TORSIONAL EFFECT OF IRREGULAR FLAT SLAB STRUCTURE SUBJECTED TO WIND LOADING

SANDHYA MR[1], Dr. VIJAYA GS[2]

[1]PG Student, Dept. of civil Engineering, GSKSJTI, Bengaluru-560001, Karnataka, India
[2]Associate professor, Dept. of civil Engineering, GSKSJTI, Bengaluru-560001, Karnataka, India

---

Abstract - *During an earthquake, failure of structure starts at points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. The structures having this discontinuity are termed as Irregular structures. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. For example, structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. In the present work, a 30-storey flab slab structure is considered for the study. The Flat slab structure is provided with shear wall or core wall at various different locations. The modeling is carried out for static and dynamic analysis. The structure is considered at critical zone factor. The structures are analysed and results are extracted. From the results it is concluded that, the static analysis results show that, the displacement values higher for bare frame model and is not acceptable. However, after introducing shear wall the displacement values reduce drastically. There is a huge reduction in displacement values in comparison with bare frame flat slab structure. The percentage of 48%, 53% & 36.5% reduction in displacement for model2,3& 4 respectively. From the overall analysis, it is found that, the static analysis results are slightly higher in comparison with wind loads. The flat slab structure with shear wall fail in drift condition unless it is providing at either ends as in model 3.*

***Key Words*: Displacement, Storey drift, Equivalent static analysis (EQX, EQY), Wind analysis (WINDX, WINDY).**

1. INTRODUCTION

The residential apartments and hotels are generally constructed with re-entrant corner form in plan. Since, these structures have many advantages by providing security, community life, playground and many. From the area wise it is having advantages considering high utility. Many schools are constructed in this format for the playground, swimming pool and prayer hall positioned at the centre. Increase in the construction of high-rise structure has become trend in the last two decades. The high-rise structures are more prone to wind, seismic and snow loads. The severity of these loads causes stresses in the structure and causes deflections and vibrations in the building. In many of the high-rise structure to reduce the height and to eliminate beams, the structures are constructed using flat slab structure. However, these flat slabs are not feasible from the design point of view. Due to requirement from architects the challenges are accepted and safe designs are carried out.

2. MATERIALS AND METHODOLOGY

The present objective of this work is to study and understand the High-rise structure torsional behavior for irregular RC Flat slab structure. The structure is studied for without core wall and with core wall at different location. The structure is considered at critical Zone factor 5. The proposed model is conventional RCC structure. The model is 30 storeys with 4m each storey height. The plan is irregular C shaped structure. Modeling and analysis of structure is planned to carried out using ETABs software. The below Table1 shows material properties and design parameters used.

Sl. No.	Description	Data
1.	Seismic Zone	V
2.	Seismic Zone Factor (Z)	0.36
3.	Importance Factor (I)	1.5
4.	Response Reduction Factor (R)	5
5.	Damping Ratio	0.05
6.	Soil Type	Hard Soil (Type I)
7.	Height of the building	120m (30 Storey)
8.	Story to story Height	4.0 m
9.	Span Length	5 m each direction.
10.	Column Size used	Concrete - 450x450mm & 600x600mm
11.	Thickness of Slab	150mm with 200mm thick drop slab.
12.	Floor Finish	1.5KN/m^2
13.	Live Load	3.0KN/m^2
14.	Grade of Concrete (f_{ck})	M 25 for Beams, Slabs. M35 for Columns.
15.	Grade of Reinforcing Steel (f_{yk})	Fe 500

Table 1: MATERIAL PROPERTIES

VARIOUS MODELS – Flat slab structure

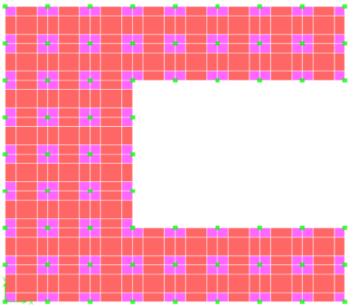

Figure 1 _Model 1_without shear wall

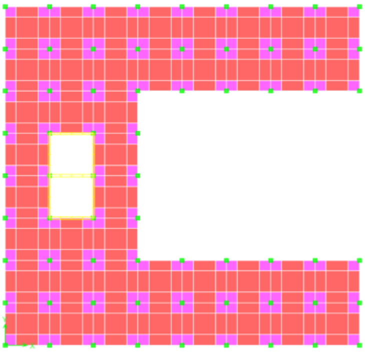

Figure 2_ Model 2_shear wall at location 1

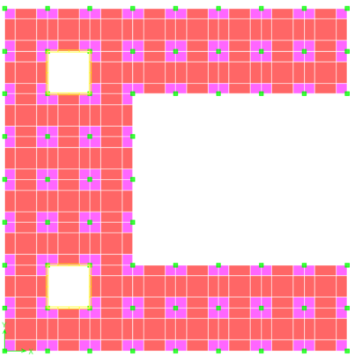

Figure 3_ Model 3_shear wall at location 2

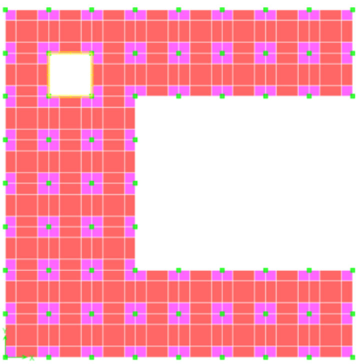

Figure 4_ Model 4_shear wall at location 3

3. RESULT AND DISCUSSION

Equivalent Static Analysis (ESA)

Displacement_ EQX and Storey Drift_ EQX

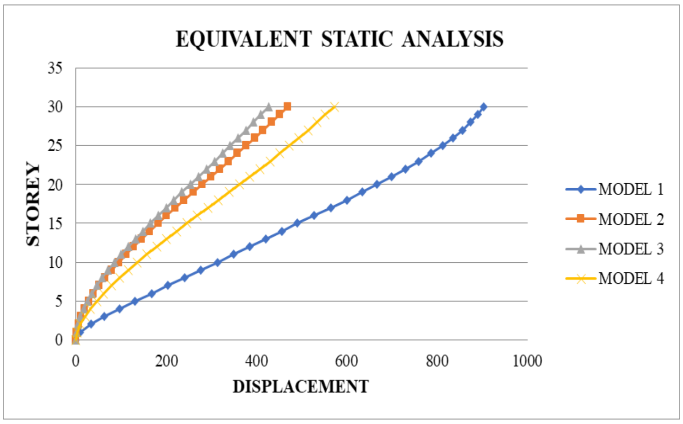

Figure 3.1 Displacement vs Storey in X Dir._ EQX

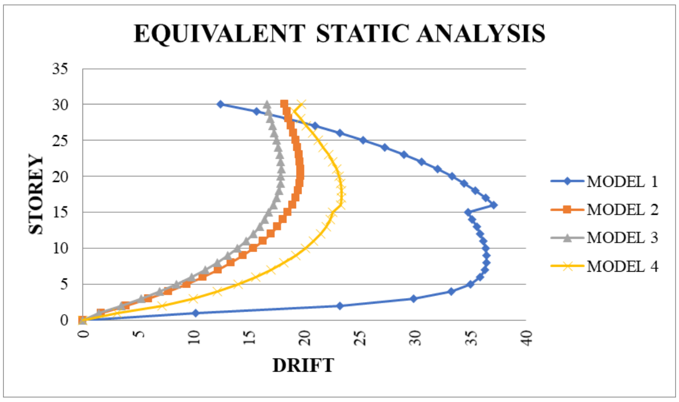

Figure 3.2 Storey Drift vs Storey in X Dir._ EQX

Maximum permissible storey displacement and permissible storey drift calculated from IS: 1893-2002 and IS: 456-2000. Maximum permissible storey displacement is limited to H/500. Where, H- total height of building. Maximum permissible storey drift is limited to 0.004 h. Where, h- height of storey. From the graph above, it is seen that model 1 is having highest displacement value compared to all other models, because Model 1 is a bare frame structure without shear wall. However, the displacement reduced drastically after the introduction of shear wall. The model 3 is having lowest displacement values compared to other models. From the graph above, it is seen that the drift values are higher in case of flat slab without shear wall i.e., MODEL 1. However, except model 1, all other models are having same drift values.Storey drift is depends on the storeydisplacement, as storey displacement decreases drift value also decreases. As MODEL 2 and MODEL 3 are having low displacement values, drift Values for MODEL2and MODEL 3 are also low.

Displacement_ EQY and Storey Drift_ EQY

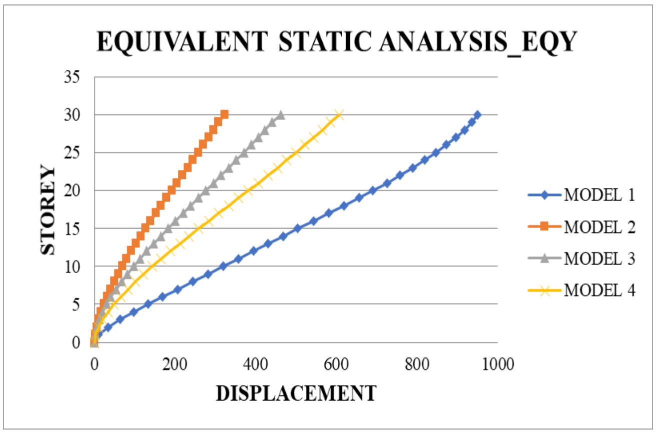

Figure 3.3 Displacement vs Storey in Y Dir._ EQY

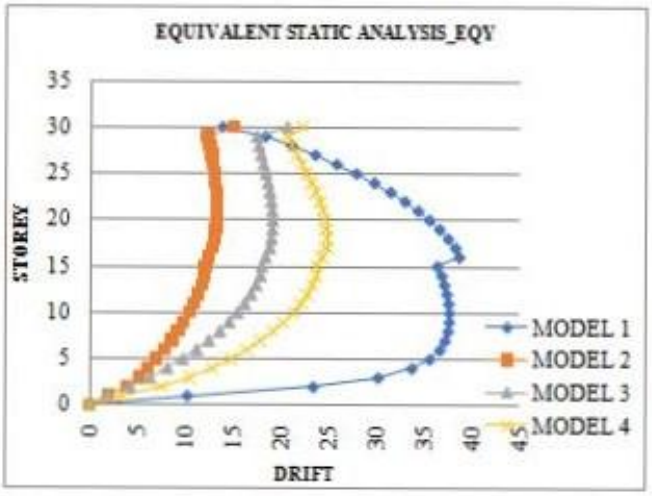

Figure 3.4 Storey Drift vs Storey in Y Dir._ EQY

In case of displacement in Y direction, the model 2 is exhibiting lowest displacement. In Y direction, model 2 is having highest stiffness compared to model 3 as in case of X direction.

The storey drift is maximum in case of MODEL1 and MODEL 4 and seem to be not feasible. However, the model 2 & 3 are having lowest drift values.

The storey drifts of MODEL 2 is within the specified limit 16 (0.004 time the storey height) as per IS code. MODEL1 and MODEL4 are failing in drift criteria.

Wind Analysis (WINDX)

Displacement_ WINDX and Storey Drift_ WINDX

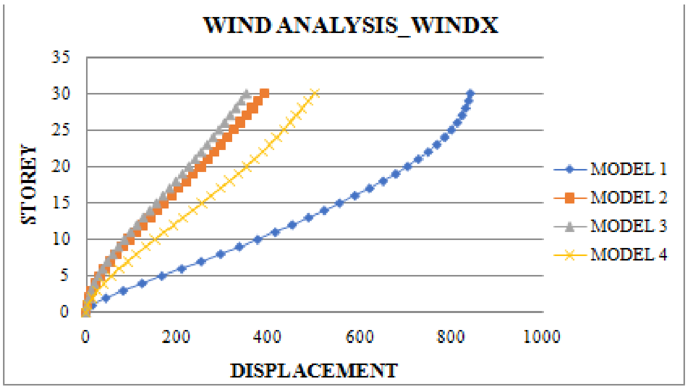

Figure 3.5 Displacement vs Storey in X Dir._ WINDX

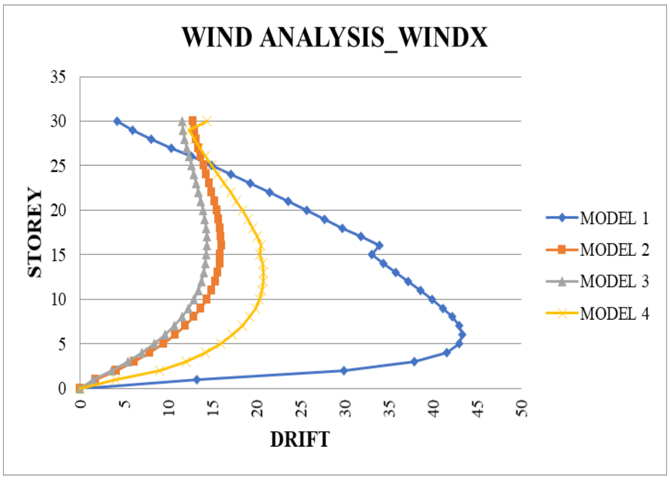

Figure 3.6 Drift vs Storey in X Dir._ WINDX

It is seen from the graph, the displacement values are maximum in case of model 1. However, the model 2 and 3 are having lesser displacement values comparatively.

From graph it is seen that drift value of both MODEL2 and MODEL 3 are within the permissible limit 16 as per IS Code. MODEL 1 and MODEL 4 are failing drift criteria.

In case of wind analysis Drift values of MODEL 1 and 4 seems to be on higher side and not acceptable. However, model 2 and 3 shows nominal drift values.

Displacement_ WINDY and Storey Drift_ WINDY

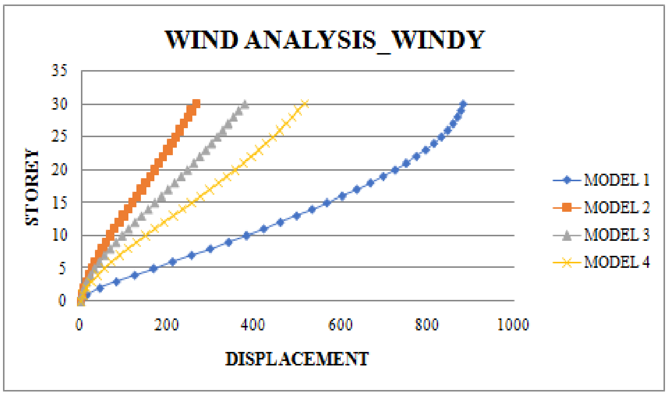

Figure 3.7 Displacement vs Storey in Y Dir._ WINDY

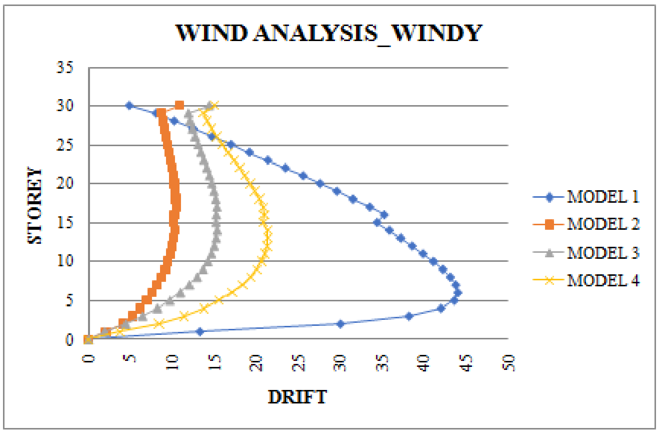

Figure 3.8 Drift vs Storey in Y Dir._ WINDY

It is seen from the graph; the displacement values are maximum in case of model 1. However, the model 2 and 3 are having lesser displacement values comparatively.

From graph it is seen that storey drift value of both MODEL2 and MODEL3 are within the specified Limit 16 as per IS code. Drift values of model 1 and 4 seems to be on higher side and not acceptable. However, model 2 and 3 shows nominal drift values.

CONCLUSIONS

1. The static analysis results show that, the displacement values higher for bare frame model and is not acceptable. However, after introducing shear wall the displacement values reduce drastically.
2. There is a huge reduction in displacement values in comparison with bare frame flat slab structure. The percentage of 48%, 53% & 36.5% reduction in displacement for model 2,3 & 4 respectively.
3. The displacement in X & Y direction are almost similar. But the displacement of static analysis in Y direction is little higher comparatively. This is due to higher stiffness in X direction. The model 3 is possessing lowest displacement in both directions.
4. In case of wind analysis, the model 1 is exhibiting highest displacement compared with other models. Next will be the model 4, the model 2 and 3 are almost same stiffness.
5. It is observed from the drift values that only model 2 and model 3 values are with in allowable drift limit.However, other models fail in drift criteria.
6. The displacement in Y axis is more in case of wind analysis as well. There is an increase of 4% when compared with X direction.The Drift values are with in limits for model 2,3. However, for model 1 and 4, the limitation is exceeding the allowable.
7. From the torsion results is found that, the model 3 is excellent in case of torsion resistant. Even though model 2 is very effective in many parameters it is not feasible to provide shear wall only at centre as in model 2, especially in irregular structures.
8. From the overall analysis, it is found that, the static analysis results are slightly higher in comparison with wind loads.
9. The Model 3 is excellent in overall performance and suggested. The shear wall at either ends are more preferable locations instead of centre as in Model 2 and at single location as in model 4. From displacement values, it is also advised not to provide flat slab structure in zone 5.
10. The flat slab structure with shear wall will fail in drift condition unless it is provide at either ends as in model 3.

Future Scope:

- The structure can be further analysed for grid slabs or coffer slab system.
- Time history analysis can be adopted to find real time behaviour.
- Pushover analysis can be adopted to assess the localized failures.

REFERENCES

1. Punith B R, Sharath H P, “Analysis of Regular and Plan Irregular Flat slab structure with and without Lateral force Resisting System (LFRS)”.
2. Anshuman Nimade, Niraj Soni, Mahesh Patidar and Vikas Joshi, “Dynamic Analysis of Flat Slab System in Vertical Irregular Building with & without Shear Wall”.
3. Mythri T S, “Collapse analysis of irregular flat slab structure at different seismic zones”.
4. Syed Asim Aman , Mohd Abdul Khali , Mohd Jameel Uddin, Syed Imranuddin, “Analysis And Design of A Multi Storey Building with Flat Slab (C+G+9) Using ETABS”.
5. Rahila Thaskeen , Shinu Shajee, “Torsional Irregularity of Multi-storey Structures”