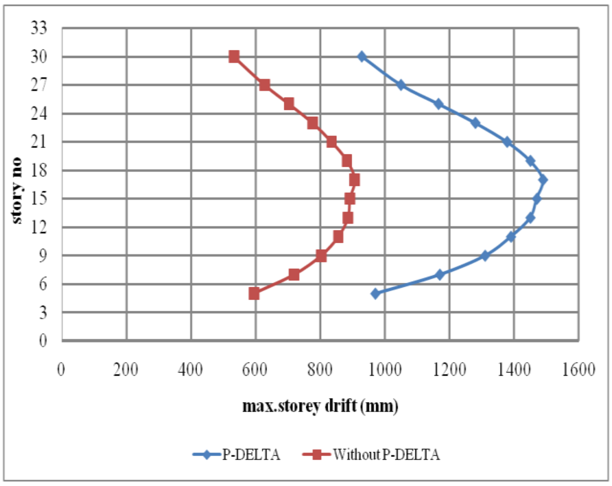


Figure.9a: Max. storey drift of storeys with and without P- Delta

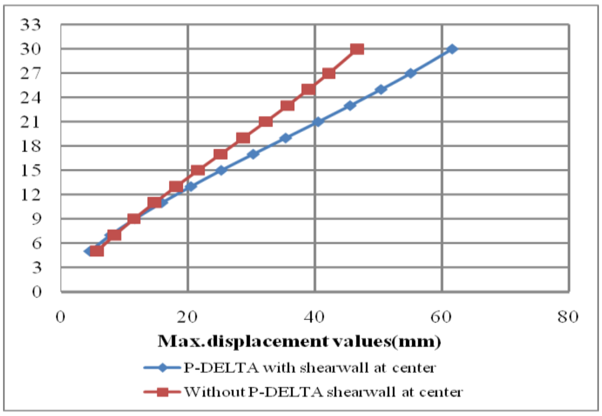


Figure 9b: Max. storey drift of storeys with and without P- Delta considering shear wall at center

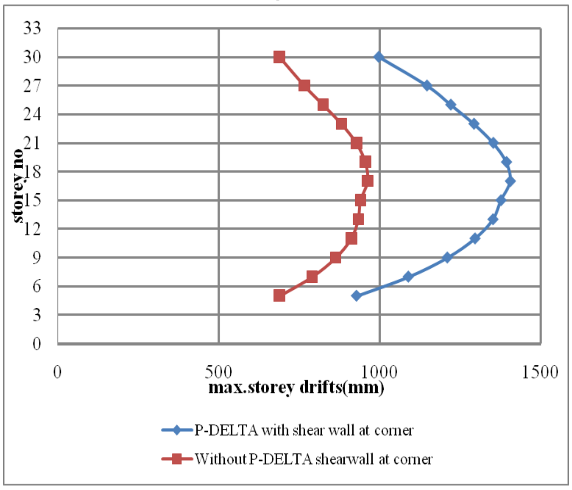
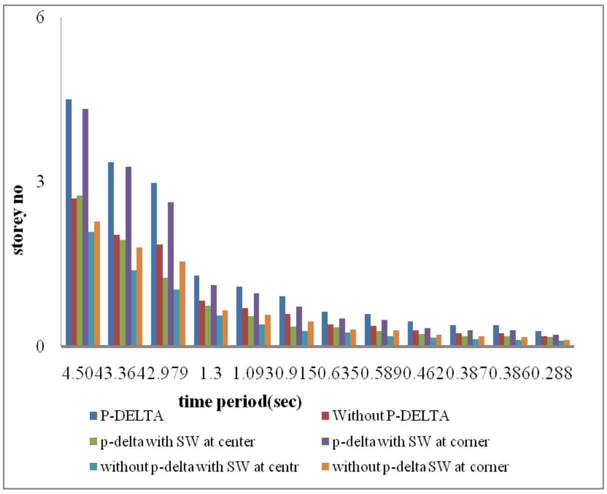


Figure.9c: Max. Storey drift of storeys with and without P- Delta considering shear wall at corner.

D. Time periods

The natural time period is found for building with p-delta effect, without p-delta & with and without p-delta and shear wall provided at center, and with and without p- delta shear wall (sw) provided at corner.



Figur.10: Time period for three cases

E. Base shear:

Base shear is found for all 6 models and compared in below figure 11.

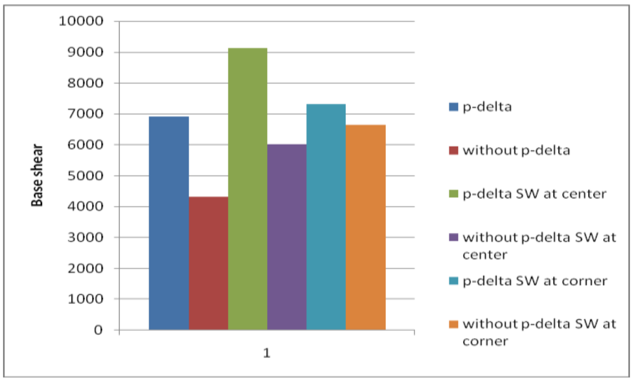


Figure 11: Base shear for three cases

F. Maximum. moments (kN-m)

This table shows the maximum bending moments of the structure in all the models

Storey no	p-delta (P-Δ)	Witho ut p-delta	With P-Δ&S W@c enter	Witho utP- Δ& SW@c enter	p-delta SW@c orner	Witho ut P-Δ&SW @corn er
5	63.91	36.32	32.89	28.06	-47.57	35.08
7	77.28	43.92	40.75	32.16	-56.49	43.38
9	86.54	49.26	47.06	36.00	-63.52	49.57
11	92.46	52.77	53.65	38.55	-68.70	53.93
13	96.18	54.74	56.80	39.34	-72.17	56.71
15	96.56	54.74	59.05	39.74	-73.01	57.14
17	99.33	56.21	63.97	43.31	-76.46	59.31
19	96.49	54.74	65.56	43.65	-75.78	58.41
21	-91.18	-51.81	65.79	-43.38	-73.49	56.25
23	-84.74	-48.18	-65.02	-42.49	-70.04	53.17
25	-77.66	-43.96	-63.53	-41.31	-66.06	49.64
27	-71.87	-39.98	-61.66	-37.69	-62.51	46.25
30	-60.92	-34.28	-54.44	-35.83	-55.34	-39.95

G. Maximum shear forces(kN)

Retrieval Number: B2282078219/19©BEIESP
DOI: 10.35940/ijrte.B2282.078219
Journal Website: www.ijrte.org

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

Table: The maximum shear force value of all models

Storey no	p-delta	Without p-delta	p-delta SW@ center	Without p-delta SW@ center	p-delta SW@ corner	With out p-delta SW @ corner
5	30.97	17.66	16.00	13.65	23.14	18.80
7	37.72	21.38	19.84	15.66	27.52	23.21
9	42.32	23.99	22.92	17.54	30.96	26.48
11	45.35	25.71	26.14	18.79	33.50	28.78
13	47.07	26.68	27.68	19.34	35.20	30.24
15	47.09	26.65	28.76	19.37	35.61	30.42
17	45.13	25.53	29.04	19.67	34.72	26.12
19	43.86	24.80	29.77	19.84	34.40	28.65
21	41.42	23.54	29.90	19.71	33.34	27.56
23	38.46	21.87	29.54	19.30	31.76	26.02
25	35.20	19.93	28.84	18.74	29.93	24.27
27	32.25	18.09	27.98	17.09	28.26	22.59
30	27.16	15.33	24.47	16.14	24.73	19.00

VI. DISCUSSION

P-delta analysis and linear static analysis by providing shear wall in 6models,the result of analysis of these models shows the effect of p-delta will be considerable when lateral loads on building. P-delta is negligible when the gravity loads on buildings. In all models the differences are observed very clearly.Storey displacement for both p-delta and without p-delta found the same trend of increasing.

VII. CONCLUSIONS

1. The displacements of conventional building models (without p-delta) is less when compare to building with p- delta.
2. The storey drifts in building models with p-delta effect are more when comparing with models analysed using equivalent static analysis method(without p-delta effect).
3. Shearwall placed at centre of frame shows more effectiveness when comparing with shear wall placed at corner and without shear wall of the structure.
4. Bending moment (BM) in column at fifth floor found75% increases after the investigation of p-delta analysis.
5. The results show the bending moment (BM) in shearwall 18% increases after p-delta effect.
6. The results of analysis were checked with P-Δ effect and without p-delta effect (P-Δ) in the building models.
7. In elastic or inelastic dynamic analyses, increase in eccentricity causes change in the of p-delta effect. The change is very important in elastic analysis and is somewhat less important in inelastic analysis. However, the variation does not have a constant increasing or decreasing trend. One of the facts that the increase in eccentricity the mass moment of inertia is not increased in all cases.

REFERENCES

1. Nikunj Ma Pushparaj J Dhawale prof .G . N. Narule "Analysis of Delta Effect on High Rise Buildings", International Journal of Engineering Research and General Science Volume 4, Issue 4, ISSN 2091 2730, July-August 2016. pro
2. Ngukiya ,ArpitRavani , YashMiyaniMehulBhavsar – "Study of "P-Delta" Analysis for R.C. Structure", Global Research and Development Journal for Engineering, March 2016.
3. PrashantDhadve , AlokRao, AtulRupanvarDeokate K, Admile P.R, Dr.Nemadde P.D. – "Assessment of PDelta Effect on High Rise Buildings", International Journal on Recent and Invation Trends in Computing and Communication ISSN: 2321-8169 Volume: 3
4. Vijayalakhmi R, Bindu N Byadgi , Vahini M, " Effect Of P- Delta On High Rise Building Located In Seismiczones",Irjet,Volumed04,Issue 8,Aug-2017regina Gaiotti And Bryan Stafford Smith , "P-Dfj,Ta Analysis Of Buildingsteuctures", Journal of Structural Engineering, Vol. 115, No.4, April, 1989. ASCE, Page no:755-770.
5. H. Scholz , "P-DELTA EFFECT UNDER REPEATED LOADING", Journal of Structural Engineering, Vol. 116, No. 8, August, 1990. ASCE,Page no: 2070-2082
6. J. Y. Richard Yen," DIRECT ANALYSIS OF SLENDER COLUMNSWITH P-DELTA EFFECTS", Journal of Structural Engineering, Vol. 119, No. 3, March,1993,page no: 871-890
7. Sheng-Jin Chen and Wu-Chyuan Wang,"MOMENT AMPLIFICATION FACTOR FOR P-d EFFECT OF STEEL BEAM-COLUMN" Journal of Structural Engineering, Vol. 125, No. 2, February, 1999,ASCE, page no: 219-223.
8. Jeffrey Ger and Phillip Yen, "PUSHOVER ANALYSIS OF BRIDGE INTERMEDIATE BENTS",ASCE 2004,Page no:153-162
9. Hyo-GyoungKwaka and Jin-Kook Kimb," P–DELTA EFFECT OF SLENDER RC COLUMNS UNDER SEISMIC LOAD", Engineering Structures 29 (2007), Page no 3121–3133.
10. Christoph Adam and Clemens Jäger," SIMPLIFIED COLLAPSE CAPACITY ASSESSMENT OF EARTHQUAKE EXCITED REGULAR FRAME STRUCTURES VULNERABLE TO P-DELTA", Engineering Structures 44 (2012), Page no:159–173.

AUTHORS PROFILE

PHANI KUMAR. V is currently working as Sr.Gr.Assistant Professor in Department of Civil Engineering Gudlavalleru Engineering College, Gudlavalleru. He got his B.Tech from Acharya Nagarjuna University in Civil Engineering. He has completed his Post Graduation from Sri Venkateswara University in Geotechnical Engineering and secured University Gold Medal. He is pursuing his Ph.D in Sri Venkateswara University, Tirupathi. He has professional memberships in Institution of Engineers (I) and Indian Geotechnical Society (IGS). His areas of interests are soil stabilization, artificial neural networks, fuzzy approach and soil structure interaction. He is actively involved in consultancy and research.

M. DEEEPTHI, P.G student in Structural Enginnering, Department of Civil Engineering, Gudlavalleru Engineering College, Gudlavalleru. She graduated in first class with distinction from Sir C.R. Redddy Engineering College, Eluru. At present she is pursuing her Post graduation with 8.5 CGPA. The interesting areas are Structural Engineering, Concrete technology, Design and analysis of high rise building using Software.

K. SAI KIRAN at present is working as Assistant Professor in Department of Civil Engineering Gudlavalleru Engineering College, Gudlavalleru He completed his B.Tech and M.Tech from JNTU, Kakinada. His specialization is Structural Engineering. Previously he worked as Assistant Professor in Gudlavalleru Engineering College, Gudlavalleru. He is Associate Member of Institution of Engineers.His areas of interest are computer aided design of buildings, soft computing techniques. He is involved in consultancy and has taken active part in the designing of various structures including high-rise structures.

R. B. N. SANTHOSH is currently working as Assistant Professor in Department of Civil Engineering Gudlavalleru Engineering College, Gudlavalleru. Prior to this, he worked as Assistant Professor in Sri Venkateswara College of Engineering & Technology, Chittoor. He obtained B.Tech Civil Engineering from JNTU, Kakinada and M. Tech Structural Engineering from JNTU, Ananthapur in First Class with Distinction. He is Associate Member of Institution of Engineers. His areas of interest are High-Rise Structures, Foundation Systems for problematic soils, alternate building materials.