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Performance Evaluation of High Rise Residential Building with Different Column and Floor System: A Case Study

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ABSTRACT

Reinforced concrete and steel are the materials that are mostly used in the framing systems for most of the buildings of high tensile strength and ductility while concrete members have advantages of high compressive strength and stiffness. In the present study, G+23 multistory residential building, Bengaluru, which is situated in earthquake Zone II, considered with three different column and floor systems A, B, and C. The systems are A -"Beam slab system-1," L-shaped vertical elements are defined as columns, B - "Beam slab system-2," L-shaped vertical elements are defined as walls. C - "Flat plate system," L-shaped vertical elements are defined as columns, peripheral beams are considered. There are no internal beams, so it gives esthetic appearance and more spacious than traditional beam slab system.A three-dimensional modeling and analysis of structure are carried out with the help of ETABS software. Equivalent static analysis, response spectrum method, and p-delta analysis are carried out on the multistory residential building. L-shaped columns are defined by section designer. For seismic analysis provision of IS: 1893 (Part 1) is considered. Loads are considered from Indian standards. The results are compared in terms of the story shear, story drift, and diaphragm center of mass displacement. Parametric studies are carried out by considering two interior columns, two exteriors, and two corner columns. In those columns, axial forces, moments, and major and minor bending moments are compared. Here, three types of comparison are done for the multistory residential building, namely, static verses dynamic analysis, dynamic analysis considering without P-delta effect verses with P-delta effect, and dynamic analysis considering without live load reduction verses with live load reduction. From the analysis, it is observed that relatively system-B is more flexible and system-C is stiffer.

Key words: *Equivalent static analysis, Response spectrum method, P-delta, Flat plate system.*

1. INTRODUCTION

The structure proposed for residential condominium development is of cast *in situ* concrete construction with shear walls and columns suitably placed. The core walls around lifts and shear walls are of cast *in situ* concrete to resist lateral forces.

The structural design of the proposed project is based on Indian Standard codes and is analyzed for dead, live, wind and seismic load conditions taking into relevant load combinations recommended by the codes and structural elements are designed in limit state design as per IS code.

The vertical loads including the dead and superimposed loads and the reinforced concrete core walls/shear walls, columns, and footings. Lateral loads due to wind and seismic forces are transferred to the soil through proposed.

2. BUILDING DETAILS (XENON TOWER)

2.1. Seismic Load as Per IS-1893 2002 [6]

Zone	II
Zone coefficient	0.1
Importance factor	1.0
Response reduction factor	3.0 shear wall with OMRF
Fundamental natural period (s)	Ta=0.09 h/√d
Soil type	Type II
Height considered for cal. time period	From base
Application of lateral force	From base

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2.2. Wind Load as Per IS-875 Part-III [5]

Zone	Bengaluru
Basic wind speed (Vb) m s^{-1}	33 m s^{-1}
Risk coefficient (k1)	1.0
Terrain, height and size factor (k2)	1.13
Topography factor (k3)	1.0
Design wind speed (Vz)	Vz=Vb*k1*k2*k3
Design wind pressure (Pz)	Pz=0.6*Vz2

H=80.8 m, minimum width=45.2 m, maximum width=51.5 m

2.3 Architectural Drawing

The project site is located in Amruthahalli yelhanka hobli, at Northern part of Bengaluru. This Phase of development consists of Residential towers and club house.

3. COMPARATIVE STUDY [1]

3.1. Static and Dynamic Analysis Results

Load case considered in the parametric studies:

- For static analysis: EQX in X-direction and EQY in Y-direction.
- For dynamic analysis: SPECX in X-direction and SPECY in Y-direction.

3.1.1. Story shear (Figure 2)

It is the sum of design lateral forces at all levels above the storey under consideration.[5]

3.1.2. Story drift (Figure 3)

It is the displacement of one level relative to the other level above or below.[5]

3.1.3. Diaphragm center of mass displacement

The conclusions drawn from the Figure 4 are;

- The use of response spectrum method predicts significantly more story shear in both X- and Y-direction at higher stories as compared to those predicted due to loading the structure with static method. However, at lower story's, the dynamic story shear are significantly less than the story shear of structure obtained under equivalent static force analysis
- The diaphragm center of mass displacement due to static loading in X-direction are of higher values as compared with those obtained under dynamic response spectrum loadings in X-direction. Similar results have been obtained when loading the building in Y-direction. As it is expected the higher the story levels, the higher the diaphragm center of mass displacement
- The induced story displacements in Y-direction due to static and response spectrum show significant increase in comparison with the corresponding values in X-direction. This increase in the story displacement in Y-direction comparable to X-direction is occurring due to the overall global stiffness in Y are of lower values to the overall global stiffness in X-direction.

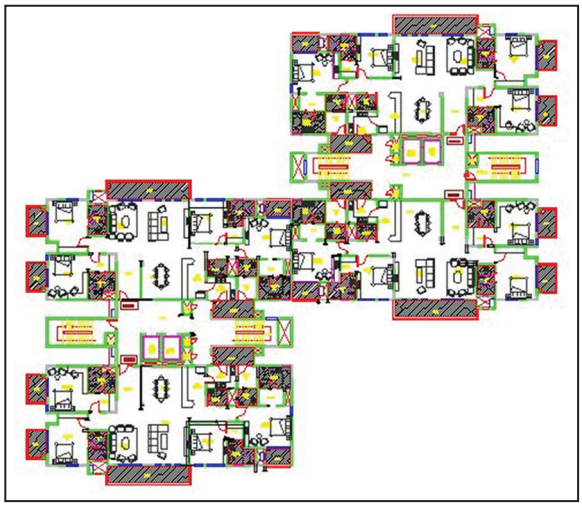
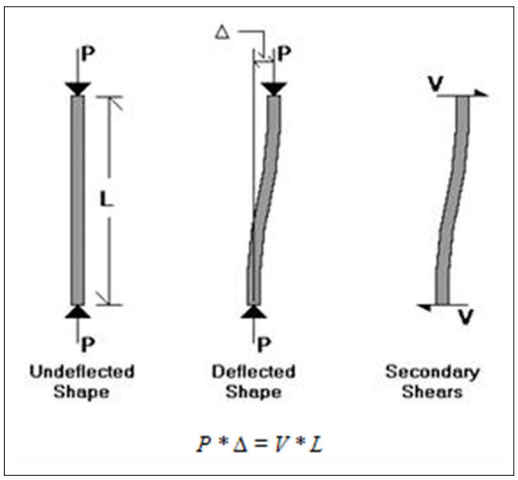


Figure 1: Architectural drawing.

4. P-DELTA ANALYSIS OF BUILDING

When a model is loaded, it deflects. The deflections in the members of the model may induce secondary moments because the ends of the member may no longer be vertical in the deflected position. These secondary effects for members can be accurately approximated through the use of P-delta analysis. Previous research showed that P-delta effects are negligible up to seven storys building [8].

This type of analysis is called "P-delta" because the magnitude of the secondary moment is equal to "P," the axial force in the member, times "delta," the distance one end of the member is offset from the other end.



P-delta effects in a structure may be controlled by increasing its stiffness, increasing its strength or by combination of these. By increasing the stiffness, structure leads to uneconomical [2].

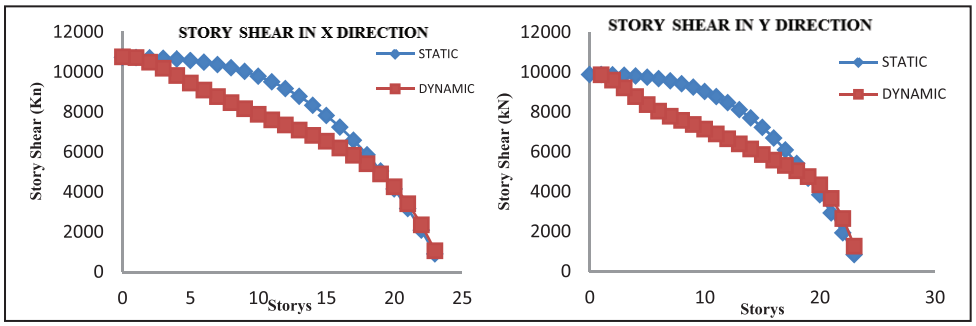


Figure 2: Story shear in X- and Y-direction in the static and dynamic analysis.

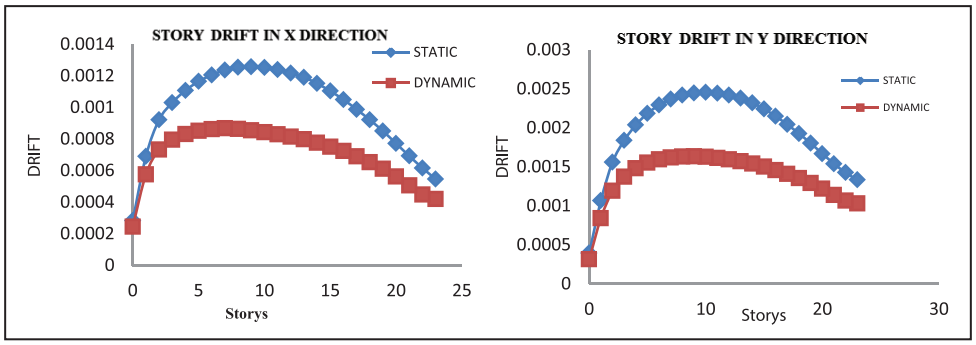


Figure 3: Story drift in X- and Y-direction in the static and dynamic analysis.

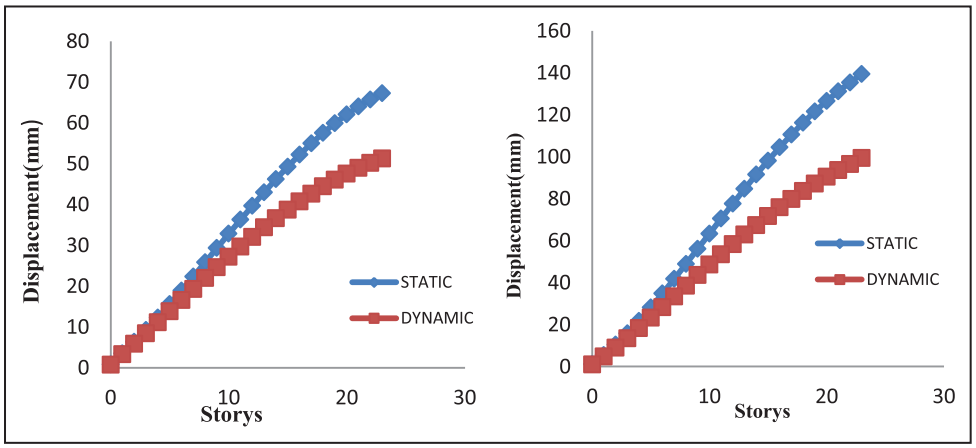


Figure 4: Centre of mass displacement in X- and Y-direction in the static and dynamic analysis.

Column considered in parameter study:

- Corner column C55 and C1
- Exterior column C2 and C59
- Interior column C39, C106 and C87 (Figures 5 and 6).

4.1. Column Forces

From comparing the column forces, we observed that there is no change in column axial forces.

Conclusion drawn from the Figures 7 and 8 are as follows:

- Axial forces obtained at each story level from P-delta analysis is almost same as that obtained from without P-delta
- Minor axis moment of columns in P-delta analysis seems to be more than that obtained in without

Figure 5: Columns considered for the parametric studies.

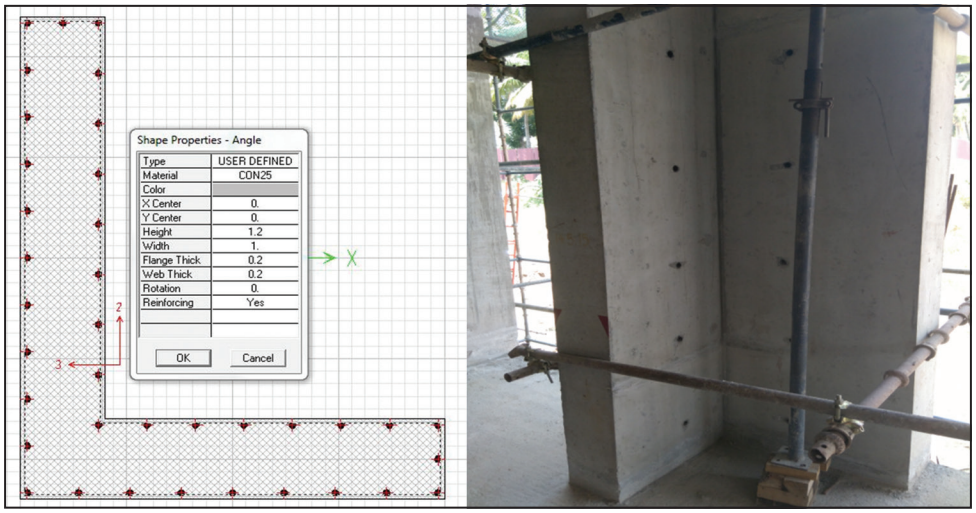


Figure 6: L-shape column.

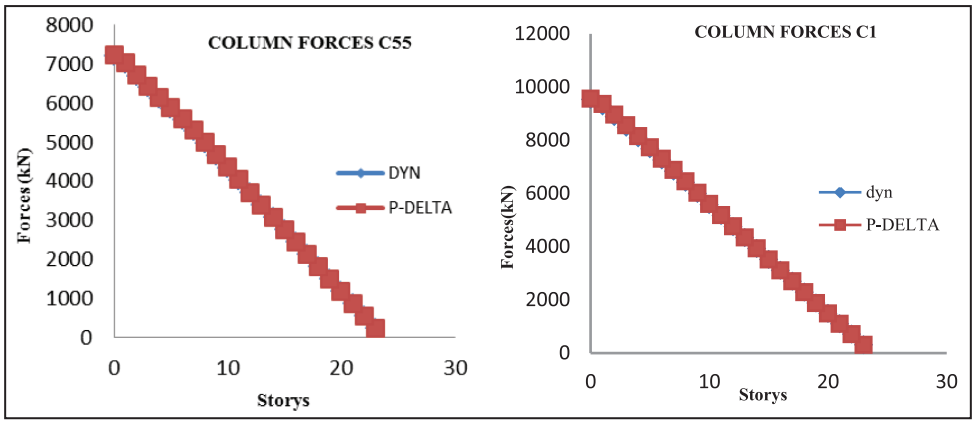


Figure 7: Column forces of C1 and C5 column in dynamic and P-delta analysis.

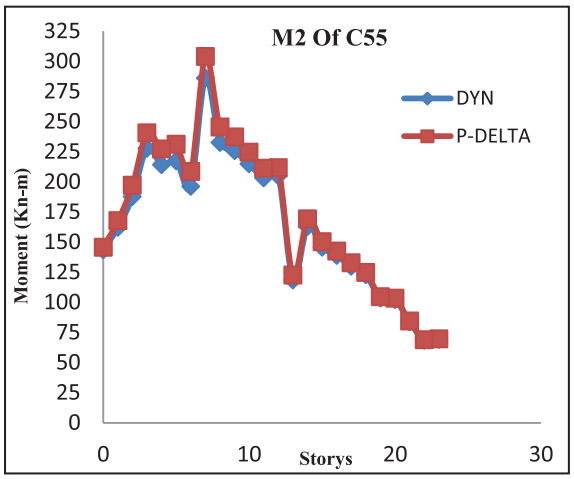


Figure 8: Minor bending moment in dynamic and P-delta analysis.

P-delta analysis

- With the increment of story height, minor axis moments of columns obtained from both P-delta analysis and without P-delta analysis coincides with each other.

5. COMPARISON BETWEEN RESULTS OF DIFFERENT SYSTEMS

Comparison of maximum displacements and story shear is done in the following section.

On this basis, we can conclude as to which method of analysis better for a residential building.

Structure is modeled in three ways:

- Model A (Flat plate system): Column with flat plate system, L-shaped vertical elements are defined as columns. Peripheral beams are considered.
- Model B (Beam slab system 1): Columns with intermediate beams, L-shaped vertical elements are defined as columns. Portion of beam is defined as flat plate.
- Model C (Beam Slab System 2): Walls with intermediate beams, L-shaped vertical elements are defined as walls.

6. COMPARISON OF RESULTS AMONG DIFFERENT SYSTEMS OF MODELING

- Base shear of Model B is higher compared with Model A and C, which indicates Model-B is more

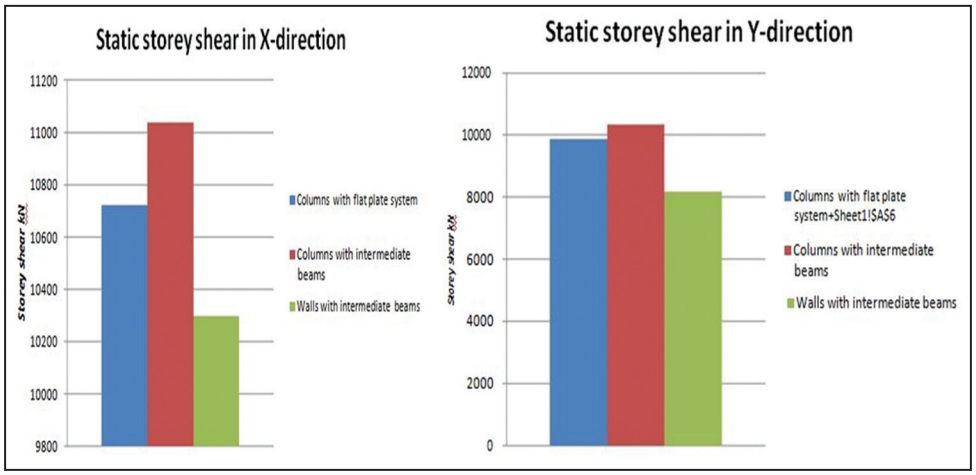


Figure 9: Comparison of static story shear in X- and Y-direction

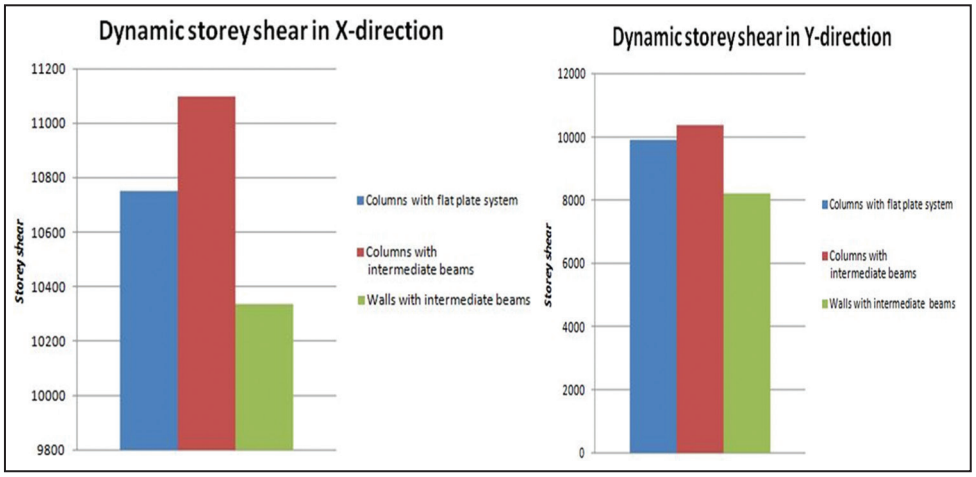


Figure 10: Comparison of dynamic story shear in X- and Y-direction.

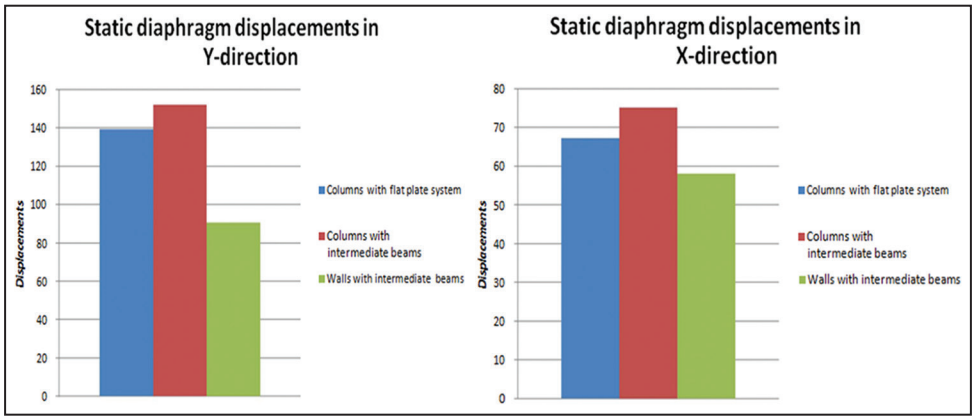


Figure 11: Comparison of static diaphragm displacement in X- and Y-direction.

flexible than Model A and C

- Displacement in Model C is less compared with Model A and B, which indicated Model C is very stiff than Model A and B
- From the comparison of live load reduction and without live load reduction, there are not much variations in the column forces as the considered structure is for residential purpose. The same would have more variation in case of commercial buildings where live load considered would be much higher
- From P-delta analysis, variations in the design forces are considerable at middle storys that at the upper and below storys.

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