http://dx.doi.org/10.21172/ijiet.103.05

Comparative study of multi storey buildings with conventional bricks and autoclaved aerated lightweight bricks considering with and without p-delta effect

Mr.Rajesh Ganiger[1], Pavan Gudi[2], Sachin Kulkarni[3]

[1]PG Student, Department of Civil Engineering, Gogte Institute of technology Belagavi Visvesvarayya Technological University Belagavi, Karnataka, India

[2,3]Assistant Professor, Department of Civil Engineering, Gogte Institute of technology Belagavi Visvesvarayya Technological University Belagavi, Karnataka, India

Abstract- Tall building developments are rapidly increasing worldwide nowadays. Due to the frequent earthquakes happening around the world, the buildings have to be made Earthquake resistant. The second order effect or P-delta effect has to be included in the analysis. A first order analysis, in which equilibrium and kinematic relationships are taken with respect to the un deformed geometry of the structure. Second -order analysis, which imposes equilibrium and kinematic relationships on the deformed geometry of the structure, is required for stability design. In the traditional first order analysis or linear static analysis of structures, the effects of change in the structure actions due to structure deformations are neglected. However, when a structure deforms, the applied loads may cause additional actions in the Structure that are called second order or P-Delta effects. In the present study seismic analysis of a 30 storey RC building with and without P-Delta effects for conventional and autoclaved bricks with X bracings along longer direction using linear static analysis is carried out using STAAD Pro structural analysis software. The seismic zone factor of 0.16 is considered which falls under Zone-3. The seismic analysis results are compared

Key words: P-Delta effect Conventional brick, Auto claved aerated light weight brick

I. INTRODUCTION

The term P-delta refers to the additional actions induced by an axial force (P) when there is a horizontal displacement (delta) on a vertical element. P-Delta is a non-linear (second order) effect that occurs in every structure where elements are subject to lateral forces to an extent that they play a significant role in the analysis and design of structures. In First order analysis the displacements/internal forces are calculated with respect to the un-deformed structure, but in a second order analysis the displacements/internal forces are calculated with respect to the deformed structure i.e. it includes large displacement theory and Stress stiffening. When subjected to lateral displacements, the building structure will deform which in turn produces second order overturning moments and usually these are not taken into consideration in the case of dynamic and static analysis. This type of second order behavior is known as P- Delta effect as additional overturning moments in the building is equal to the arithmetic sum of story weight “P” multiplied by lateral displacements “Delta”. There are 2 types of P-delta effects a) P-Δ or Large P-delta or P-large delta b) P-δ or Small P-delta or P-small delta. P-large delta refers to the effects of gravity loads applied to structures that are laterally displaced. As a reference, seismic or wind loads create horizontal displacements (Δ) and vertical loads (P) also known as gravity loads that also act vertically on the structure displaced at the same time. Therefore, the secondary moments developed in the structure are equal to the gravity load (P) multiplied by the horizontal displacement (Δ) P- Small delta effect (P- δ) refers to the effects of axial load on a member subjected to deflection between the end points. For example, the loads in the columns due to wind loading, seismic forces and self-weight result in deflection as a result of the rays that are supported on it. The developed bending moments are proportional to the axial load. That is, P multiplied by the curvature that produced during the bending, that is, δ. It should be considered that even beams that are loaded axially will also experience this type of effects. Conventional Brick Infill Structures In the world most commonly R.C. Construction with brick masonry fill is used even in the region of the earthquake zone. The reinforced concrete building with brick filling walls is analysed and designed as a bare frame. Autoclaved Aerated Concrete is a steam-cured cementitous product manufactured from a mix of pulverized fly ash, cement, lime, gypsum and an aeration agent, giving it its unique porous nature. AAC is an intelligent building solutions system because of its light weight, excellent thermal insulation and acoustic properties and energy efficiency The blocks and panels are used for all kinds of walls, external or internal, load bearing or non-load bearing walls etc. AAC is the material of choice for all building applications.

II. LITERATURE REVIEW

Nikun Mangukiya, et al., (2016) P-delta effect in high-rise buildings located in seismic zones They have modelled a G + 24-storey building that is analysed with linear static analysis and with P-delta analysis, concluding that the comparison displacement varies from 12% to 20% In the same way, for a load combination (EQ Y-), the bending moment shows a variation of 5% to 20%, the value of the modal period and the different mode forms are also, variable.Yousef Dinar, et al., (2013) comparison of the P-delta analysis with linear static analysis They have modelled a 5storey, 10storey, 15storey, 20storey, 25storeyand 30 storey building and analyzed them by Linear static and Linear static with P-delta in STAAD.Pro They concluded that as the storey height increases the displacement and axial forces increases exponentially for the P-delta Analysis. But for the P-delta analysis moments decreases with increment of storey. Prashant Dhadve, et al., (2015), p-delta effect on multi storey building They have modelled a (G+20), (G+25) storey building analysed with linear static analysis with P-delta analysis They concluded that P-Delta effect becomes more essential as the number of stories increases. In case of 20 storey and 25 storey buildings and mostly in 25 storey building only in exterior columns and in adjacent beams in some load cases P-Delta effect is observed. If these load cases are leading load cases for design of members, then only P-Delta effect can be considerable. So it is required to check the analysis results by considering P-Delta effects and without considering P-Delta effects for the buildings. Up to 20 storey buildings there is no change in the results, so P-Delta analysis is considered for designing a minimum of 25 storey building considering seismic loads and buildings up to 25 stories can be designed by linear analysis or conventional primary analysis.P V Dhanshetty et al, (2015), investigated the action of p delta effect on multi storey buildings In this work, multi-storeyed reinforced concrete building models with different number of storeys were analysed by using STAAD Pro V8i structural analysis software. The maximum response values in buildings in terms of storey drifts, column moments, beam moments, column shear and beam shear were investigated. It was observed that the P-Delta effect will be substantial when lateral forces exist on the structure and this increases with increase in number of storey. The P-Delta effect is not predominant on buildings up to seven storeys and it is very negligible when only gravity loading exists on the structure. Manasa C K et al,(2016), examined the behaviour of reinforced concrete buildings under lateral load. The objective of the study was to evaluate the P-Delta effect in high RC buildings. Five building models with 10, 20, 30, 40 and 50 floors are analysed using the static non-linear analysis method in ETABS 2015. The drift ratio is determined considering the P-Delta effect for all building models. The results demonstrated the effectiveness of P-Delta analysis in high RC buildings. They concluded that the P-Delta effect increases as the height of the building increases and can be reduced to some extent by the construction of the cutting wall. Ajay Patre and Laxmikant Vairagade, et.al(2016) Analysis of High Rise Building Using Light Weight Infill Blocks and Conventional Bricks This research work on comparison of seismic analysis and design of G+15 building using ALC (Aerated light weight concrete block) and conventional bricks. The performance of the building is analyzed for different position of shear wall, aerated light weight concrete block and conventional brick. They concluded that The ALC block material can basically be used to replace conventional bricks as infill material for RC frames built in the earthquake prone region. Shear wall construction will provide large stiffness to the building by reducing the damage to the structure by considering the infill wall the roof displacement of the structure reduces.

III. OBJECTIVE AND METHODOLOGY

3.1 Objectives

To Analyse G+30 storey building with and without P-Delta effect for the following cases
The building with Conventional bricks.
The building with Auto claved lightweight Aerated bricks.
To Study the behavior of the structure with and without P-Delta effect for the following cases
The building with conventional bricks.
The building with Auto claved lightweight Aerated bricks.
To Compare the results of the structure with and without P-Delta effect for the following cases
The building with conventional bricks.
The building with Auto claved lightweight Aerated bricks

3.2. Methodology

Linear Static Analysis or Equivalent Static Analysis

The linear static analysis for (G+30) storey building is carried out without considering the P-delta effect. From the analysis results, displacements, storey shear, axial force and bending moment at the base and at various structural members are obtained.

Non-Linear Static or P-Delta Analysis

The nonlinear static analysis for (G+30) storey building is carried out considering the P-delta effect. From the analysis results, displacements, storey shear, axial force and bending moment at the base and at various structural members are obtained

3.3.Modelling

The buildings are analyzed by different loads using STAAD.Pro. The structure is analyzed as per the standards. Structural members of requisite shape (Rectangular/Circular) for vertical frame structure were chosen

3.4 Generation Of The Model

The structure may be generated following coordinates
Depth of the footing: 1.5m
Height of the each floor: 3.0
Seismic zone 3
Depth of slab 130 mm
Density of conventional brick is 20 kN/m3
Density of Auto clave light weight brick is 6.5 kN/m3
Beam size 750×300 mm
X bracing size 200 ×200× 25

3.5 Load Calculations

load of slab =0.13×25=3.25kN/m2
Dead Dead load of CB Main wall of 20 kN/m3=0.23×2.25×20=13.5 kN/m
Dead load of LWB Main wall of 6.5 kN/m3=0.23×2.25×6.5=3.38 Kn/m

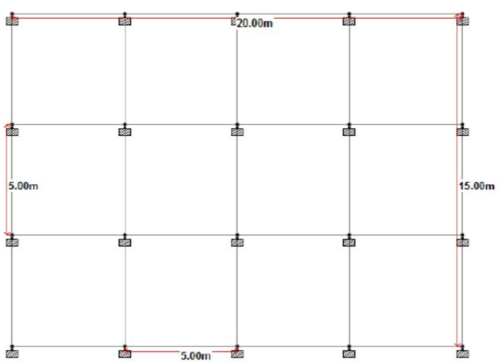

Fig 1 building plan

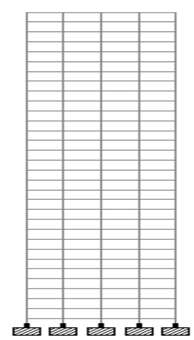

Fig 2 Elevation of building

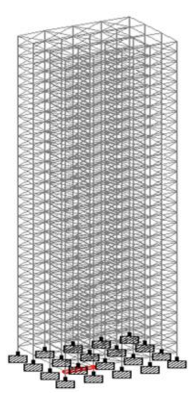

Fig 3 Beam comparison

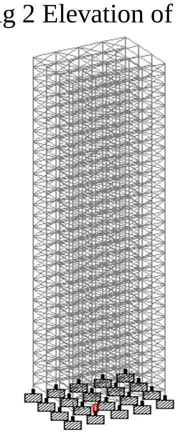

Fig 4 Column comparison

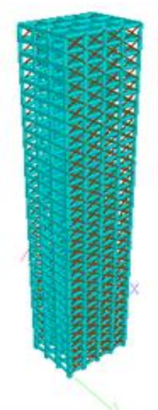

Fig 5 3D renderd view

IV. RESULTS

The Following two tables shown below the base shear values obtained for with P-Delta And Without P delta Method Along +x and +Z direction

Base Shear Values			
G+30	Building Type	Without P-Delta	With P-Delta
	Conventional Brick	6398.9	6525.2
	Light Weight Brick	4383.32	5254.4

Base shear values			
G+30	Building Type	Without P-Delta	With P-Delta
	Conventional Brick	5801.6	5916.19
	Light Weight Brick	3974.21	4764.05

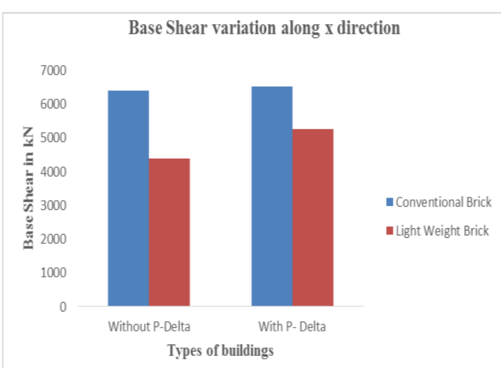

Fig 6 Base shear variation

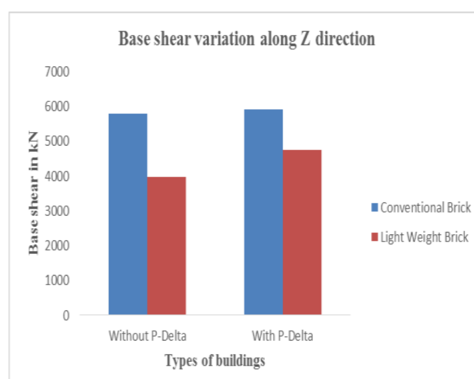

Fig 7 Base shear variation

The below table shows the displacement variation for conventional brick and auto clave light weight brick

Table 1 Displacement variation for cb

Displacement Variation for CB block		
Storey	Without P-Delta	With P-Delta
30	13.89	42.19
29	13.43	41.18
28	12.98	40.08
27	12.49	38.8
26	12.03	37.63
25	11.09	36.29
24	10.69	34.87
23	10.16	33.42
22	9.7	31.90
21	9.24	30.34
20	8.78	28.75
19	8.32	27.13
18	7.88	25.60
17	7.41	24.05
16	6.96	22.50
15	6.52	20.94
14	6.07	19.38
13	5.64	17.83
12	5.19	16.30
11	4.78	14.79
10	4.34	13.30
9	3.94	11.84
8	3.5	10.47
7	3.12	9.12
6	2.7	7.8
5	2.32	6.54
4	1.93	5.31
3	1.55	4.13
2	1.19	3.0
1	1.08	2.10
0	1.02	1.05

Table 2 Displacement variation for alc

Displacement variation for ALC		
Storey	Without P-Delta	With P-Delta
30	10.52	12.58
29	10.17	12.17
28	9.82	11.75
27	9.48	11.33
26	9.13	10.92
25	8.78	10.50
24	8.43	10.09
23	8.08	9.67
22	7.74	9.26
21	7.39	8.84
20	7.05	8.43
19	6.70	8.0
18	6.36	7.61
17	6.02	7.20
16	5.68	6.80
15	5.34	6.39
14	5.02	6.0
13	4.68	5.59
12	4.36	5.2
11	4.02	4.81
10	3.71	4.45
9	3.38	4.04
8	3.08	3.68
7	2.75	3.30
6	2.46	2.95
5	2.15	2.57
4	1.88	2.23
3	1.57	1.88
2	1.28	1.53
1	1.01	1.21

The below table shows the lateral load variation for conventional brick and auto clave brick

Table 3 Lateral load variation

Lateral loads in kN		
Storey	Without p delta	With p delta
1	0.099	0.098
2	1.303	1.32
3	3.618	3.6
4	7.09	7.23
5	11.72	11.95
6	17.51	17.86
7	24.45	24.95
8	32.56	33.21
9	41.82	42.66
10	52.24	53.29
11	62.56	63.84
12	73.52	75.06

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13	86.86	88.68
14	99.97	103.44
15	116.89	119.3
16	133.56	136.36
17	151.35	154.52
18	170.26	173.82
19	190.27	194.25
20	211.40	215.85
21	227.44	232.32
22	243.35	248.72
23	266.51	272.39
24	290.73	297.15
25	315.9	322.9
26	342.32	349.8
27	369.9	377.8
28	398.12	406
29	427.60	437
30	458.14	468.25
31	489.72	500.5

Table 4 Lateral load variation

Lateral Loads in kN		
Storey	Without P-Delta	With P-Delta
1	0.109	0.108
2	1.43	1.46
3	3.99	4.07
4	7.82	7.97
5	12.93	13.19
6	19.31	19.70
7	26.97	27.51
8	35.91	36.63
9	46.13	47.06
10	57.62	58.78
11	68.99	70.41
12	81.09	82.79
13	95.81	97.8
14	110.27	114.09
15	128.92	131.62
16	147.31	150.40
17	166.94	170.43
18	187.78	191.71
19	209.86	214.2
20	233.16	238.04
21	250.85	256.24
22	268.4	274.32
23	293.94	300.40
24	320.65	327.73
25	348.52	356.2
26	377.56	385.89
27	407.75	416.75
28	439.10	448.80
29	471.62	482.03
30	505.3	516.45

31	540.1	552.06

Table 5 Lateral load

Lateral Loads in kN		
Storey	Without P-Delta	With P-Delta
1	0.03	0.05
2	0.90	1.125
3	2.52	3.12
4	4.94	6.12
5	8.18	10.12
6	12.22	15.12
7	17.07	21.1
8	22.7	28.1
9	29.19	36.1
10	36.46	45.1
11	44.54	54.6
12	53.43	64.8
13	63.12	76.67
14	73.63	89.42
15	84.94	103.16
16	97.06	117.8
17	109.9	133.59
18	123.7	150.2
19	138.27	167.9
20	153.6	185.1
21	169.7	203.01
22	186.7	223.30
23	204.53	244.56
24	223.12	266.78
25	242.51	289
26	262.71	314.12
27	283.72	339.12
28	305.54	365.3
29	328.17	392.3
30	351.6	420.4
31	375.84	449.3

Lateral loads in kN		
Storey	Without p delta	Withp delta
1	0.03	0.04
2	0.82	1.02
3	2.28	2.83
4	4.48	5.51
5	7.41	9.1
6	11.08	13.7
7	15.47	19.14
8	20.60	25.49
9	26.46	32.74
10	33.06	40.89
11	40.38	49.05
12	48.4	58.83
13	57.23	69.51
14	66.7	81.08

15	77.01	93.53
16	88	106.8
17	99.73	121.1
18	112.11	136.2
19	125.37	152.26
20	139.29	167.6
21	153.94	184
22	169.33	202.4
23	185.4	221.73
24	202.2	241.88
25	219.8	262.9
26	238.19	284.8
27	257.2	307.58
28	277.02	331.2
29	297.54	355.7
30	318.7	381.1
31	340.7	407.4

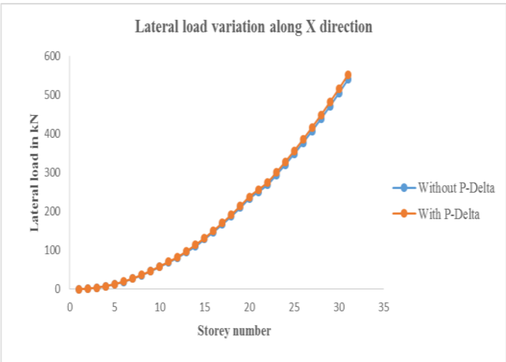

Fig 8 Lateral load variation

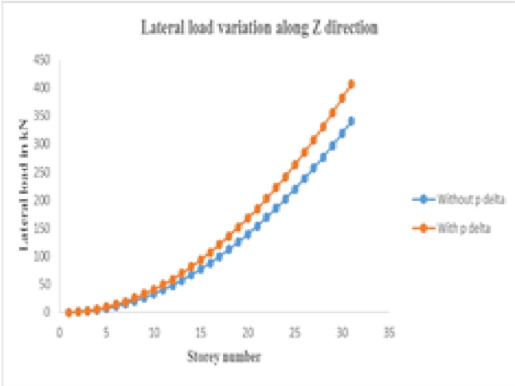

Fig 9 Lateral load variation

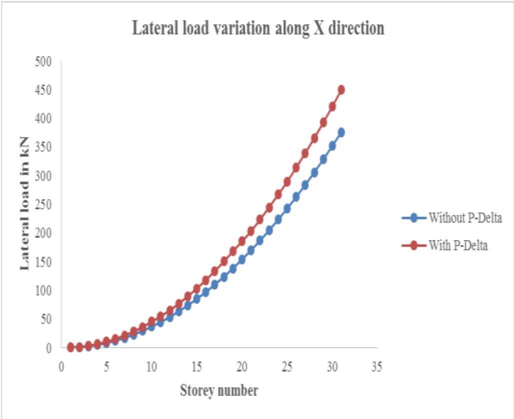

Fig 10 Lateral load variation

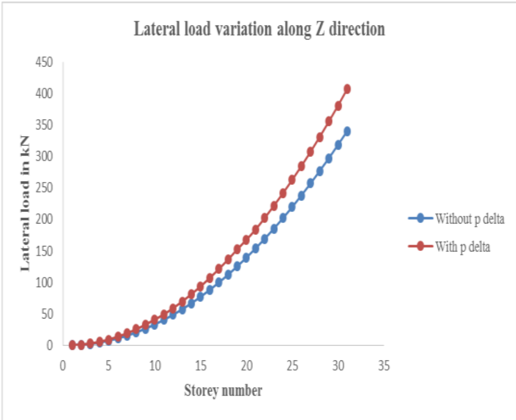

Fig 11 Lateral load variation

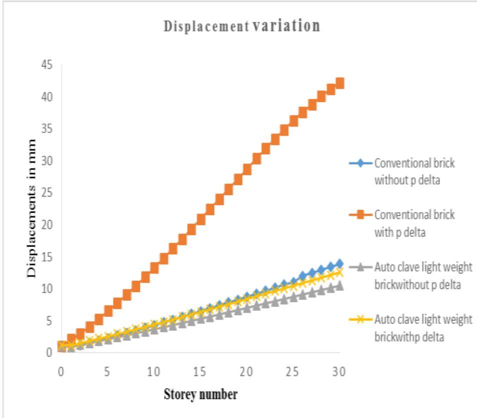

Fig 12 Displacement variation

Table 7 Bm values

BM values for beam number 11			
G+30	Building Type	Without P-Delta	With P-Delta
	Conventional Brick	4.27	35.7
	Light Weight Brick	4.7	5.63

Table 8 Sf value

SF values for beam number 11			
G+30	Building Type	Without P-Delta	With P-Delta
	Conventional Brick	1.13	14.5
	Light Weight Brick	1.28	1.53

Table 9 Axial forces

Axial force of column no 48				
G+30	Building Type	Without P-Delta	With P-Delta	Percentage increases
	Conventional Brick	38.60	78.73	50.97
	Light Weight Brick	12.23	17.28	29.22

Table 10 Bm values

BM Value of column no 48				
G+30	Building Type	Without P-Delta	With P-Delta	Percentage increases
	Conventional Brick	20.5	29.23	30
	Light Weight Brick	9.22	12.63	26.9

V. CONCLUSIONS

The behaviour of structures such as buildings with conventional bricks and light bricks is studied. The building was modelled and analysed using the STAAD Pro software considering with and without p delta effects comparison between the different cases, such as construction with conventional bricks and light weight bricks. According to the analysis data, the following conclusion were drawn.

The deadweight of the structure is almost 30% reduced in the case of the aerated light blocks of auto clave compared to conventional bricks so that the economy in the design can be achieved.

As the floor height increases the displacement also increases, Bracings in the longer direction helped reduce the nodal displacements by almost a 65% in conventional bricks and a 17% in light autoclave aerated bricks

The bending moment for light bricks have been reduced by almost 35% like conventional bricks, so there is a reduction in the size of the sections.

The axial forces and the bending moment in the column reduced about of 30% and 28% compared to conventional bricks; therefore, there is a reduction in the column sizes and a reduction in reinforcement.

http://dx.doi.org/10.21172/ijiet.103.05

There is a reduction of almost 20% in the shear of the base for LWB in comparison with the conventional bricks less than the shear of the base and lower the lateral force and the shear in the floor.
The overall performance of the AAC block is superior to that of conventional buildings Light weight brick buildings can be effectively used in high-rise buildings in the earthquake-prone area.
Scope for further study
The present work can be extended for the following conditions
The model can be analysed considering the effect of wind on high rise buildings.
The model can be studied by providing dampers and at suitable locations along with shear walls.
The study can be extended for push-over analysis.

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