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COMPARATIVE STUDY OF VERTICALLY REGULAR AND IRREGULAR STEEL STRUCTURE

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Abstract – *The widely used material for construction in the world is steel. It is one of the fastest growing materials which are used now days.*

When designing steel structures the effect of wind loads is important to be considered. The designing of the steel building is based on codes, IS 800, IS 875 PART 2, IS 875 –PART3.The aim of this thesis is to analyze the building for vertically irregularity and regular building. The frame consist of six storey and has 3 bays on both x and y direction. The selection of the frame sections are done, the column section selected is box ISMC 400, the beam sections selected are ISLB 325, ISLB 175 are secondary beams, the slab section considered is composite deck sheet. The irregular models of stiffness irregularity, mass irregularity, weak storey and set back irregular models are prepared using the same structural frame sections. The study of wind loads is focused in this paper. Comparative studies of the results tabulated are done for different parameters. The parameters which are studied are storey displacement, storey drift, storey stiffness and base shear.

The software used for the analysis is ETABS –v2016.

Key Words: Regular building, soft storey, mass, setback, weak storey.

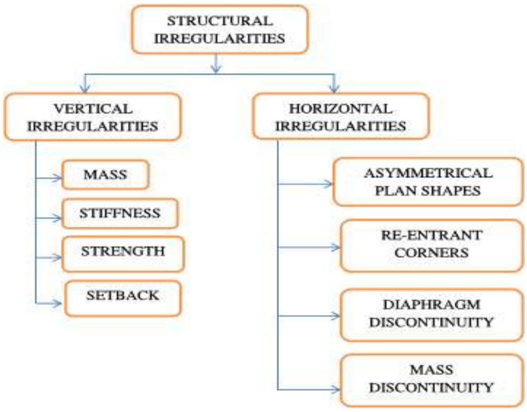
1. INTRODUCTION

This thesis focuses on a comparative study and on the behavior of steel buildings. Particularly on vertically irregular steel structures. There is no such building in practice which can be termed as a perfect regular building.

Irregularities are in configuration of structures i.e. how the parts of structure are arranged and if the arrangement is irregular then there are consequences in the structure. The irregularities occur due to mass, geometry, stiffness and strength thus from the above information we can study that failure occurs at certain point of weakness, because of irregularity. When we take any urban infrastructure in to consideration we can observe that the irregular building covers a large number of infra-structure.

1.1 Irregularities

Classification of Irregularities:



The irregularities studied in this paper are only verticle irregularities

1.2 OBJECTIVES.

- To carry out analysis of vertically regular steel structures and irregular steel structures having irregularities such as mass, stiffness and set back irregularity in ETABS-v2016 software.
- To compare results of vertically irregular steel structures with regular steel structures subjected to wind loads

2. SCOPE OF STUDY.

- Using ETABS-v2016 the steel structure analysis is studied.
- Vertical irregularity was studied comparing to regular steel structures.
- Column is considered to be fixed joints as restraints.
- Studying of Storey Displacement, Storey Drift, Storey Stiffness

3. METHODOLOGY

- The present literature by various authors was studied.
- Different structures are selected with different irregularities.
- Modeling is done for the structure's which are selected
- Analysis is done and results are noted.

4. LITERATURE REVIEW

1) Avadhoot Bhosale, Robin Davis, Pradip Sarkar (2018) - "Seismic safety of vertically irregular buildings: performance of existing indicators." This paper evaluates the seismic risk of vertically irregular buildings on the basis of fragility curves, annual collapse, drift hazard curves, and confidence levels and correlates seismic risk with the corresponding degree of irregularity using different existing irregularity indicators. This paper includes checking of adequacy of present irregularity indicators through probability-based seismic risk assessment. The results of this paper contradict some conventional beliefs on the vulnerability of vertically irregular buildings. The results presented in this paper show that the existing irregularity indicators do not correlate with the associated seismic risk of vertically irregular buildings.

2) George georgoussis achilleas Tsompanos & Triantafyllos Makarios (2015) –

"Approximate seismic analysis of multi-story buildings with mass and stiffness irregularities". Setback buildings with mass and stiffness discontinuities are mainly observed in the growing infrastructure in the urban areas they are observed to be irregular in plans .for the equivalent single storey system the south wells formula is adopted. For the structural detailing by the pseudo static designing against equilateral lateral load there is no such provision to do so. Hence a basic dynamic data is collected from the approximate analysis i.e. the frequency and the base resultant force. The vertically irregular building are then overviewed for As-symmetric high rise structures including stiffness and mass irregularity the accuracy level is examined.

5. MODELLING-

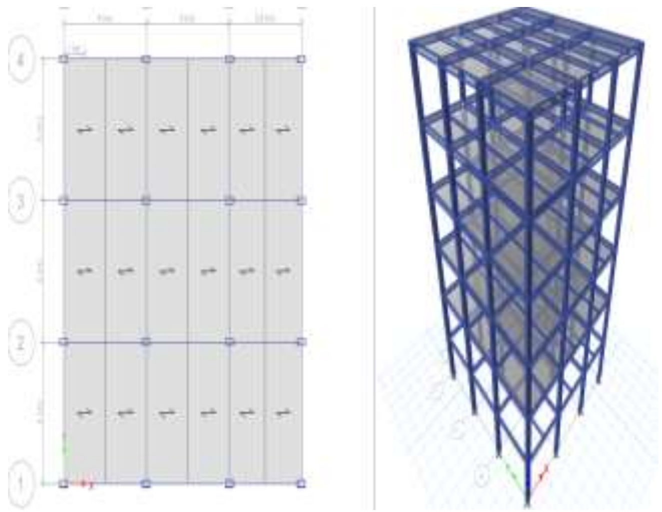


Fig.1: Plan & Rendered view of regular model.

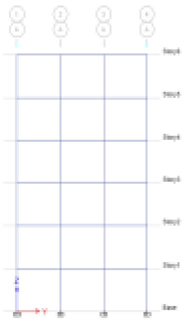


Fig.2: Elevation view of regular steel structure

MODEL 2 - Stiffness Irregularity - soft storey model

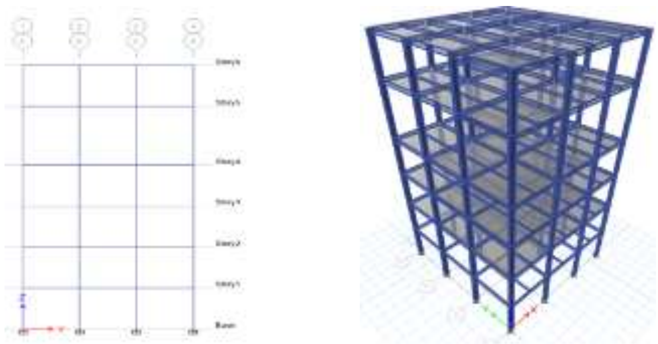


Fig 3: stiffness irregularity

MODEL- 3: Mass Irregularity

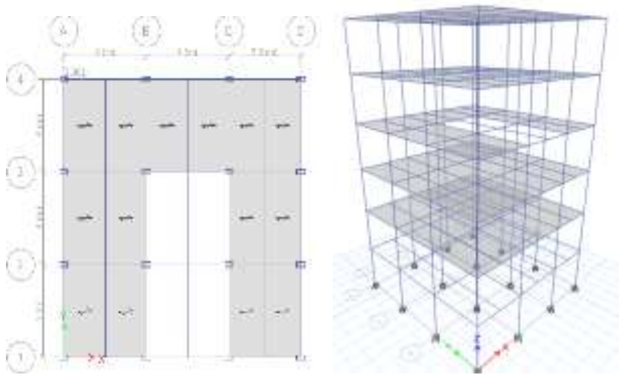


Fig 4-Plan and 3D view of mass irregularity

Model -4: Weak Storey

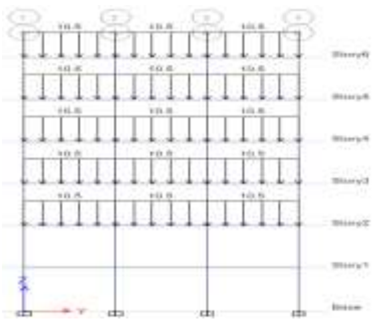


Fig 5-Weak Storey.

MODEL -5: Set Back Irregularity.

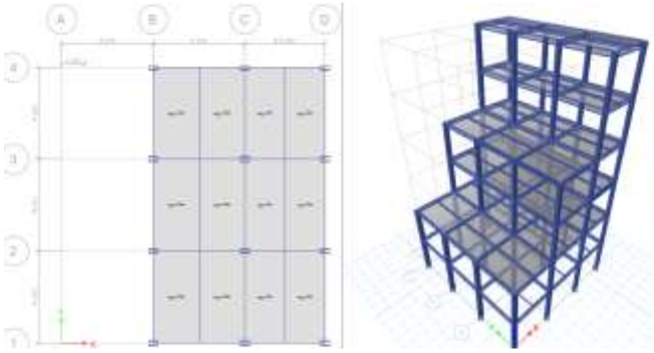


FIG 6-Plan at storey4 rendered view of set back irregularity

5.1 ANALYSIS OF BUILDING FOR WIND LOADS:

- Winds are produced by the difference in the atmospheric pressure which are primarily due to temperature difference.
- Wind load produces lateral force on the structure similar to that of earthquake forces. Hence it is important to study this effect of wind load. It causes moment of free air it act as lateral force
- Its intensity increases with the increase in height of structure.
- It produces positive and negative pressure effect on building when it obstructs the flow of air.
- It depends on the geographic location of the building wind load Indian Standard Code Is 875-part 3 explains the calculation of building as in table 2

Table 1:

Live Load	5kN/m^2
Reinforced concrete density	25kN/m^3
deck sheet thickness	163mm
steel beam section	ISMB 325
Column sizes	Box ISMC400
Density of infill	20kN/m^3
Thickness of wall	150mm
Storey Height	3.5m
Earthquake Zone	III
Damping	5 percent
Importance factor	1.0
Soil condition	Rocky
Structure type/use	Steel Moment Resisting Frame
Response reduction Factor	5.0
Zone factor	0.16

Table 2:

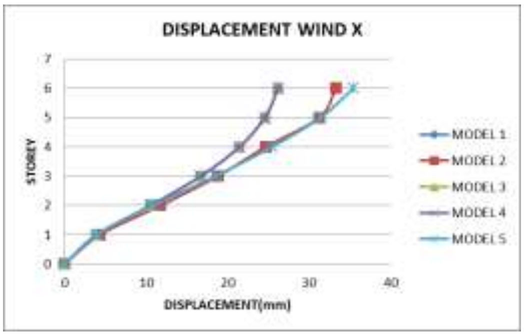
1.Wind exposure parameters:	
a)Wind directions :	
Windward coefficient ,cp	0.8
Leeward coefficient ,cp	0.5
2.Wind coefficients :	
Wind speed V_b	50(m/s)
Terrain category	2
Structure class	B
Risk coefficient k1	1
Topography factor k2	1

RESULTS:

Table 5 :Displacement in X direction

Story	Model-1	Model-2	Model-3	Model-4	Model-5
	X-Dir	X-Dir	X-Dir	X-Dir	X-Dir
	mm	mm	mm	mm	mm
6	26.226	33.342	26.226	26.226	35.467
5	24.58	31.267	24.58	24.58	31.416
4	21.466	24.67	21.466	21.466	25.445
3	16.723	18.832	16.723	16.723	18.532
2	10.573	11.778	10.573	10.573	10.798
1	3.934	4.363	3.934	3.934	3.993
0	0	0	0	0	0

Chart -1: Displacement for wind load

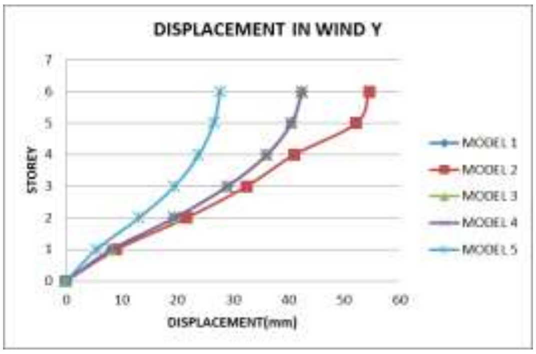


Graph 1: Displacement for wind load

Table 6 : Displacement in Y-Direction

Story	Model-1	Model-2	Model-3	Model-4	Model-5
	Y-Dir	Y-Dir	Y-Dir	Y-Dir	Y-Dir
	mm	mm	mm	mm	mm
6	42.498	54.622	42.498	42.498	27.767
5	40.574	52.235	40.574	40.574	26.601
4	36.142	41.097	36.142	36.142	23.911
3	29.072	32.49	29.072	29.072	19.548
2	19.53	21.643	19.53	19.53	13.125
1	8.228	9.099	8.228	8.228	5.528
0	0	0	0	0	0

Chart -2: Displacement for wind load

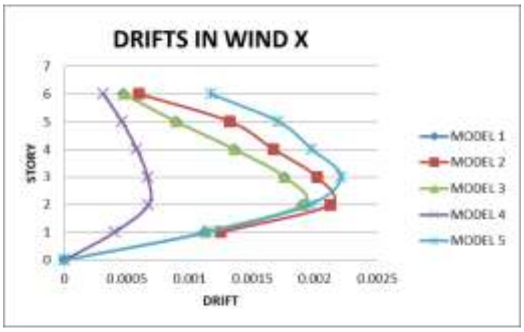


Graph 2: Displacement for wind load

- The displacement is observed to be maximum in y direction for model 2
- The minimum displacement is observed in model-1, model-3, and model-4 in x direction.
- The displacement is observed to be nearly 50% more for stiffness irregularity and 50% less for setback irregularity than regular structure.

TABLE 9: STOREY RESPONSE DRIFTS IN X DIR					
Story	MODEL 1	Model-2	Model-3	Model-4	Model-5
	X-Dir	X-Dir	X-Dir	X-Dir	X-Dir
6	0.00047	0.000593	0.00047	0.000308	0.001167
5	0.00089	0.001319	0.00089	0.000458	0.001706
4	0.001355	0.001668	0.001355	0.000577	0.001975
3	0.001757	0.002015	0.001757	0.000662	0.00221
2	0.0019	0.002122	0.0019	0.000671	0.00196
1	0.001124	0.001247	0.001124	0.000398	0.001141
0	0	0	0	0	0

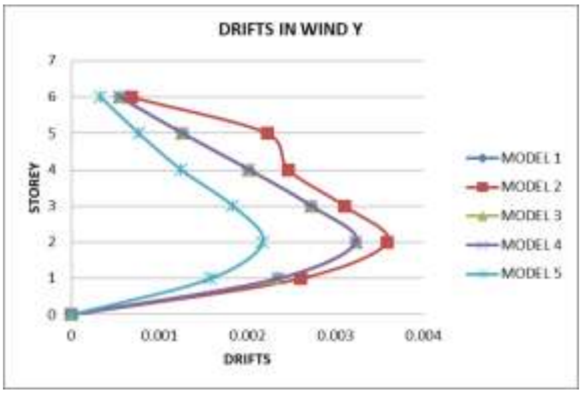
Chart -3: Storey Drift for wind load



Graph 3: Storey Drift for wind load

TABLE 10: STOREY RESPONSE DRIFTS IN Y DIR					
Story	Model-1	Model-2	Model-3	Model-4	Model-5
	Y-Dir	Y-Dir	Y-Dir	Y-Dir	Y-Dir
6	0.00055	0.000682	0.00055	0.00055	0.000333
5	0.001266	0.002228	0.001266	0.001266	0.000768
4	0.00202	0.002459	0.00202	0.00202	0.001247
3	0.002726	0.003099	0.002726	0.002726	0.001835
2	0.003232	0.003587	0.003232	0.003232	0.002172
1	0.002351	0.0026	0.002351	0.002351	0.001579
0	0	0	0	0	0

Chart -4: Storey Drift for wind load

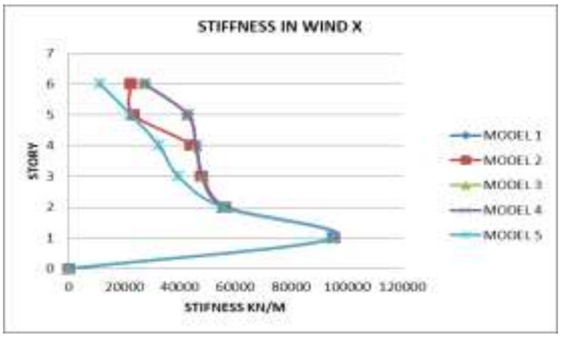


Graph 4: Storey Drift for wind load

- The peak Storey Drift is observed in storey 2 of model 2 in Y direction.
- The minimum storey drift is observed in model-4, storey-6 in X direction.

TABLE 13:STOREY RESPONSE STIFFNESS IN X DIR					
Story	Model 1	Model 2	Model 3	Model 4	Model 5
	X-Dir	X-Dir	X-Dir	X-Dir	X-Dir
	kN/m	kN/m	kN/m	kN/m	kN/m
6	27364.2	22036.2	27364.2	27364.2	11072.8
5	42645.34	23261.73	42645.34	42645.34	22283.82
4	45665.16	43837.99	45665.16	45665.16	32316.05
3	48184.78	47592.86	48184.78	48184.78	39325.01
2	56442.24	55836.22	56442.24	56442.24	55058.78
1	95467.19	95115.75	95467.19	95467.19	94647.76
0	0	0	0	0	0

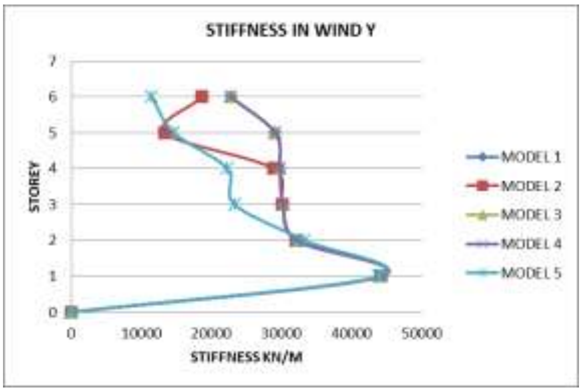
Chart -5: Storey Stiffness for wind load



Graph 5: Storey Stiffness for wind load

TABLE 14:STOREY RESPONSE: STIFFNESS IN Y DIR					
Story	Model-1	Model-2	Model-3	Model-4	Model-5
	Y-Dir	Y-Dir	Y-Dir	Y-Dir	Y-Dir
	kN/m	kN/m	kN/m	kN/m	kN/m
6	22768.943	18634.498	22768.943	22768.943	11428.834
5	29101.984	13363.625	29101.984	29101.984	14642.829
4	29760.396	28888.681	29760.396	29760.396	22244.138
3	30167.272	30063.754	30167.272	30167.272	23313.562
2	32173.532	32028.428	32173.532	32173.533	33307.765
1	44227.593	44194.509	44227.593	44227.594	43876.896
0	0	0	0	0	0

Chart -6: Storey Stiffness for wind load



Graph 6: Storey Stiffness for wind load

- Maximum stiffness is observed in storey 1 of model-1 in x direction.
- Minimum stiffness is observed in storey 6 of model 5 in X direction.
- The stiffness shows sudden decrease at the soft storey level.

6. CONCLUSIONS

This project work studied the analysis of steel structure with 3 bays in both directions the different models with different vertical irregularities like stiffness irregularity, weak storey, mass irregularity, set back irregularity were studied in this project and a comparison of the results of different parameters was done i.e. the displacement, storey drift, stiffness of a structure, base shear for wind load cases.

- The results when compared for different load condition the displacement due to soft storey increased by 50% than regular building.
- Displacements are observed to be linearly increasing as the height of building affects the displacement.
- This maximum displacement is observed at top storey for wind load case acting in y direction.
- According to the analysis the storey stiffness is observed to reduce at storey 5 to about 50% of the storey 4 for the model 2 of stiffness irregularity
- The results were observed nearly same for mass irregularity and weak storey.
- The drifts are observed to get reduced by almost more than 50% for weak story comparing it to the drifts of the regular models.
- It can be suggested that the weak storey effect and the mass irregularity effect can be efficient to some extent as the results obtained are similar to that of regular building.
- The maximum destruction can be observed due to the soft storey effect.
- The use of bracing system can be done to reduce such destructions.

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[2] George Georgoussis, Achilleas Tsompanos and Triantafyllos Makarios (2015) -"Approximate seismic analysis of multi-story buildings with mass and stiffnessirregularities." Elsevier journal of 'Procedia Engineering' 125 (2015), pp. 959 – 966.

[4] IS 875 PART 2 -1987 code of practice for design loads (other than earthquake) for buildings and structures(imposed loads)

[5] IS 875 PART 3 code of practice for design loads (other than earthquake) for buildings and structures (wind loads)

[6] IS 800-2007 code of practice for design of steel structures.