*International Journal of Engineering Science & Invention*
*ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726*
*www.ijesi.org ||Volume 6 Issue 6|| June 2017 || PP. 06-13*

# Effect of P-Delta Due To Different Eccentricities in Tall Structures

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*Highlights: Study Includes Comparison Of Symmetrical And Asymmetrical Building In Zone 4 & 5 Due To P-Effect.*

***ABSTRACT:*** *P-effect in structure mainly rises from the direct action of lateral forces and the structure in a state of equilibrium where the deformed structure shape is a more responsible factor. This kind of effect is made in the analysis of second order, where the geometry of the elements is come from their changed condition. Gravitational loads on the construction elements, deform producing extra forces, which are not taken into account during calculations of structures in un-deformed shape. The given gravitational loads are more precisely defined, in the group of action forces in a structure, can't be said that their change from project values, will be the determining factor in the effect of P-Delta, but in defining order remains the geometry of the structure. More detail the geometry is defined as the correct second order effects could be considered in structures. In this paper static & dynamic analysis has been performed using with and without P-delta for symmetry & asymmetry Reinforced Concrete (RC) frame building models by varying different eccentricities levels from 0, 10, 20 & 30 percent. Results of comparison between symmetrical & Asymmetrical building in zone 4 & 5 are conferred and conclusions are made.*
***Keywords:*** *Wind load (EQX), Displacement, and different level of eccentricity, P-delta analysis, Symmetry & Asymmetry building.*

## I. Introduction

P-Δ effect on structure mainly arise from the direct action of lateral forces & terminate the structure in a state of equilibrium where the deformed structure shape is a more determining factor. This kind of effect is made in the analysis of second order, where the geometry of the elements comes from their changed condition. Gravitational loads on their way through the construction elements, where this one are deformed to produce additional forces, which are not taken into account during calculations of structures in un- deformed shape. The given gravitational loads are the loads, more precisely defined, in the group of action of forces in a structure, we can't say that their change from project values, will be the determining factor in the effect of P-Delta, but in deforming order remains the geometry of the structure.

## II. Literature Survey

Some of the parametric studies on buildings considering effect of P-Delta by different eccentricities on tall buildings by considering symmetry as well as asymmetry building with static and dynamic behavior with & without P-Delta for different eccentricity level.

**Rafael Shehu, 2014 [1],** Building behaviour is an element of various elements and their interaction versus outside activity picked by us. This exchange transcends the geometry of the structure, its hardness and their connections capacities. The primary parameters of the connection capacities are loads at the current stage. With loads we mean static and dynamic, while the calculation stage I refer to the stage conduct of the material and structure, the flexible stage or post versatile stage, without distorted or twisted components. Every stage is acknowledged or let's say, inexact in estimations techniques and altering some standard methods. In this discussion we will address in a compact manner, two key factors in the configuration of structures, which are second order effects (P-Delta) and the ductility of structures. Both components have risen as a need of approximating genuine complex conduct in a design system. Will would like to better comprehend the connection of these two different methodologies, contemplating distinctive philosophy and way to deal with the issue by looking at the outline necessities. What we remain for change, is to expand the exactness of basic analyses for structures at the design stage of internal force. It is realized that a nonlinear examination is more precise than a direct analyses, however then again is an inefficient analysis in term as time consuming with calculations and PC memory. The arrangement for our situation would oblige a little memory and quick time.

**Yousuf Dinar, Nazim Uddin Rahi, Pronob Das, 2013 [2],**

This paper assesses deflection of the steel skyscraper structure because of the P-Delta impact considering the global slenderness of the entire structure. For simple and fast plan just Linear Static examination is performed and secondary loading impact is neglected in a few underdeveloped and developing nations of South Asia. Utilizing STAAD Pro v8i, 40 different models is recreated to watch the seriousness of the P-Delta wonder against standard Linear Static system. 4 different stories were joined with 5 varying span in both directions for differing the slenderness of the structure. During investigation lateral load imposed with UBC94 to perform the seismic events in two different seismic moderate danger zone of Bangladesh utilizing Bangladesh National Building Code (BNBC) comparing coefficients however wind load is overlooked to watch the seismic event impact in Steel skyscraper structure exclusively expecting result choice would be same if the reproduction would accomplished for wind load too. This examination uncovers how pivotal side of the structure creates different deflections with changing slenderness. Test outcomes were assessed by story deflection (in 'mm') and rate of variety of deflection was performed by looking at P-Delta yields with Linear Static Method outputs.

**Christoph Adam, Luis f. Ibarra, Helmut Krawinkler, 2011 [3]**

This paper addresses the evaluation of destabilizing impacts of gravity, generally referred to as P-Delta impacts, in exceptionally inelastic structures when subjected to seismic excitations. The proposed methodology is taking into account an identical single-degree of freedom (ESDOF) system of the real building. Appropriate properties of the ESDOF framework are characterized, taking into account after effects of a relating global pushover analysis investigations. P-Delta impacts are consolidated by which is pivoted by a uniform stability coefficient. The methodology is assessed for a few multi-story generic fame structures. The breakdown limit of these structures is derived from a set of Incremental Dynamic Analysis (IDA) studies including 40 ground movements whose power is expanded until P-Delta instability occurs. The results are translated from the ESDOF area into the space of the multilevel of-opportunity (MDOF) framework, and used for the estimation of P-Delta effects in MDOF structures. "Careful" results are contrasted from results of the investigations using ESDOF frameworks. Assumption and limitations of the ESDOF framework methodology are examined. The accentuation is on the level of reaction at which the structure approaches dynamic instability (sideway fall).

## III. Details of Structure

In the present study, 3D RC frames of symmetry and asymmetry building with 5 x 5 bays and 8 x 4 bays with G+40 and G+ 41 storeys are taken into consideration. The RC frames to be designed as per BIS codes. Namely, IS 456-2000, “Plain and Reinforced Concrete code of practice”, IS 1893-2002 (Part 1), “Criteria for Earthquake Resistant design of structures” and, M25 concrete is assumed and both mild steel and tor steel are used for reinforcement. But in this journal there is only static case with zone 4.

**Symmetry case** : Live load =4kN/$m^2$
: Super dead load =1.5kN/$m^2$
**Asymmetry case :** Live load =1.5kN/$m^2$
**:** Super dead load =3.5kN/$m^2$

## IV. Details Of Frame

- Breadth of Beam, b = 0.23 m
- Depth of Beam, d = 0.60 m
- Breadth of Column, b = 0.90 m
- Depth of Column, d = 0.90 m
- Thickness of slab, = 0.230 m
- Height of masonry infill, h = 3.6 , 3 m (For Bottom &Other Floors)
- Grade of Steel = Fe 415
- Poisson’s ratio of concrete, μ = 0.20

## V. Details Of Frame

- Breadth of Beam, b = 0.23 m
- Depth of Beam, d = 0.60 m
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- Depth of Column, d = 0.90 m
- Thickness of slab, = 0.230 m
- Height of masonry infill, h = 3.6 , 3 m (For Bottom &Other Floors)
- Grade of Steel = Fe 415
- Poisson’s ratio of concrete, μ = 0.20

## VI. Parameters

**Symmetric building** the plan regular building structure consists of 5 X 5 bays i.e. 5 bays along each X and Y direction. Dimensions of plan area 20m X 20m.

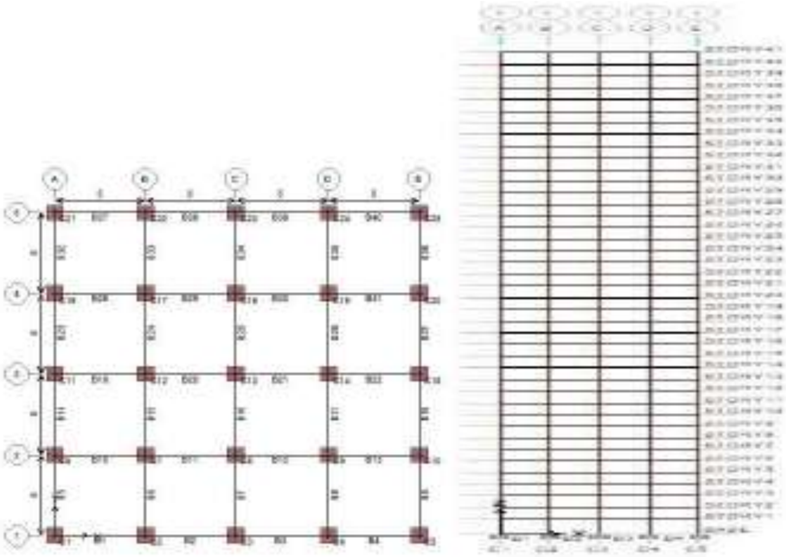


**Figure-1:** Model 1 Symmetrical Building (Plan & Elevation)

**Model type 1**: 5 m X 5 m, G+41, at 0, 10, 20, and 30 percent of eccentricity level with p delta and without p delta is evaluated using ETABS analysis software, and compared with seismic zone 4 with earthquake loading in X direction.

**Table-1:** Displacement for Static Case along X Direction

| Comparison of EQX with p delta | | | | |
|---|---|---|---|---|
| Story | eqx0 | eqx10 | eqx20 | eqx30 |
| STORY40 | 190.1784 | 215.1094 | 240.0397 | 264.9696 |
| STORY35 | 176.9113 | 200.7886 | 224.6652 | 248.5416 |
| STORY30 | 157.7328 | 179.5496 | 201.3657 | 223.1815 |
| STORY25 | 133.9044 | 152.8549 | 171.8048 | 190.7545 |
| STORY20 | 106.8846 | 122.3754 | 137.8657 | 153.3556 |
| STORY15 | 78.0449 | 89.6649 | 101.2844 | 112.9037 |
| STORY10 | 48.6479 | 56.137 | 63.6258 | 71.1144 |
| STORY5 | 20.1351 | 23.3874 | 26.6395 | 29.8915 |
| STORY1 | 1.9376 | 2.2723 | 2.6069 | 2.9416 |

For symmetrical building in zone 4 the equivalent static case with P-delta along EQX direction table -1 gives a clear explanation regarding the maximum displacement along various storey levels with improving its eccentricity levels up to 30 percent.


**Figure-2:** Displacement for static case along x direction with p-delta.

In the Table-1 and Figure-2, the maximum displacement at 40 storey level is 190.178mm along X direction for 0 eccentricity for 10 percent of eccentricity 215.1094mm for 20 percent eccentricities 240.397mm similarly for 30- percent eccentricity 264.9696mm. Since in all the level of storey as the eccentricity increases the level of displacement also increases as shown in the Figure-1 with P-Delta.

**Table-2:** Displacement for Static Case Along X Direction Without P-Delta

| Comparison of EQX without p delta | | | | |
|---|---|---|---|---|
| Story | eqx0 | eqx10 | eqx20 | eqx30 |
| STORY40 | 157.604 | 194.0638 | 217.2544 | 240.4449 |
| STORY35 | 146.1777 | 180.6271 | 202.783 | 224.9388 |
| STORY30 | 129.6829 | 160.7359 | 180.8916 | 201.0474 |
| STORY25 | 109.4198 | 136.0219 | 153.435 | 170.8481 |
| STORY20 | 86.7847 | 108.2213 | 122.3729 | 136.5246 |
| STORY15 | 63.0155 | 78.8614 | 89.4192 | 99.9771 |
| STORY10 | 39.1759 | 49.2427 | 56.0228 | 62.8028 |
| STORY5 | 16.3322 | 20.6568 | 23.6115 | 26.5661 |
| STORY1 | 1.6187 | 2.0652 | 2.376 | 2.6867 |

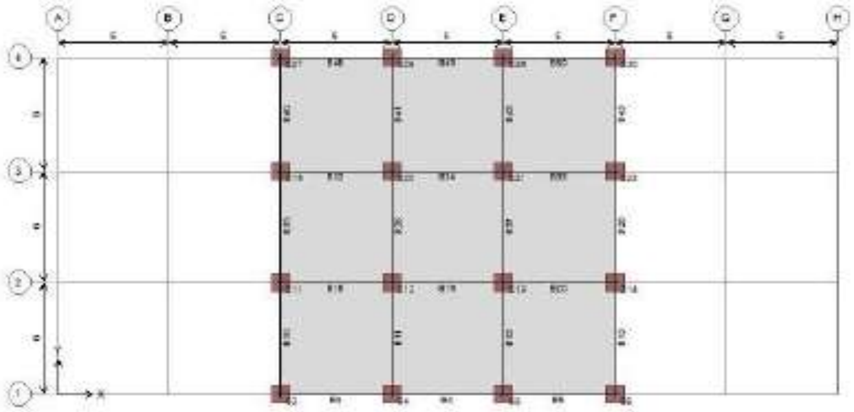
For symmetrical building in zone 4 the equivalent static case without P-delta along EQX direction Table -2 gives a clear explanation regarding the maximum displacement along various storey levels with improving its eccentricity levels up to 30 percent.


**Figure-3:** displacement for static case along x direction without p-delta

**Table -3:** Displacement for static case along X direction with p-delta.

| Comparison of EQX with p-delta | | | | |
|---|---|---|---|---|
| Story | eqx0 | eqx10 | eqx20 | eqx30 |
| STORY40 | 190.1784 | 215.1094 | 240.0397 | 264.9696 |
| STORY35 | 176.9113 | 200.7886 | 224.6652 | 248.5416 |
| STORY30 | 157.7328 | 179.5496 | 201.3657 | 223.1815 |
| STORY25 | 133.9044 | 152.8549 | 171.8048 | 190.7545 |
| STORY20 | 106.8846 | 122.3754 | 137.8657 | 153.3556 |
| STORY15 | 78.0449 | 89.6649 | 101.2844 | 112.9037 |
| STORY10 | 48.6479 | 56.137 | 63.6258 | 71.1144 |
| STORY5 | 20.1351 | 23.3874 | 26.6395 | 29.8915 |
| STORY1 | 1.9376 | 2.2723 | 2.6069 | 2.9416 |

**Asymmetric building** the plan irregular building structure consists of 8X4 bays. Dimensions of plan area 42m X 18m



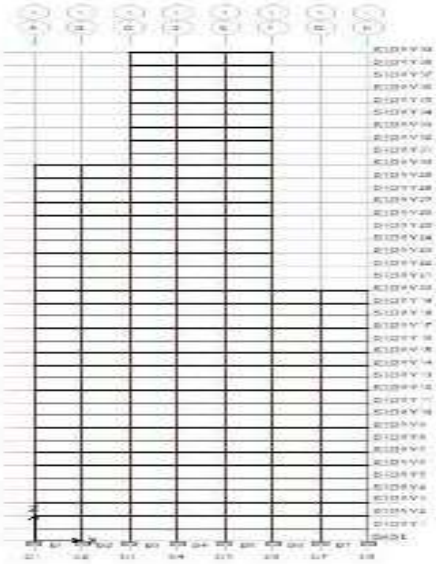


**Figure-4:** model 2 asymmetrical building (plan & elevation)

**Model type 2**: 8 m X 4 m, G+40, at 0, 10, 20, and 30 percent of eccentricity level with p delta and without p delta is evaluated using ETABS analysis software, and compared with seismic zone 4 with earthquake loading in X direction.

**Table-3:** displacement for static case along x direction with p-delta

| Comparison of EQX with p delta | | | | |
|---|---|---|---|---|
| Story | eqx0 | eqx10 | eqx20 | eqx30 |
| STORY40 | 226.12 | 244.93 | 277.67 | 297.7 |
| STORY35 | 212.97 | 230.43 | 257.33 | 275.55 |
| STORY30 | 187.45 | 201.89 | 222.03 | 236.87 |
| STORY25 | 158.59 | 170.34 | 185.79 | 197.78 |
| STORY20 | 124.92 | 133.64 | 144.66 | 153.52 |
| STORY15 | 93.671 | 100.2 | 108.22 | 114.83 |
| STORY10 | 59.768 | 63.929 | 68.968 | 73.182 |
| STORY5 | 24.58 | 26.291 | 28.345 | 30.076 |
| STORY1 | 1.789 | 1.9132 | 2.0621 | 2.1878 |

In the Table-3 and Figure-3, the maximum displacement at 40 storey level is mm along X direction, for 0 eccentricity 226.12mm for 10 percent of eccentricity 244.93mm for 20 percent eccentricities 277.67mm similarly for 30- percent eccentricity 297.7mm. Since in all the level of storey as the eccentricity increases the level of displacement also increases as shown in with P-Delta.

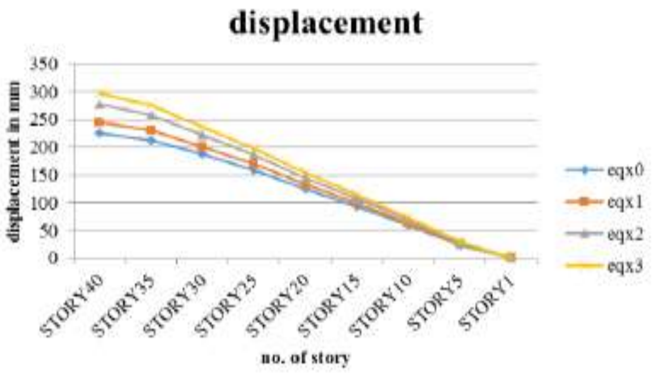



**Figure-5:** Displacement for Static Case Along X Direction With P-Delta

**Table-4:** Displacement for Static Case Along X Direction Without P-Delta

| Comparison of EQX with p delta | | | | |
|---|---|---|---|---|
| Story | eqx0 | eqx10 | eqx20 | eqx30 |
| STORY40 | 221.74 | 240.88 | 260.02 | 279.16 |
| STORY35 | 205.48 | 222.84 | 240.2 | 257.56 |
| STORY30 | 177.98 | 192.03 | 206.08 | 220.13 |
| STORY25 | 148.86 | 160.16 | 171.46 | 182.76 |
| STORY20 | 116.02 | 124.32 | 132.62 | 140.93 |
| STORY15 | 86.221 | 92.378 | 98.535 | 104.69 |
| STORY10 | 54.656 | 58.557 | 62.457 | 66.358 |
| STORY5 | 22.532 | 24.136 | 25.739 | 27.343 |
| STORY1 | 1.6787 | 1.7972 | 1.9158 | 2.0343 |

In the Table-4 and Figure-5, the maximum displacement at 40 storey level is mm along X direction, for 0 eccentricity 226.12 .for 10 percent of eccentricity 244.93mm for 20 percent eccentricities 277.67mm similarly for 30-percent eccentricity 297.7mm. Since in all the level of storey as the eccentricity increases the level of displacement also increases as shown in with P-Delta.


**Figure-6:** Displacement for Static Case Along X Direction Without P-Delta.

## VII. Conclusions

1. In the elastic static analyses, impact of P-Delta dependably increased, as number of stories of structures or their eccentricity will increase.
2. In the dynamic analyses, the impacts of P-Delta becomes more reduce the response. The reason is to execute P-Delta analyses in implementing change in stiffness matrix of building, consequently the normal periods and other dynamic properties of the building will change. On the other hand acceleration comparing to the new natural time of building, response spectrum of the earthquake, is not as much as increasing speed reaction relating to the first normal period, then decrease in building reactions for the case were P-Delta can be normal.
3. "Effect of different eccentricities of building due to tall structures" basically relies on upon the type of horizontal Load resisting system of building. The outcomes show that the kind of horizontal load resisting system assumes a vital part in degree that torsion changes the P-Delta effects. It is reasoned that the qualities of lateral load resisting framework has significantly more significance stand up in comparison with the number of stories in building.
4. It is seen that the impacts of P-Delta is quite sensitive to ground movement, for example, the frequency content of quake. The affectability is still vital however not exactly the dynamic cases. All in all, the affectability to ground motion increases, as the eccentricity increases.
5. In flexible or inelastic dynamic analyses, increase in eccentricity causes change in the impact of P-Delta. The change is essential in elastic analysis and is fairly less critical in inelastic analysis. Then again, the variation does not have a constant expanding or decreasing pattern. One of the reasons is the way that with expansion in the eccentricity, the mass moment of inertia has not expanded in all cases.
6. From the above results it can be reasoned that the impact of "P-Delta" analyses is discovered higher in static and dynamic analyses and the impact of "P-Delta" analyses is much higher when the plan of building is asymmetric with respect to symmetric building.

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