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Out of Plane Offset in Multistoried Buildings: Analysis and Significance for Best Possibility Model Case

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Abstract: ***The phenomenon of out of plane offset in multistoried buildings has gained significant attention in the field of structural engineering. Out of plane offset refers to the vertical displacement or misalignment of structural components, such as walls or columns, in relation to the main vertical load-bearing elements of a building. This research paper aims to investigate the best possible strategies associated with out of plane offset in multistoried buildings. For this, total 6 possibility model cases with one additional case of 1.1 has made and all 7 cases analysed. When compared the result parameters, it has found that the possibility case 6 performs best among all and should be recommended that always use out of plane offset at top floors only.***
Keywords: Multistory Building, Seismic activities, Response spectrum method, Plan irregularities, Out of Plane offset

I. INTRODUCTION

In multistoried buildings, the columns and beams are typically designed to be perfectly vertical and horizontal, respectively. However, due to various factors such as construction tolerances, fabrication errors, and foundation settlement, these elements may deviate from their intended positions. If the deviation is small, it may not significantly affect the structural performance of the building.

However, if the deviation is significant, it can cause problems such as:

1) *Reduced Structural Strength:* Out of plane offsets can reduce the strength of columns and beams by inducing bending stresses in them.
2) *Structural Instability:* Large out of plane offsets can cause columns or beams to tilt or buckle, leading to the instability of the entire structure.
3) *Damage to Finishes:* Out of plane offsets can also cause damage to finishes such as plaster, tiles, or drywall, as they may not align properly.

To avoid these problems, it is important to carefully assess and control the out of plane offsets during the design and construction phases.

This can be achieved by:

a) *Ensuring Proper Construction Techniques:* Builders should use proper construction techniques to ensure that the columns and beams are installed as per the design specifications.
b) *Regular Quality Checks:* Regular quality checks should be conducted during the construction phase to ensure that the out of plane offsets are within acceptable limits.
c) *Providing Adequate Structural Support:* Adequate structural support should be provided to the columns and beams to ensure that they can withstand the loads they are expected to carry.

In summary, out of plane offsets can have a significant impact on the structural performance and stability of multistorey buildings. Therefore, it is important to carefully assess and control them during the design and construction phases to ensure the safety and durability of the building.

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II. PROCEDURE AND 3D MODELING OF THE STRUCTURE

Earthquake analysis is carried out on a G+10 Storey Commercial Building by using software approach. The seismic data is taken as per the IS 1893(PART1):2016. The response spectrum analysis method is adopted for analysis of building. Model descriptions and input details are mentioned below:-

Table 1: Model Description

Models	Description
Possibility 1	General Structure with out of plane offset provided at foundation level.
Possibility 1.1	General Structure with out of plane offset provided at ground floor level.
Possibility 2	General Structure with out of plane offset provided at first floor level.
Possibility 3	General Structure with out of plane offset provided at third floor level.
Possibility 4	General Structure with out of plane offset provided at fifth floor level.
Possibility 5	General Structure with out of plane offset provided at seventh floor level.
Possibility 6	General Structure with out of plane offset provided at ninth floor level.

Table 2: Input details for Commercial Building for all cases

Constraint	Assumed data for all buildings
Soil type	Actual soil data used
Seismic zone	III
Response reduction factor (ordinary shear wall with SMRF)	4
Importance factor (For all commercial building)	1.5
Damping ratio	5%
Fundamental natural period of vibration (T_a)	$0.09*h/(d)^{0.5}$ For X and Z direction = 0.8625 sec & 0.7874 sec
Plinth area of building	575 sq. m
Height of building	47.92 m
Floor to floor height	3.66 m
Depth of foundation	4 m
Beam sizes	650 mm X 550 mm
	550 mm X 350 mm
	450 mm X 300 mm
Column sizes	750 mm X 650 mm
	650 mm X 550 mm
	500 mm X 400 mm
Slab thickness	135 mm (0.135 m)
Shear wall thickness	140 mm (0.14 m)
Stair case waist slab thickness	135 mm (0.135 m)
Material properties	M 30 Concrete Fe 550 grade steel

III.RESEARCH OBJECTIVES

1) To study the various cases of Out of plane offset provided in the multi-storey building at different floor levels and comparing them by using Response Spectrum Method of dynamic analysis using Staad pro software.
2) To calculate Maximum displacement, Base Shear and Drift values and then comparing all the cases.
3) To determine maximum Axial Forces in columns at base level for various cases.
4) To study the variation of maximum Bending Moments & Shear Forces in columns of all cases for commercial building.

5) To study and compare maximum Bending Moments & Shear Forces in beams parallel to X and Z directions.
6) To evaluate maximum Torsional Moments in beams along X and Z directions.

The main and foremost objective is to determination of the best Possibility case after comparison of various result parameters that will be recommended for construction in the similar field.

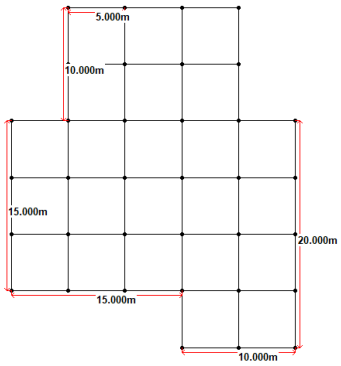


Fig. 1: Plan of all buildings

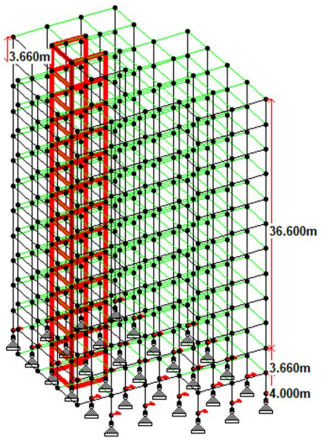


Fig. 2: 3D view of all buildings

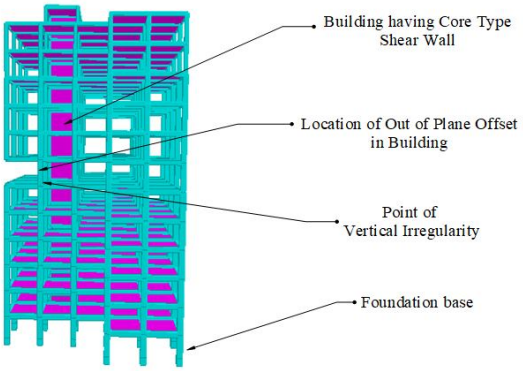


Fig. 3: Out of plane offset in multistoried building

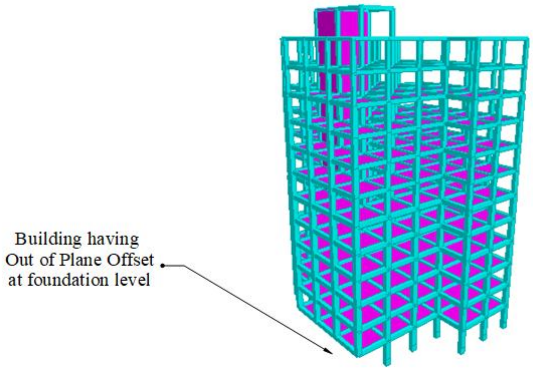


Fig. 4: Model Possibility 1 - General Structure with out of plane offset provided at foundation level

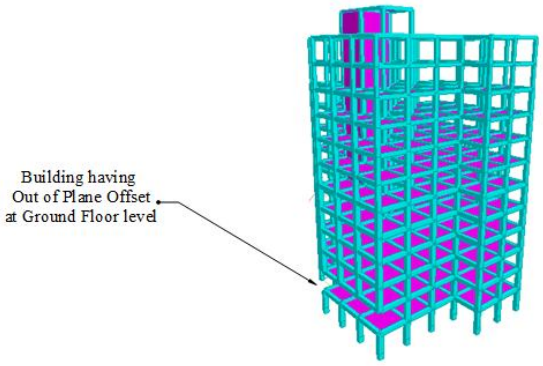


Fig. 5: Model Possibility 1.1 - General Structure with out of plane offset provided at ground floor level

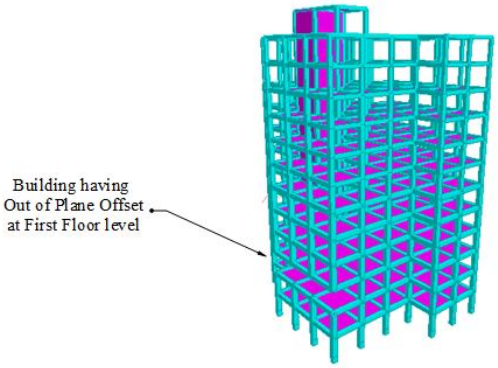


Fig. 6: Model Possibility 2 - General Structure with out of plane offset provided at first floor level

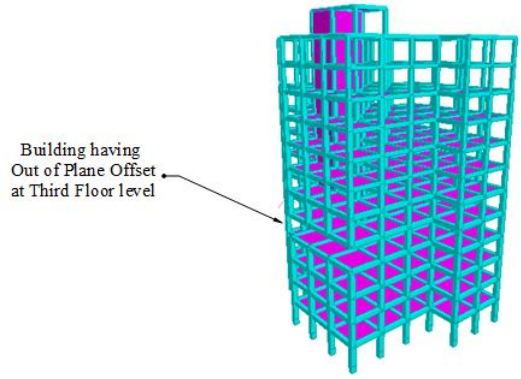


Fig. 7: Model Possibility 3 - General Structure with out of plane offset provided at third floor level

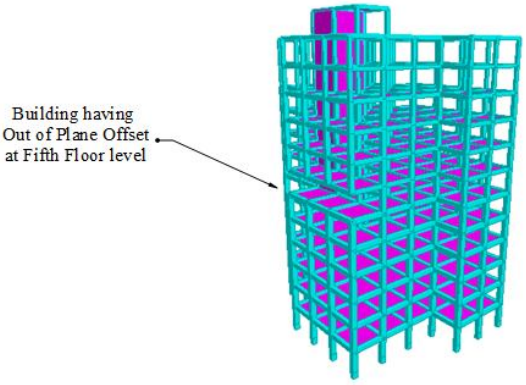


Fig. 8: Model Possibility 4 - General Structure with out of plane offset provided at fifth floor level

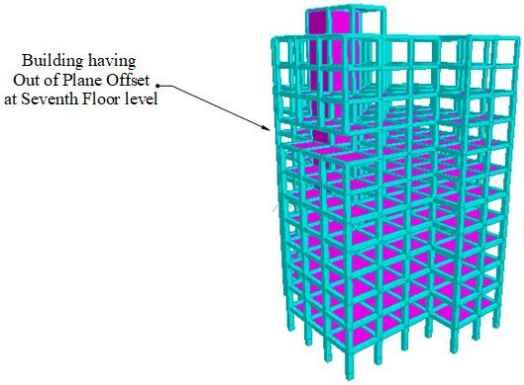


Fig. 9: Model Possibility 5 - General Structure with out of plane offset provided at seventh floor level

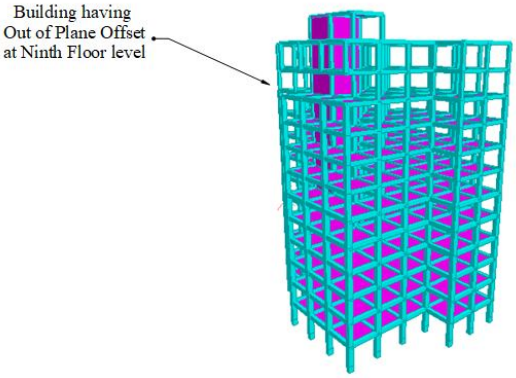


Fig. 10: Model Possibility 6 - General Structure with out of plane offset provided at ninth floor level

IV. RESULTS ANALYSIS

The application of loads and their combinations on different cases as per the Indian Standard 1893:2016 code of practice yield result parameters:-

Result of each parameter has discussed with its representation in graphical form below:-

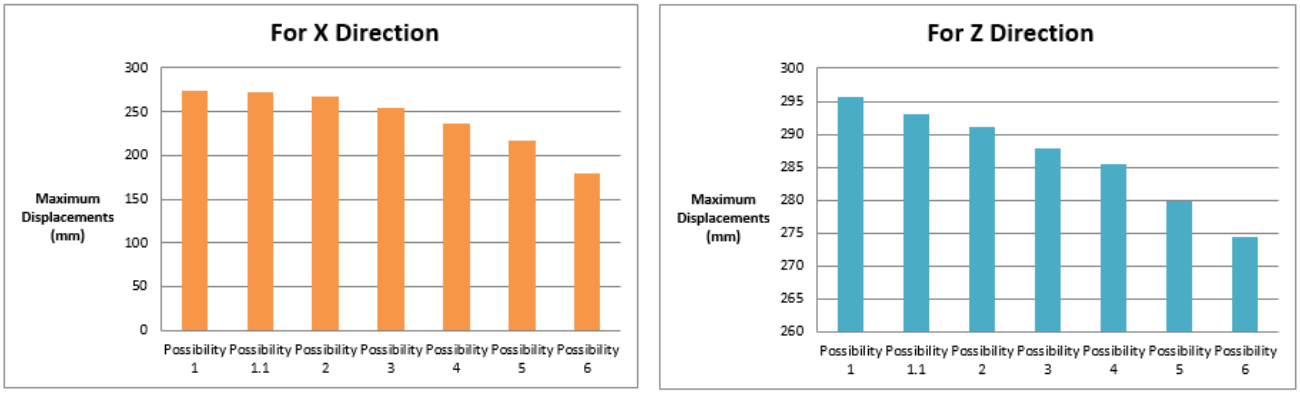


Fig. 11: Maximum displacement in X and Z directions for all possibility cases

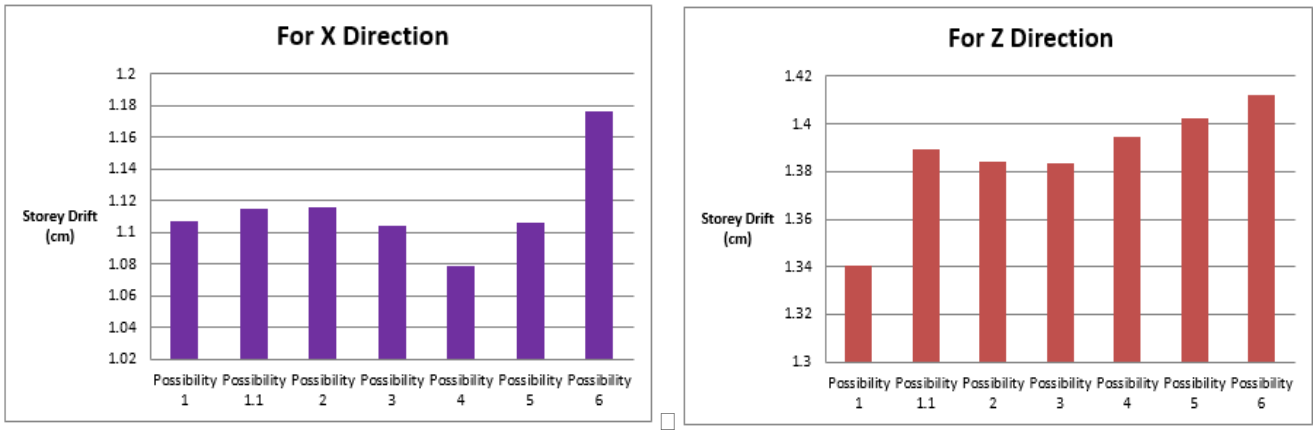


Fig. 12: Storey drift in X & Z directions for all possibility cases

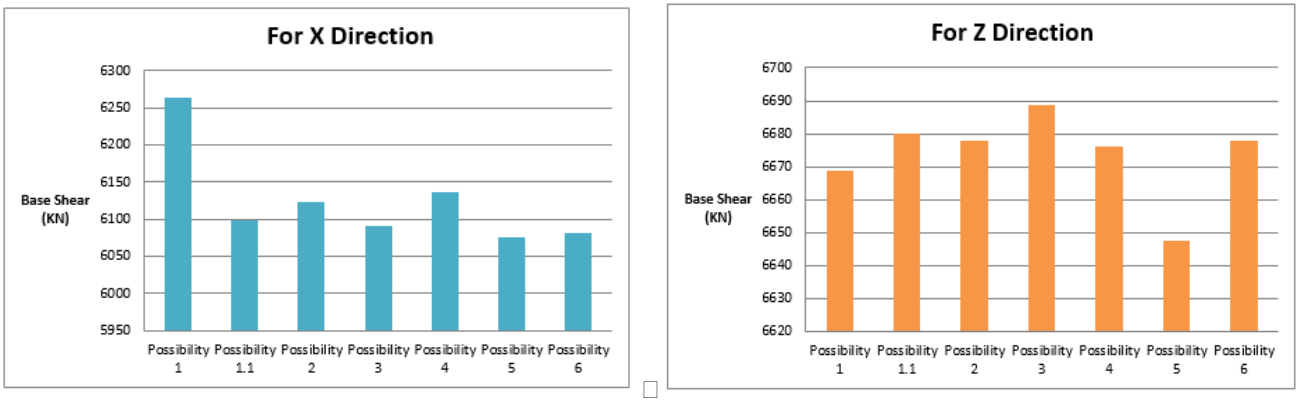


Fig. 13: Base shear in X & Z directions for all possibility cases

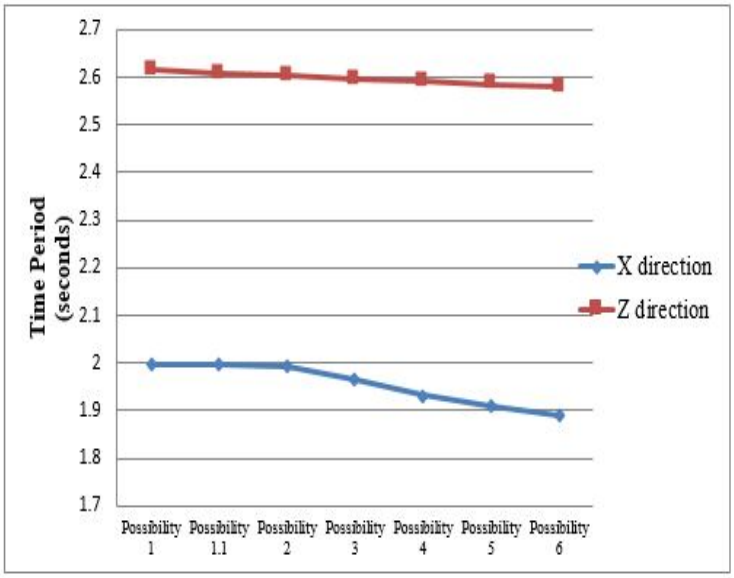


Fig. 14: Time period in X & Z directions for all possibility cases

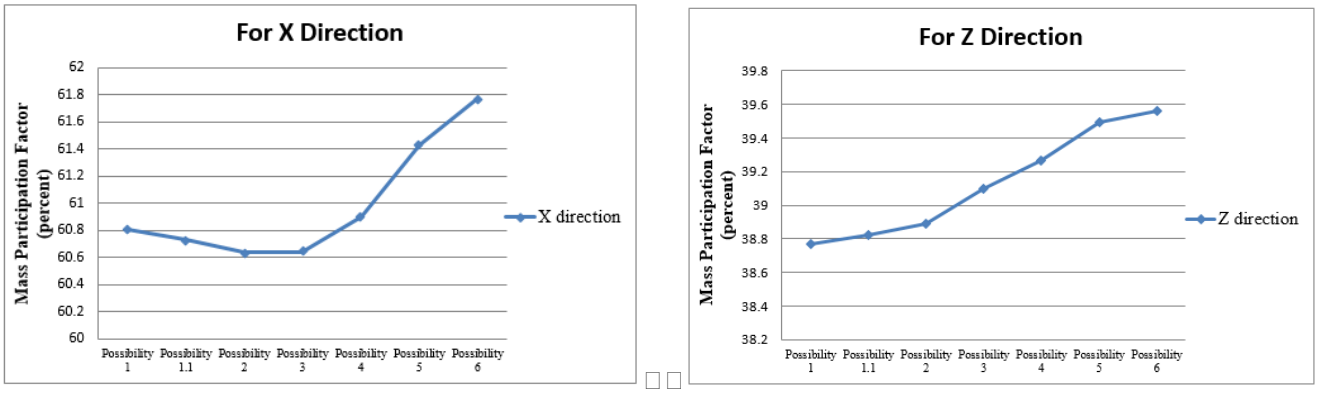


Fig. 15: Mass participation factors in X & Z directions for all possibility cases

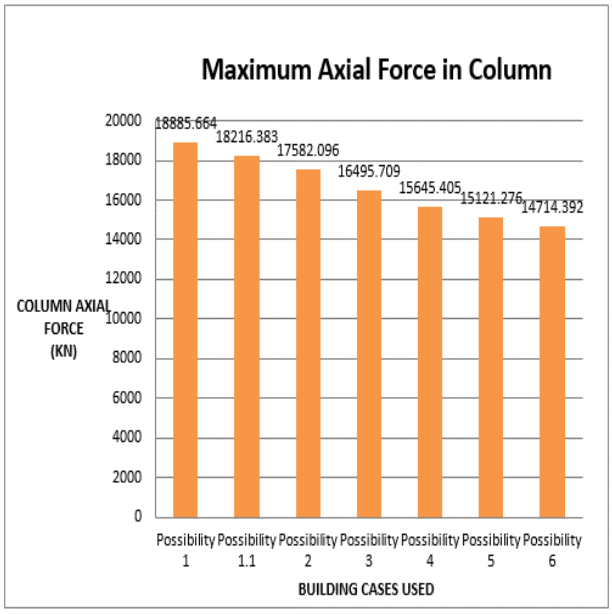


Fig. 16: Maximum axial forces in X & Z directions for all possibility cases

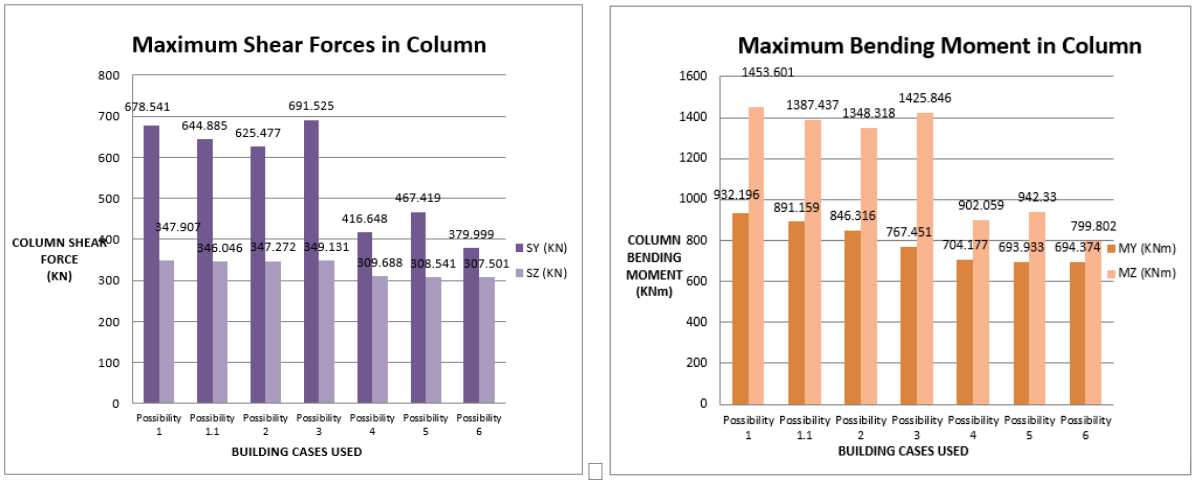


Fig. 17: Maximum shear forces and bending moment for all possibility cases

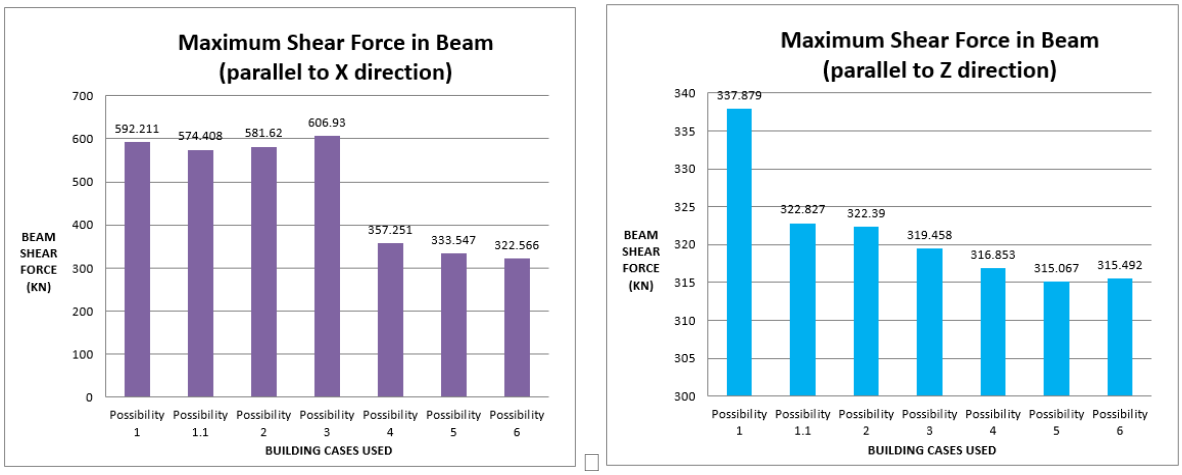


Fig. 18: Maximum shear forces in beams parallel to X and Z direction for all possibility cases

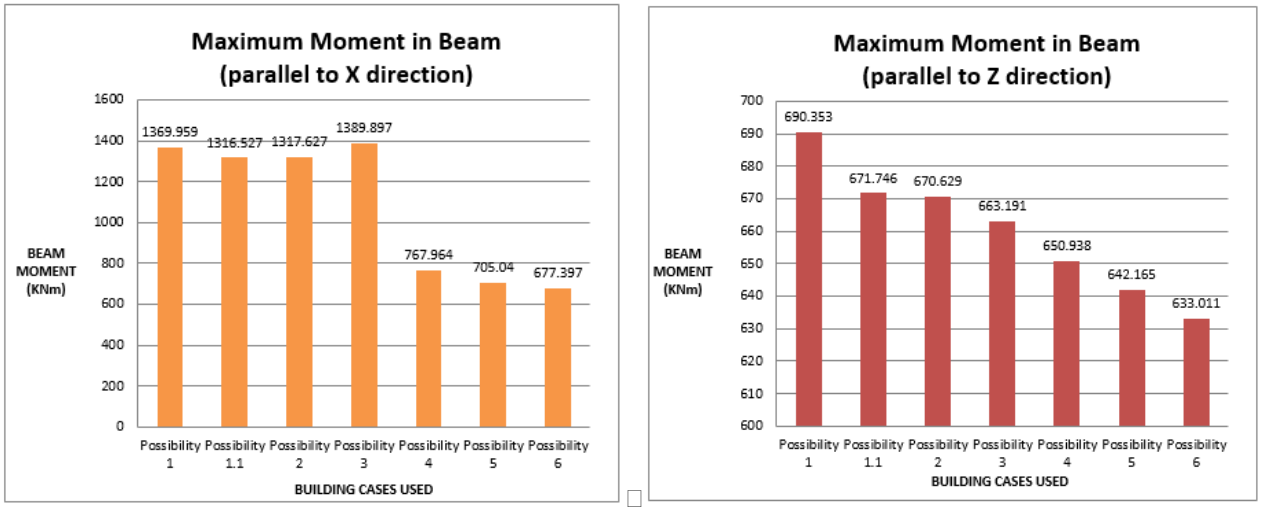


Fig. 19: Maximum bending moment in beams parallel to X and Z direction for all possibility cases

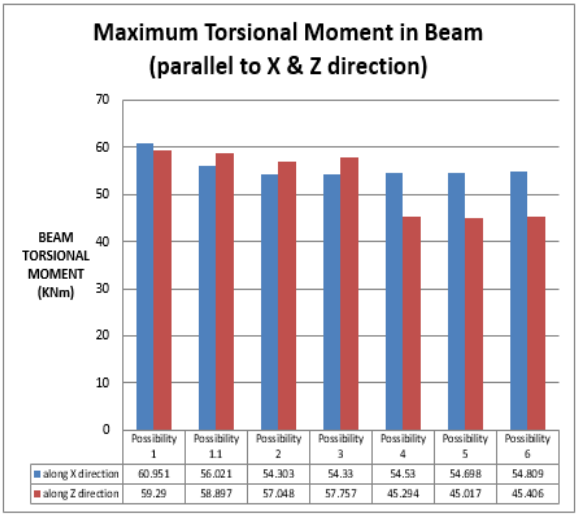


Fig. 20: Maximum torsional moment in beams along X and Z direction for all possibility cases

V. CONCLUSIONS

The conclusion can be pointed out are as follows:-

As we analyzed about seven diverse cases regarding out of plane offset in Multistory building by providing the same at various floor levels. This approach gives the variety of outcome regarding every cases in the structure. In term of mentioned cases subsequent outcome are obtained from this comparative analysis.

1) On comparing Possibility 1 to Possibility 6 models, it has been concluded that the Possibility 6 performs better in maximum displacement in X direction for all possibility cases

2) Again, on comparing Possibility 1 to Possibility 6 models, it has been concluded that the Possibility 6 performs better in maximum displacement in Z direction for all possibility cases

3) Storey drift shows lesser value in Possibility 4 model for X direction, but in Z direction, it seems to be lesser in Possibility 1 model. As per IS codal provisions, the calculation for storey drift shown below:-

For General case

The IS codal provision recommend the storey drift limitation as in any direction, it shall not exceed 0.004 times the storey height. i.e. $\frac{\mathbf{L}}{\mathbf{250}}$.

Therefore, for out of plane offset type, the IS codal provision recommend the storey drift limitation as in any direction, it shall not exceed **0.2%** i.e. **0.002** which comes out to be $\frac{\mathbf{L}}{\mathbf{500}}$ (with stories having offset and stories below)

Hence, structural provision for best case of storey drift will be out of plane offset provided upto 7.66m from foundation level.

Therefore, safe limit for drift obtained is (%) $= \frac{\text{Safe height}}{\text{Total Height}} = \frac{7.660}{47.920} \mathbf{X}\ 100 = \mathbf{15.98\%}$, i.e. Possibility 1.1 model.

4) Base shear values seems less in Possibility 5 model for both X and Z direction.

5) As when out of plane offset shifted to top floors, the time period obtained lesser value in Possibility 6 models in both directions.

6) The mass participation factor depends on the summation of total 1st three modes should not be less than 65% in each principal plan direction, if this will be exist, the building is said to have lateral storey irregularity. In this case, none of the models show such behavior. (Ref. IS 1893:2016, Table 6, vii, point a)

7) Axial forces in column seems less in Possibility 6 model on comparing.

8) On comparing maximum shear forces in column, the minimum values seems to be in Possibility 6 model and proved to be the best case.

9) Possibility 6 model verified to be the best case on comparing maximum bending moment in column, since the minimum values seems to be least.

10) On comparing maximum shear forces in beam, the minimum values seems to be in Possibility 6 model and proved to be the best case for beams parallel to X direction and Z direction respectively.

11) Again on comparing maximum moment in beam parallel to X and Z direction, again Possibility 6 model proved to be the best case with least values.

12) The torsional moment in beam parallel to X and Z direction seems to be less in possibility 6 model, when out of plane offset shifted to top floors.

This project concluded that when comparing all the result parameters, in most of the cases, Possibility 6 model obtained as best case and hence should be recommended when this type of construction procedure adopted, i.e. always use out of plane offset at top floors.

VI. ACKNOWLEDGEMENTS

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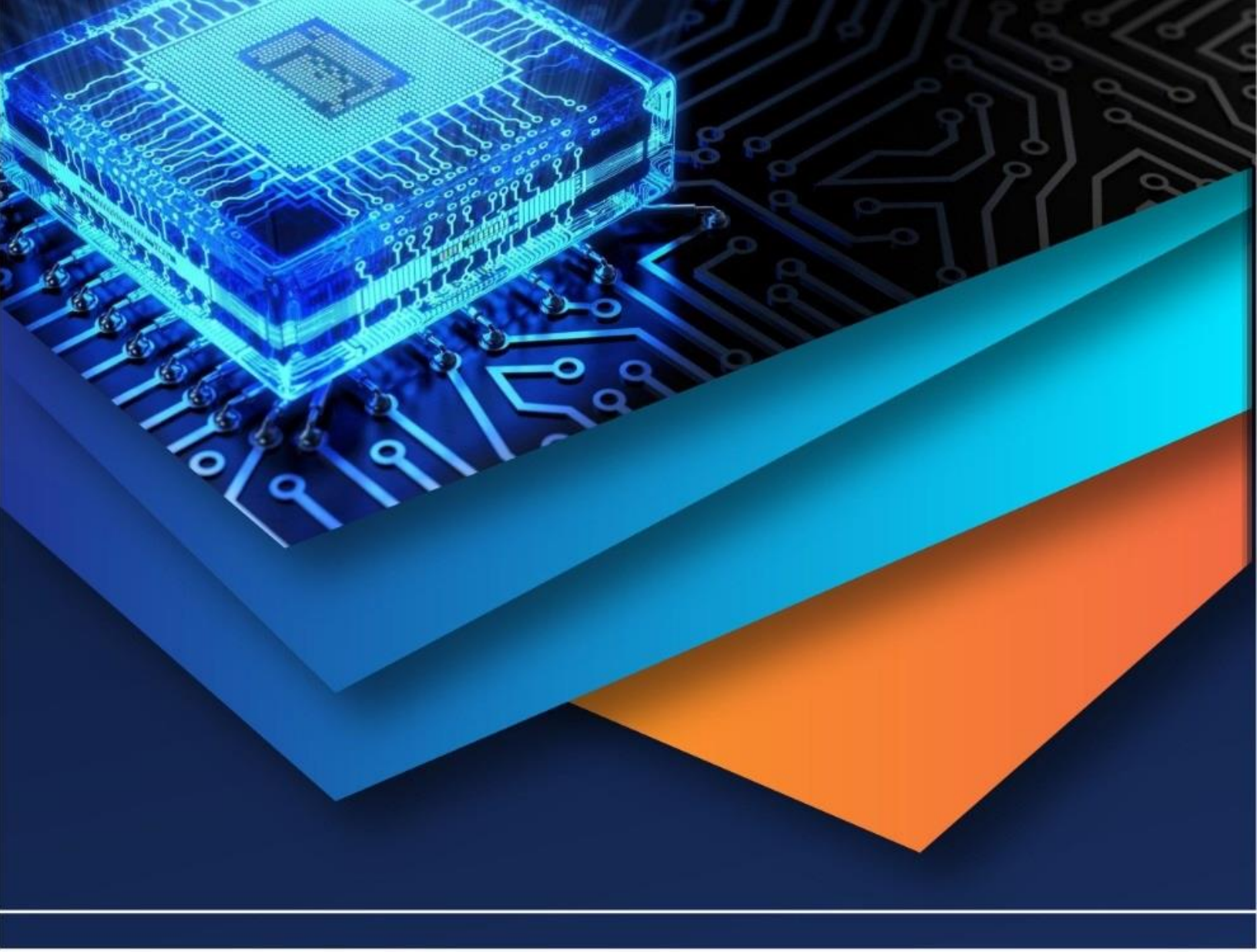
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