ANALYSIS OF P-DELTA EFFECT ON HIGH RISE BUILDING

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Abstract: P-delta effect is secondary or second order effect on structure. It is also known as ‗Geometric Nonlinearity effect'. As number of storey increases, P-delta effect becomes more important. If the change in bending moments, shear forces and displacements is more than 10%, P-delta effect should be considered in design. In this study the P-delta effect on high rise building is studied. Linear static analysis (without P-delta effect) and nonlinear static analysis (with P-delta effect) on high rise buildings having different number of storey is carried out. For the analysis G+19, G+24, G+29 (i.e. 20, 25, 30 storey) R.C.C. framed buildings are modeled. Earthquake load is applied on model of structure as per IS-1893(2002) for zone IV in ETABS-2015 software. Load combinations for analysis are set as per IS-456(2000). All analysis is carried out in software ETABS-2015. Bending moment, story displacement with and without P-delta effect is calculated and compared for all models. The results show that it is essential to consider the P-delta effect for 25 storey building. So buildings having height more than or equal to 75m, should be designed considering P-delta effect. Also we can say that up to 25 storey building, it is not necessary to consider P-delta effect in design and first order analysis is sufficient for design.

Keywords: P-delta effect, high-rise building, Static nonlinear analysis, displacements, bending moments, ETABS-2015, second order effect.

1. INTRODUCTION

At present, common practice of analyzing the building or any high rise built is linear elastic method. This procedure comes under first order structure analysis, wherein displacements and internal forces are calculated with respect to un-deformed structure. Sometimes the deflection of the structure is also considered for higher order analysis based on the real-time behavior of structure. This comes when nonlinearity of the structure is taken into account. Usually, iteration method is considered that is done with the help of computer programs and is considered under second order analysis. In such process, both deformations and internal forces are not in proportionality with the applicable load.

Second-order effects are generally considered, wherein the additional displacements, moments, and forces are produced by the motion of the structure. All these effects are called "second-order effects. Many a time, people make use of first order analysis for working out the second order results. These comprise the additional moments, forces, and displacements that are crucial for the designing purpose. In the following research study, an analysis of the high rise structure is carried out by making use of some software. Many iterations are carried out in order to test the final outcomes of the study.

2. AIM AND OBJECTIVE OF STUDY

Aim

To study the impact of P-Delta effect on the high rise buildings

Objectives

- To Study the effects of axial loadings on high rise buildings.
- To study the impact of axial loading on skyscrapers.
- To analyze G+14 story building made up of RCC without or with consideration of P-delta effects.
- To work out the percentage change in deflections, forces and moments while considering with or without considering P-Delta effect.

3. ANALYSIS OF HIGH RISE BUILDINGS INETABS-2015

- Plan of building:-

1) Commercial building, RCC framed structure.

2) Storey height is 3.04m.

3) Length of building in X-direction = 12m.

4) Length of building in Y-direction = 12m.

5) Story of building= B+G+14.

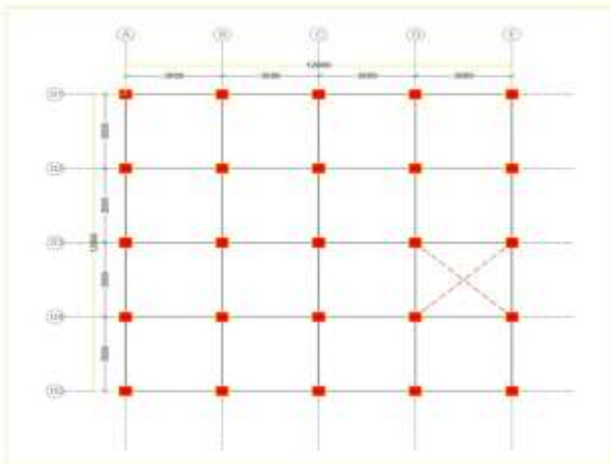

FIGURE: TYPICAL FLOOR PLAN OF BUILDING

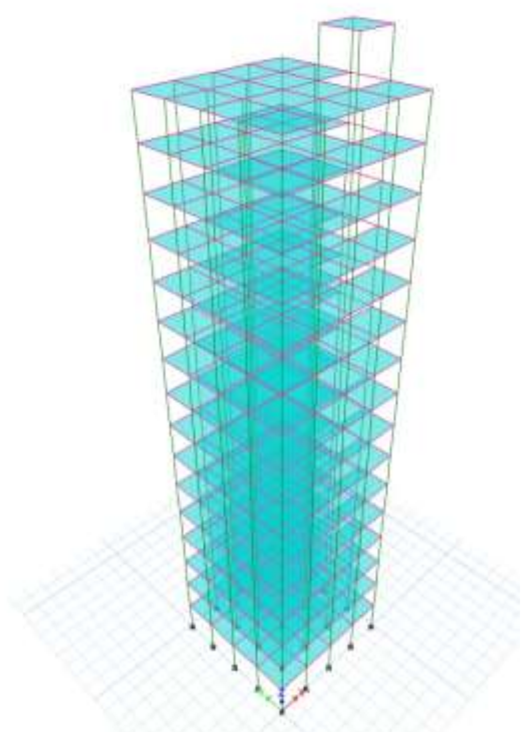

FIGURE: ETABS MODEL (3D VIEW)

❖ **Properties of the material considered in the design**

1. **Grade of Concrete: M25**

   Density of the concrete: 25 KN/m^3

   Poisson ratio: 0.2

   Young Modulus Value considered: 25000 N/mm2

2. **Steel Grade considered: Fe500**

   Density of steel: 7850 Kg/m^3

   Young Modulus Value considered: 2.1 X 105 N/mm^2

   Poisson's ratio: 0.3

3. **Masonry material type**: Brick

   Density considered= 20 KN/m^3

❖ **Section Properties:-**

1. Dimensions of Beam:0.30mX 0.45m
2. Dimensions of the Column: 0.40m X 0.40m
3. Slab: Varying section with minimum thickness of 0.15m

❖ **Loads:-**

1. **Dead load:**

A. Self weight.

B. Floor finish: 1.5 KN/m^2

C. Wall load:

Load = Height x thickness x density of masonry

For 3.04m height of wall:

For 230 mm thick wall, Load = 13.98 KN/m

For 1.2m height of wall (Parapet wall):

Load = 5 KN/m

2. **Live load:**

A. Floor = 3 KN/m^2

B. Roof = 2 KN/m^2

3. **Earthquake loads:**

According to IS-1893-2002, analysis for the seismic load acting on the structure is carried out. For designing of "horizontal seismic coefficient" Ah, the following considerations have been taken.

- EQX: X direction Earthquake load
- EQY: Y direction Earthquake load in Y-direction
- Response reduction factor = 5
- Zone factor = 0.24 (as the site is in zone IV)
- Importance factor = 1
- Soil type = Type II

4. **Wind loads:**

Calculation of Wind load according to IS 875 (Part3)

Design wind speed (Vz) can be calculated based on the formula given below

"Vz = Vb×K1×K2×K3"

Wherein, Vbis the basic design wind speed

K1, K2, K3 can be taken from IS: 875 (part3)

Pzis the Design wind pressure

"Pz = 0.6 Vz2"

- "Risk Coefficient (k1 Factor) : 1"
- "Terrain Category: 3"
- "Wind Speed: 47 m/s"
- "Topography (k3 factor): 1"
- "Structure Class: B"

❖ **LOAD CASES:-**

As per IS-456(2000) in which both gravity and lateral loads are included.

1) 1.2 (DL + LL + EQX)"
2) "1.2 (DL + LL – EQX)"
3) "1.2 (DL + LL + EQY)"
4) "1.2 (DL + LL -EQY)"
5) "1.5(DL + EQX)"
6) "1.5(DL - EQX)"
7) "1.5(DL + EQY)"
8) "1.5(DL - EQY)"
9) "0.9DL + 1.5EQX"
10) "0.9DL - 1.5EQX"
11) "0.9DL + 1.5EQY"
12) "0.9DL - 1.5EQY"

4. ANALYSIS RESULTS

❖ **Table for Story displacement at each story**

WITH P-DELTA EFFECT		
Story Displacement		
Story	x direction	y direction
Footing to Basement	7.12	5.44
Footing to GF Roof	17.59	13.44
Footing to 1F Roof	28.08	21.46
Footing to 2F Roof	38.13	29.14
Footing to 3F Roof	47.66	36.44
Footing to 4F Roof	56.74	43.36
Footing to 5F Roof	65.29	49.9
Footing to 6F Roof	73.33	56.04
Footing to 7F Roof	80.81	61.76
Footing to 8F Roof	87.71	67.03
Footing to 9F Roof	93.99	71.82
Footing to 10F Roof	99.61	76.12
Footing to 11F Roof	104.52	79.88
Footing to 12F Roof	108.66	83.04
Footing to 13F Roof	111.94	85.56
Footing to 14F Roof	114.33	87.39

❖ **Table for Story displacement at each story**

WITHOUT P-DELTA EFFECT		
Story Displacement		
Story	x direction	y direction
Footing to Basement	6.68	5.09
Footing to GF Roof	16.32	12.43
Footing to 1F Roof	25.97	19.79
Footing to 2F Roof	35.28	26.88
Footing to 3F Roof	44.19	33.67
Footing to 4F Roof	52.7	40.16
Footing to 5F Roof	60.8	46.33
Footing to 6F Roof	68.47	52.18
Footing to 7F Roof	75.68	57.67
Footing to 8F Roof	82.38	62.78
Footing to 9F Roof	88.53	67.46
Footing to 10F Roof	94.08	71.7
Footing to 11F Roof	98.97	75.43
Footing to 12F Roof	103.12	78.6
Footing to 13F Roof	106.41	81.12
Footing to 14F Roof	108.8	82.95

❖ **PERCENTAGE OF DIFFRENCE OF DISPLACMENT**

PERCENTAGE DIFFRENCE OF DISPLACMENT		
STORY	X-Dir.	Y-Dir.
Footing to Basement	6.18	6.43
Footing to GF Roof	7.22	7.51
Footing to 1F Roof	7.51	7.78
Footing to 2F Roof	7.47	7.76
Footing to 3F Roof	7.28	7.60
Footing to 4F Roof	7.12	7.38
Footing to 5F Roof	6.88	7.15
Footing to 6F Roof	6.63	6.89
Footing to 7F Roof	6.35	6.62
Footing to 8F Roof	6.08	6.34
Footing to 9F Roof	5.81	6.07
Footing to 10F Roof	5.55	5.81
Footing to 11F Roof	5.31	5.57
Footing to 12F Roof	5.10	5.35
Footing to 13F Roof	4.94	5.19
Footing to 14F Roof	4.84	5.08

5. CONCLUSIONS

This chapter presents the major conclusions and future scope of the p-delta effects on High Rise RC building.

In this chapter, the major points and finding of the study has been highlighted. In addition to this, the future scope of the p-delta on high-rise structure has been shown.

1. From the result of ETABS, it is very much clear that axial force increases with increase in number of storey.
2. Displacements of the buildings w.r.t. earthquake load considering P-delta effects are larger while comparing with the earthquake load.
3. It was found that the displacement value of storeys is within the permissible limit.
4. This concludes P-delta effects have more effect in designing of a structure rather than linear order effects.
5. The P-Delta effects have more importance in the designing process as compared to linear order effects.
6. With the increase in number of floors, the significance of P-delta impact also increases.
7. It is quite important to compare the result of the analysis with or without considering the p-delta impact.
8. The results are valid for all the regions and seismic zones of India.

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