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P-Delta Analysis of Multi-Storey Building Using ETABS Software

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***Abstract* - P-Delta is a non-linear effect that occurs in every structure where elements are subject to axial load. Due to little knowledge of P-Delta and complexity of analysis, architectures and structural engineers are tempted to perform linear static analysis, which may cause sudden collapse of the structure. To study these effects on multistorey building we are adding shear wall in the structure. With the help of shear wall what are parameter changes in structure we will check. For this topic we made model in ETAB of having shear wall and without shear wall. The objective of this work is to find out the effect of P-Delta analysis (Second-order effects) upon the responses of the structures such as displacement, bending moment, shear forces against the linear static analysis. Also, to study the uses of shear wall in reducing the P-Delta effect.**

Keywords: P-Delta, Shear wall, Displacement, Storey drift, ETAB, Base shear.

I. INTRODUCTION

The first order analysis is used to analyze buildings using linear elastic methods. In a first order analysis displacements and internal force are calculated in relation to the geometric undeformed structure. It does not consider buckling and material yielding. In the case of first order elastic analysis, the structure's deflection is not assessed by the first order linear analysis. This kind of geometric non-linearity can be examined by iterative procedures, which can only be carried out with the aid of computer programs. It is generally known as second order analysis. In this type of analysis, the deformations and internal forces are not proportional to the applied loads.

1.1 First Order Analysis

The equilibrium is defined in terms of the geometry of the unreformed structure in conventional first order analysis. Here, it is assumed that every property of the material is constant. The relationship between displacement and an external force is proportionate in the case of a linearly elastic structure. In additional, the material's relationship between stress and strain is linear. This technique so excludes non-linearity by definition, yet it generally accurately captures service demand circumstances

1.2 Linear Static Analysis (LSA)

Responses to the building are time-independent in linear static analysis. We may examine the minor deflections, bending moments, and shear forces for the applied load on the structure in this analysis.

1.3 Equivalent Static Method

In equivalent static method seismic analysis of most structures is carried out on the assumption that the lateral (horizontal) force is similar to the actual (dynamic) loading. In this method we have to make less effort because, we don't need to calculate the fundamental period, and shapes of higher natural modes of vibration are not required. The acceleration coefficient and lump mass of the structure are multiplied to determine the base shear, which is the entire horizontal mass of the structure.

Calculating fundamental time intervals and creating forms is also necessary. We can calculate the overturning moment, displacement, torsion, bending moment, and shear forces. The base shear can be dispersed along the member, and the total distributed forces cannot increase the base shear. In order to save time, we now use computational programs to determine the fundamental time period and base shear.

1.4 Second Order Analysis

The additional displacements, forces, and moments created by utilizing operations on a deflecting structure can often be used to explain second order effects. The term "second-order effects" refers to them. In certain circumstances, a first-order analysis may be used to gauge the impacts of a second-order analysis via method that is appropriate for computer- based elastic frame analysis. Additional deflections, moments, and forces beyond those predicted by first-order analysis are introduced by second order effects. The design should take this into account. The "Beam-Column" component, which is subjected to both

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bending and axial compression, is where the problem primarily manifests itself.

II. P-DELTA EFFECT

P-Delta is a geometrical non-linearity and it give the additional shear forces and bending moment to the structure due to the applied force P, whereas P is the load and delta is a lateral deformation. Actually, P-Delta is just one of several second-order effects. It is a real effect that is connected to a displacement (delta) and the size of the applied axial load (P). The analysis of a building system subjected to lateral displacements produces second-order overturning moments in P-delta effects when the structural mass is moved to a deformed position. These moments are typically ignored in static and dynamic analysis. This second- order behavior has been termed the P-delta effect since the additional overturning moments on the building are equal to the sum of storey weight "P" and the lateral displacement "Delta".

2.1 Types P-Delta effects

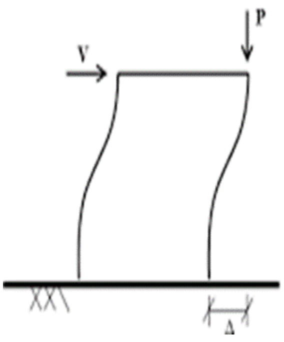

Figure 1: P-Δ Effect

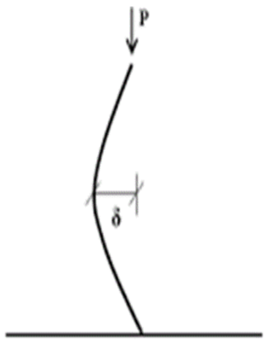

Figure 2: P-δ Effect

2.1.1 P-Δ Effect (P-Big Delta):

For instance, when a structure is subjected to wind or earthquake forces (V), the displaced structure is simultaneously subjected to vertical gravity loads (P). The total vertical load P multiplied by the structural displacement (Δ) causes secondary moments to be produced into the structure.

2.1.2 P-δ Effect (P-Small Delta):

P-δ refers to the consequences of an axial load on a single member that is deflected (curved) between its endpoints. For instance, a column that has a curvature caused by the connection circumstances of supported beams is subject to column loads (P) from gravity, wind, and/or seismic forces. Axial load P times member deflection δ cause moments to be induced in the member.

III. METHODOLOGY

3.1 General

A G+24 storey building with a 3 m storey height is analyzed using ETABS by taking into account the p-delta effect and the absence of the effect. Additionally, the models were analyzed by including shear walls with and without the p-delta effect.

3.2 Sharp edges at the Corners of building

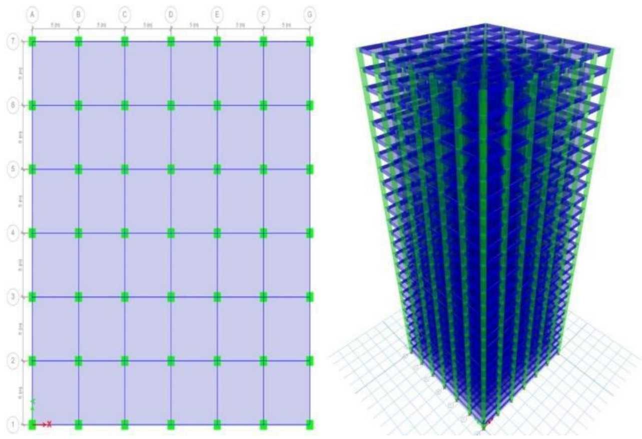

Figure 3: 2-D and 3-D View of Sharp edge at the corners of the building

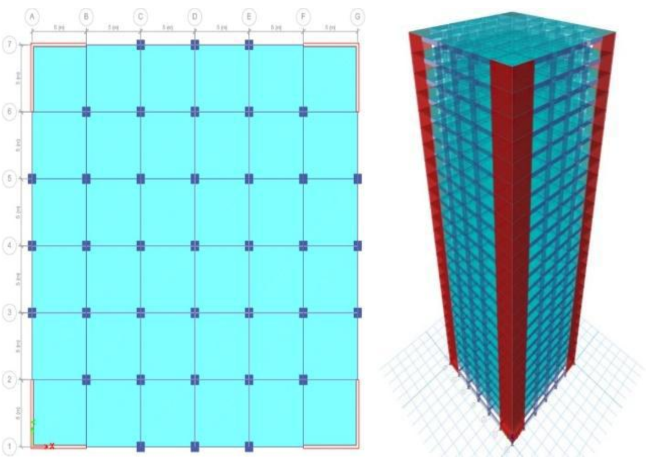

Figure 4: 2D and 3D rendered view of sharp edge at the corners of building with shear wall

IV. RESULTS

4.1 General

This chapter gives the tabulation of results of analysis. For each case of analysis results are noted. The parameters taken in this analysis includes,

1. Storey Displacement
2. Storey drift
3. Base shear
4. Overturning moments.

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LSA and P-Delta analysis also with and without shear wall models. The variation of displacement, drift, base shear and overturning moments are derived from LSA and P-Delta analysis and are plotted in graphs. The results and discussions given are considered in detail with reference figures.

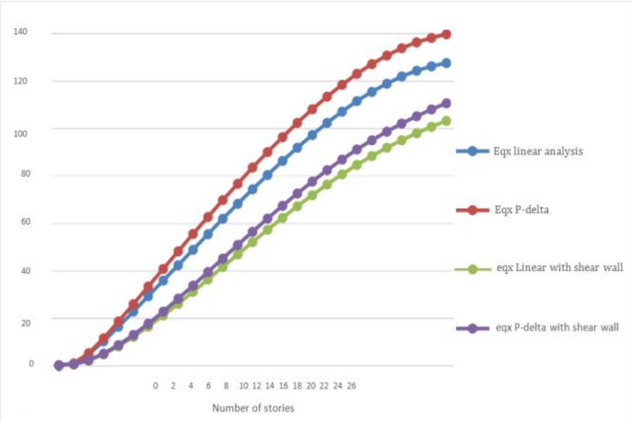

Figure 4: Storey Displacement in X-Direction

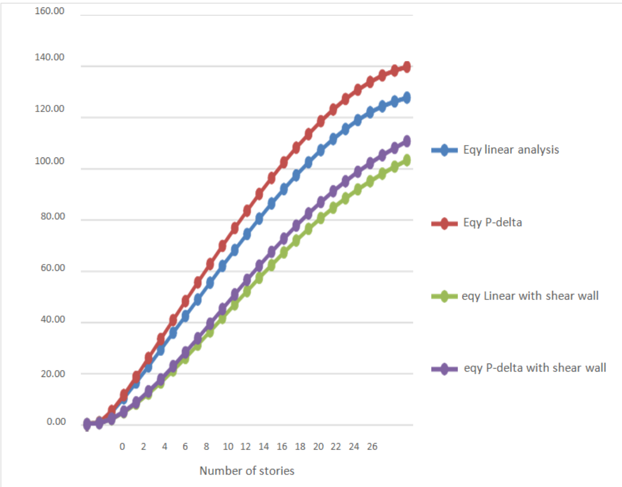

Figure 5: Storey Displacement in Y-Direction

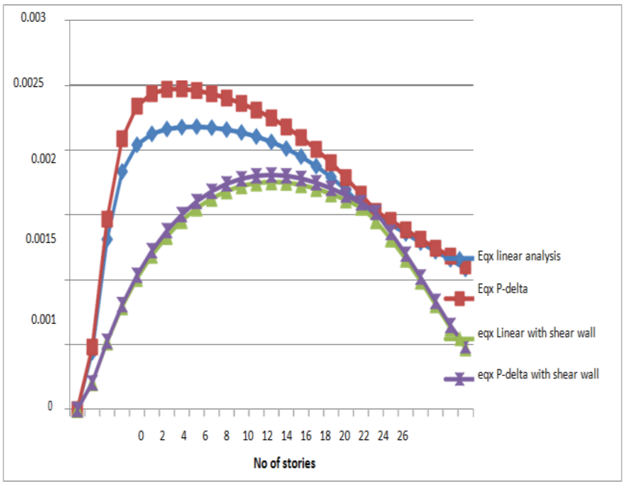

Figure 6: Storey Drift in X-Direction

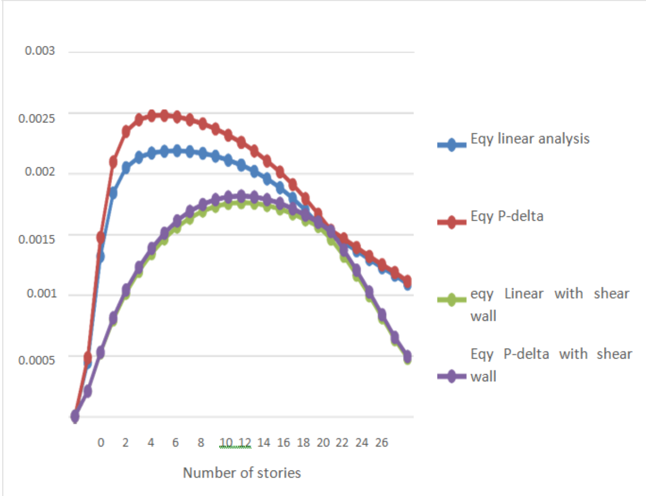

Figure 7: Storey Drift in Y-Direction

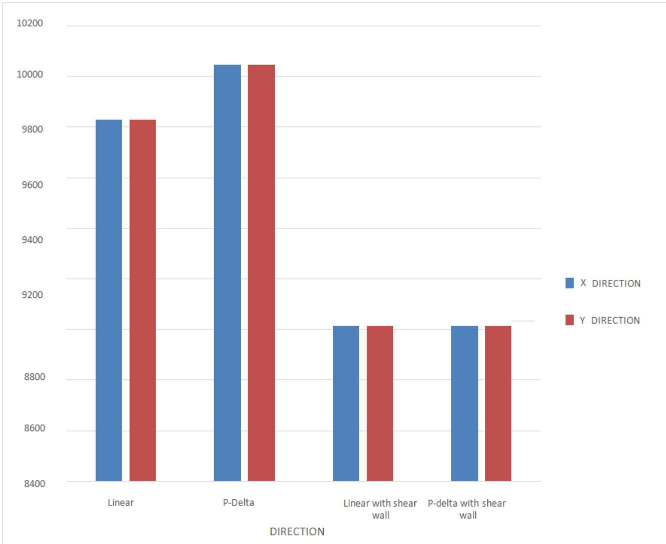

Figure 8: Base Shear in both directions

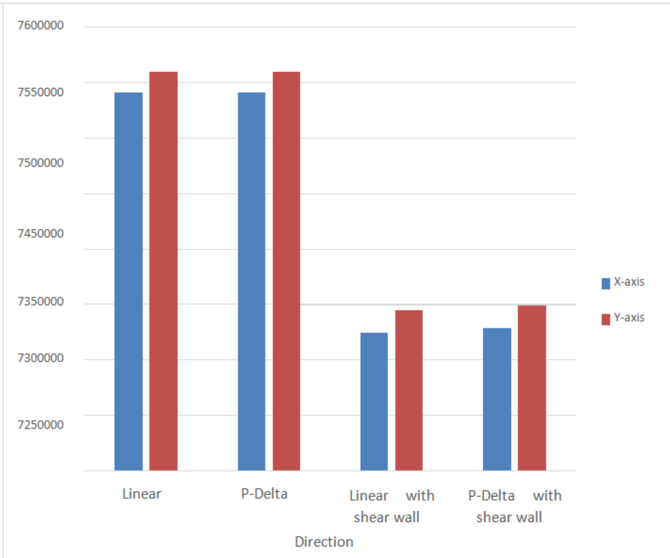

Figure 9: Overturning moment in both directions

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V. CONCLUSION

1. From the above model results it can be seen that linear static analysis consider only first order loading effect that is not realistic for tall building structures, but P-delta analysis is suitable for getting iterative action as it consider second order loading effect after the first order effects.
2. The displacement values of conventional building model (without P- Delta) are less when compared with building model with P-Delta. Obtained storey displacement values are within permissible limit.
3. Storey drift is found maximum in near about middle storey's in the structure.
4. By comparison all the cases, shear walls are highly efficient in resisting lateral loads.
5. No significant amount of variation base shear and overturning moments due to shear walls.
6. It is necessary to check the results of analysis with and without considering P-delta effect for a multistoried building.
7. P-delta effect can be seen only in high rise buildings.

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