ANALYSIS OF MASS IRREGULARITY IN RC STRUCTURE SUBJECTED TO WIND LOAD

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***ABSTRACT*: Now a day multi-story building is constructed for the purpose of residential commercial etc., In general, for design of tall buildings both wind as well as earthquake loads need to be considered. In a vertically irregular structure, failure of structure starts at a 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. . 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. For the present study ETABS software is used for modelling and analysis of structural members. All the RC structural elements are designed as per IS 456:2000. Wind load with respect to IS 875-1987 along with self-weight of the structure are considered for analysis of the structure. Here three types of buildings were constructed one is regular structure and rest is of mass and geometrical irregular structure. To study the effect of lateral forces on regular and irregular buildings using wind load as lateral load and to compare the results of different structures. To compare the results of maximum roof displacement, story drifts and base shear for different models.**

***KEYWORDS:* Mass irregularity, Wind load, ETABS, Vertical irregularity.**

1. INTRODUCTION
1.1 GENERAL
In a vertically irregular structure, 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. Irregular structures contribute a large portion of urban infrastructure. 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.
IS 1893 definition of vertically irregular structure,the irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

1.2 VERTICALLY IRREGULARITIES
There are two types of irregularities.
1. Plan Irregularities

2. Vertical Irregularities.

Mass Irregularity-Mass irregularity occurs where seismic weight of any storey is two times as that adjacent stories. In case of top storey or roof the mass irregularity must not be considered.

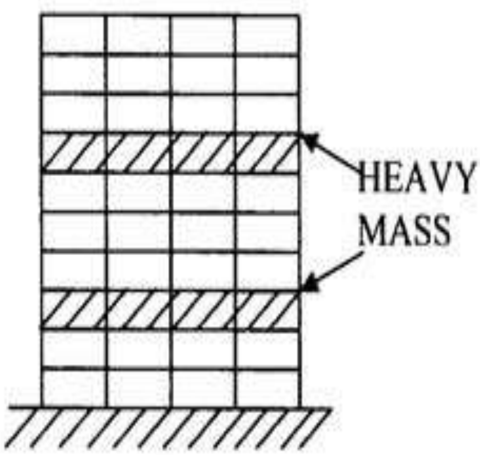


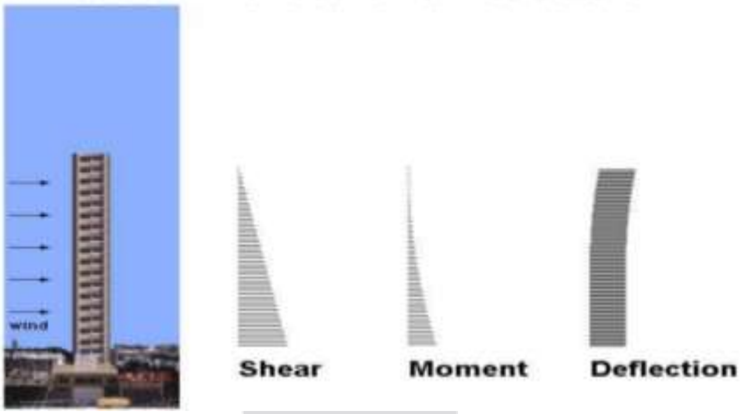
Fig-1.4: Mass Irregularity

1.3 Irregularity limits by IS 1893:2002

Types of Irregularities		IS 1893:2002
Horizontal		
a)	Re-entrant corners	Re-entrant corners <= 15%
b)	Torsional irregularity	Maximum drift computed at a particular storey <= 1.2(Average of drifts computed at both sides of a structures)
c)	Diaphragm Discontinuity	Open area in diaphragm > 50% Diaphragm stiffness > 50%
Vertical		
a)	Mass	Mass of i^{th} storey < 2*(Mass of storey adjacent to i^{th} storey)
b)	Stiffness	Stiffness of i^{th} storey < 0.7(Stiffness of i+1th storey) Stiffness of i^{th} storey < 0.7(Stiffness of i+1th storey) Stiffness of i^{th} storey < 0.8(Stiffness of i+1th storey)
c)	Setback	Setback of i^{th} storey < 1.5(Stiffness of adjacent storey)

Wind load: Wind is essentially the large scale horizontal movement of free air. It plays an important role in design of tall structures because it exerts loads on building. A building having height more than 15m as per national code 2005 of India is called a high rise building.Wind is caused by air flowing from high pressure to low pressure. Since the earth is rotating, however, the air does not flow directly from high to low pressure, but it is deflected to the right (in the northern hemisphere; to the left in the southern hemisphere), so that the wind flows mostly around the high and low pressure areas. **Variation of wind velocity with height:**Near the earth's surface, the motion is opposed, and the wind speed reduced, by the surface friction. At the surface, the wind speed reduces to zero and then begins to increase with height, and at some height, known as the gradient height, the motion may be considered to be free of the earth frictional influence and will attain its "gradient velocity".

Effect of wind load on tall structure



Wind effects on Structures:
Wind effects on structures can be classified as 'static' and 'dynamic'.

Static: Static wind effect primarily causes elastic bending and twisting of Structure.

Dynamic: For tall, long span and slender structures a 'dynamic analysis' of the structure is essential. Wind gusts cause fluctuating forces on the structure which induce large dynamic motions including oscillations.

2. LITERATURE REVIEW

Sarkar et al. (2010): proposed a new method of quantifying irregularity in vertically irregular building frames, accounting for dynamic characteristics (mass and stiffness). The salient conclusions were as follows:
(1)A measure of vertical irregularity, suitable for stepped buildings, called regularity index', is proposed, accounting for the changes in mass and stiffness along the height of the building.

(2) An empirical formula is proposed to calculate the fundamental time period of stepped building, as a function of regularity index.

Lee and Ko (2007): subjected three 1:12 scale 17-story RC wall building models having different types of irregularity at the bottom two stories to the same series of simulated earthquake excitations to observe their seismic response characteristics. The first model had a symmetrical moment-resisting frame (Model 1), the second had an in filled shear wall in the central frame (Model 2), and the third had an infilled shear wall in only one of the exterior frames (Model 3) at the bottom two stories. The total amounts of energy absorption by damage are similar regardless of the existence and location of the infilled shear wall. The largest energy absorption was due to overturning, followed by shear deformation.

Poonam et al. (2012):- Results of the numerical analysis showed that any storey, especially the first storey, must not be softer/weaker than the storeys above or below. Irregularity in mass distribution also contributes to the increased response of the buildings. The irregularities, if required to be provided, need to be provided by appropriate and extensive analysis and design processes.

2.1 OBJECTIVES

1. To study the effect of lateral forces on regular and irregular buildings using wind load as lateral load and to compare the results of different structures.

2. To study mass irregularities.

3. To find the maximum roof displacement and its respective base shear.

4. To compare the results of maximum roof displacement, story drifts and base shear for different models.

3 METHODOLOGY

For the present study ETABS software is used for modelling and analysis of structural members. All the RC structural elements are designed as per IS 456:2000. Wind load with respect to IS 875-1987 along with self-weight of the structure are considered for analysis of the structure.

Three types of Irregular buildings were considered, Regular structure, Mass irregular structure, and vertically geometric irregular building. All three structures are of 15 storeys.

3.2 STRUCTURAL MODELLING:

SPECIFICATIONS	
Height of the structure	45m
Floor area	$900m^2$
Live Load	$3kN/m^2$
Density of RCC considered	$25kN/m^3$
Thickness of slab	150mm
Depth of beam	600mm
Width of beam	300mm
Dimension of column	300x600mm
Density of infill	$20kN/m^3$
Thickness of outside wall	20mm
Thickness of inner partition wall	20mm
Height of each floor	3m
Wind load	39m/s
Terrain category	3
Windward co-efficient	0.8
leeward co-efficient	0.5
Structure class	C

4. RESULTS AND DISCUSSION

4.1: Model-1: Regular structure (15 storeys):

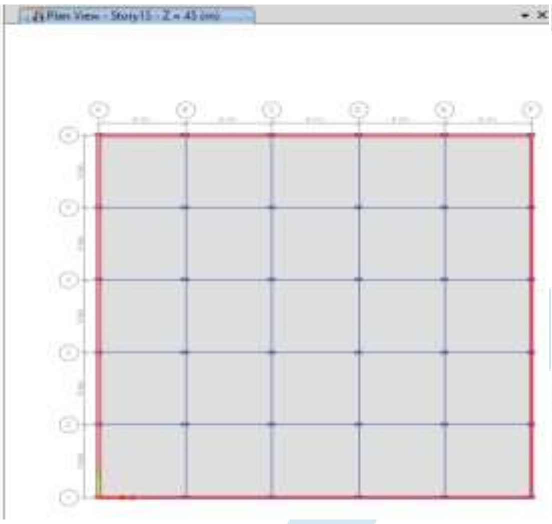
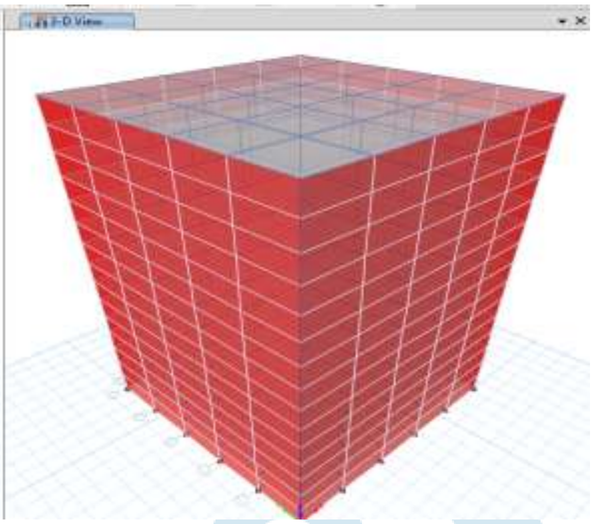
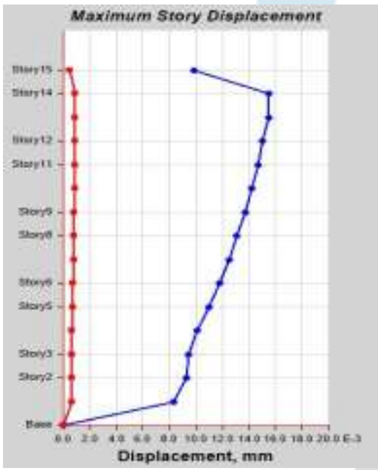


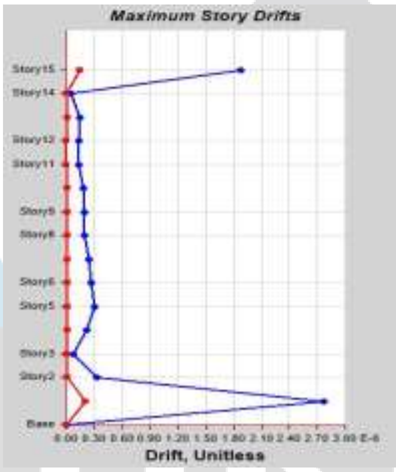
Fig- plan model-1



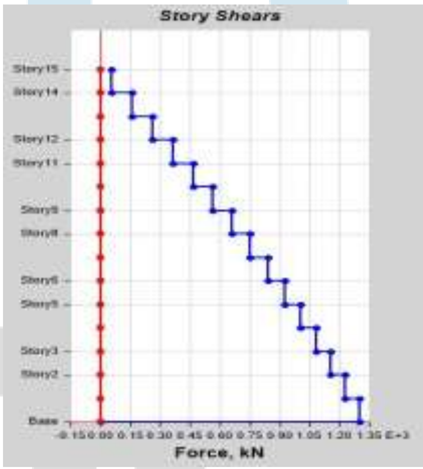
3d Elevation



Story displacement of model-1



story drifts of model-1,



story shear of model-1

➢ From the graph 1 maximum and minimum story Displacement found to be in X direction 0.01549mm and 0.008317mm for story 13 and story 1.

➢ From the graph 2 maximum and minimum story Drift found to be in X direction 2.00E-06 and 7.69E-08 for story 15and story 3.

➢ From the graph 3 base shear decreasing gradually from story 1 1298.623KN to story 15 53.9223KN as story height increases base shear decreases base shear is Maximum at base only.

4.2: Model-2: Structure with mass irregularity

Additional weight of 5kN/m^{2}is applied at middle strip of 10th story as shown in figure

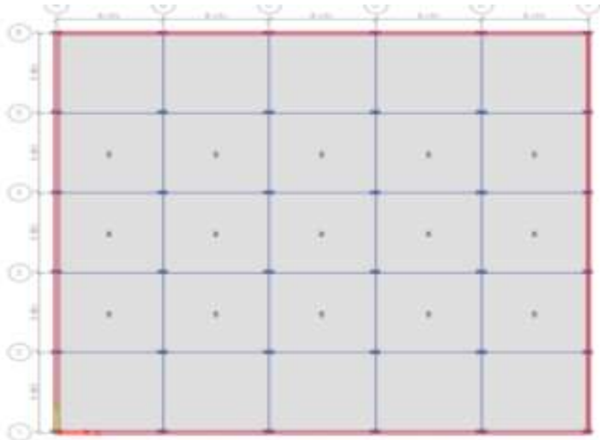
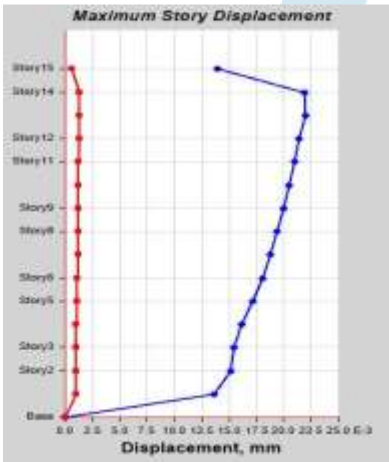
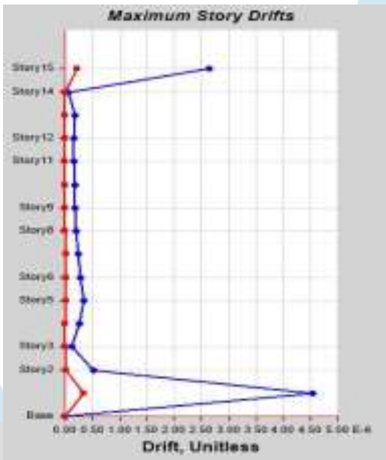


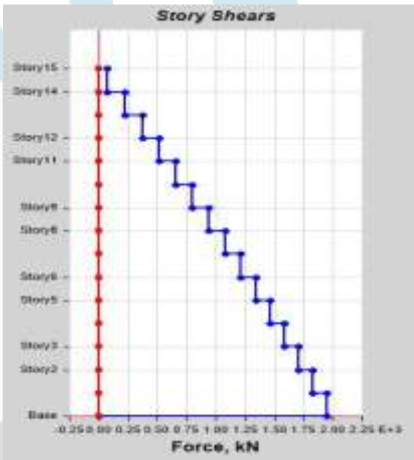
Fig: 4.7- plan model-2



story displacement of model-2



story drifts of model-2



story shear of model-2

- From the graph 1 maximum and minimum story Displacement found to be in X direction 0.02195mm and 0.01361mm for story **13** and story **1**.

- From the graph 2 maximum and minimum story Drift found to be in X direction 3.00E-06 and 1.13E-07 for story **15** and story **3**.

- From the graph 3 base shear decreasing gradually from story **1** 1942.8441KN to story **15** 75.42KN as story height increases base shear decreases base shear is Maximum at base only.

4.3: Model-3: Structure with mass irregularity

Additional weight of 5kN/m^2 is applied at middle strip of 5th and 10th story as shown in figure.

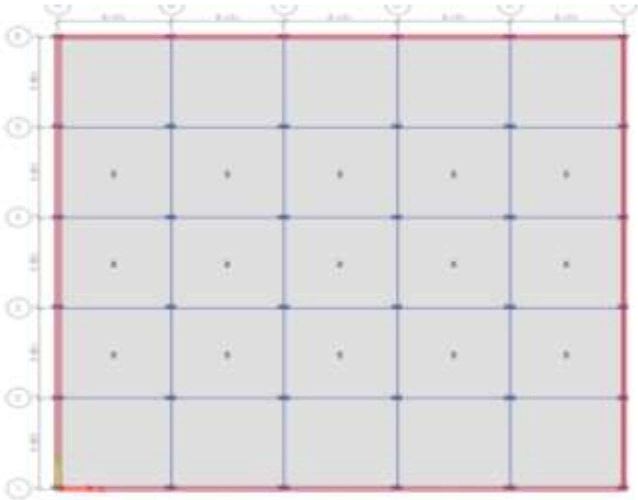
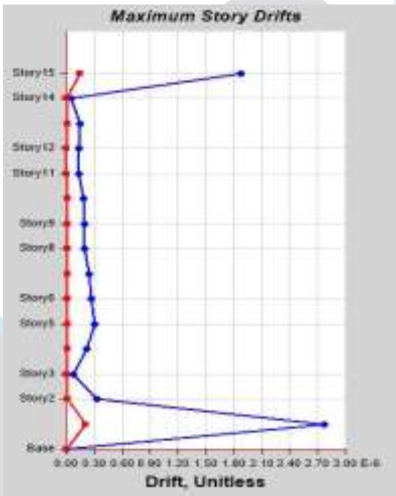
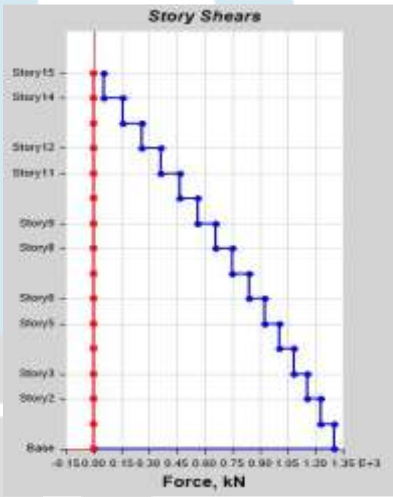


Fig 4.11- plan model-3

story displacement of model-3



story drifts of model-3



story shear of model-3

- From the graph 1 maximum and minimum story Displacement found to be in X direction 0.01549mm and 0.008317mm for story 13 and story 1.
- From the graph 2 maximum and minimum story Drift found to be in X direction 2.00E-06 and 7.69E-08 for story 15and story 3.
- From the graph 3 base shear decreasing gradually from story 1 1298.623KN to story 15 53.9223KN as story height increases base shear decreases base shear is Maximum at base only.

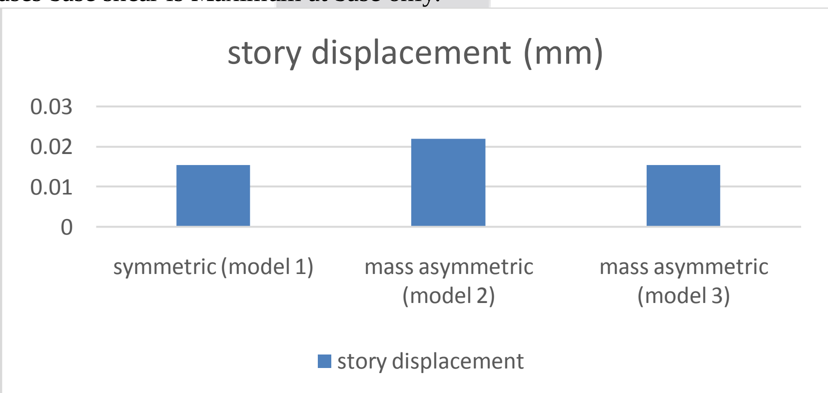


Chart-1: comparison of displacements

From the above chart it is evident that building with mass asymmetry at higher elevation shows more displacement than the regular structure and structure with additional mass in lower elevation.

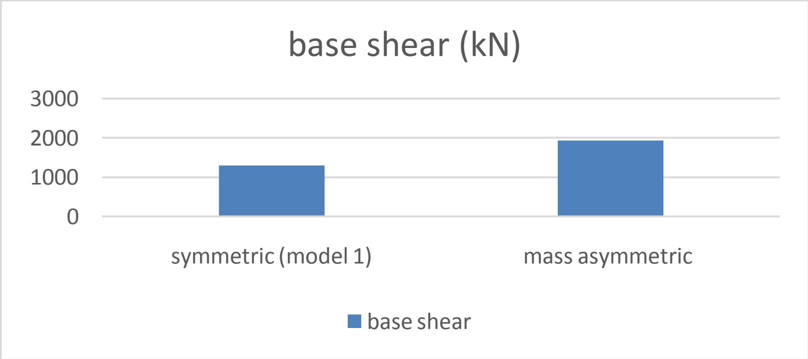


Chart-2: comparison of base shear

From the above chart it is evident that building with mass asymmetry at higher elevation (model 2) shows more base shear than the regular structure.

5. CONCLUSIONS

Three types of irregularities namely mass irregularity, stiffness irregularity and vertical geometry irregularity were considered .All three kinds of irregular RC building frames had plan symmetry. Wind load analysis was conducted for each type of irregularity corresponding to the above wind velocity and structure class and story displacements, story drifts, and base shear were compared.

Results can be summarized as follows:

1. According to results obtained, the storey shear force was found to be maximum of 1942.8441 KN(MODEL 2) for the first storey and75.42KN(MODEL 2) for the 15th storey and it decreased to a minimum in the top storey in all cases.
2. According to results of obtained, it was found that mass irregular building frames experience larger base shear of 1942.8441 KN(model 2) than similar regular building 1298.623 KN(model 1) frames.
3. The geometrically irregular building experiences same base shear 1298.623 KN but has larger inter storey drifts due to offset provided at the inter stories.

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