Analysis of super structure building with plan and elevation irregularities using response spectrum method

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Abstract - *When there is an earthquake, the ground vibrates, causing the structures that are supported by it to move. Plan with vertical abnormalities, irregularity in strength and stiffness, mass irregularity, tensional irregularity, and other variables all contribute to structural damage during earthquakes. So we need to how response spectrum analysis to evaluate the performance of irregular building with torsion irregularity in plan and vertical geometric irregularity in elevation. So We Use Different shape model was used like rectangle, L, T and U. And application of shear walls in the model. To understand the effects of earthquake on the different structure modeled. Analyzing the buildings in ETABS software to carry out the storey displacements, story drift, and torsional irregularity ratio of regular and irregular structures and compare the results of different models.*

Key Words: **Super Structure ,Etabs, Irregularities Building, Response Spectrum Method, Torsional Irregularity Ratio**

1. INTRODUCTION

A rock's unstable breaking, which results in an earthquake, is the result of the tension being released as waves. The naturally occurring risks that are typically unanticipated are earthquakes. The main earthquake often lasts only a few seconds to a minute or so, and it is often rather brief. Generally speaking, there are usually two or more significant peaks of motion during an earthquake. These peaks indicate earthquake's greatest influence.

The act of ignoring how earthquakes affect buildings and using subpar construction methods are two major errors that pose a serious threat to structures, as earthquakes are the most perilous natural occurrence that causes substantial devastation. Therefore, comprehending the seismic impacts on buildings is crucial, and contractors and designers must take into account the effects of seismic forces on structures to establish preventive measures against potential collapses and failures.

The devastation caused by earthquakes on structures makes it the most hazardous natural phenomenon. Neglecting the impact of earthquakes on buildings and using inferior construction techniques are the two primary causes of endangering structures. Hence, it is vital to comprehend the seismic effects on structures. To prevent collapses and failures, designers and contractors must recognize the influence of seismic forces on buildings and incorporate preventive measures.

1.1 Seismic Designs And Philosophy

The major members might receive damage that can be repaired during strong but infrequent shaking, while other parts of the structure might sustain damage that would require replacement after the earthquake. The building's major members may incur significant damage, but it should not collapse.

As a result, following mild tremors, building will be fully functioning in short period, with little repair expenses. After the damaged major members are repaired and strengthened, the building will be operational after mild shaking.

1.2 Response Spectrum Analysis

Response spectrum analysis (RSA) is a method used in seismic engineering to estimate the dynamic response of a structure to earthquakes or other types of dynamic loads. The analysis involves plotting the maximum response of a structure at different frequencies to a standardized ground motion, represented as a "spectrum." The goal of RSA is to estimate the maximum displacement, velocity, and acceleration of a structure during an earthquake and to identify which parts of the structure are most susceptible to damage. This information is used to design and retrofit structures to better resist seismic loads and ensure the safety of the people and assets they contain. RSA is a simplified method that provides a quick estimate of the seismic response of a structure, and it is typically used in conjunction with more detailed dynamic analysis methods to ensure accurate results.

1.3 Objectives

- To conduct a response spectrum analysis to evaluate the performance of irregular building with torsion irregularity in plan and vertical geometric irregularity in elevation.
- Different shape model was used like rectangle, L, T and U. And application of shear walls in the model.
- To understand the effects of earthquake on the different structure modeled.
- To ensure that the structure is safe due to irregularities. In addition, efforts are being made to eliminate the irregularities by modifying the shear wall position.
- Analyzed the buildings in ETABS software to carry out the storey displacements, story drift, and torsional irregularity ratio of regular and irregular structures and compare the results of different models.

2. METHODOLOGY

Structural analysis of mathematical model is needed to estimate force and displacement demands on various components of the structure in order to obtain seismic performance evaluation results. To forecast the seismic performance of the structures, several analytical approaches, both elastic and inelastic, are available.

A response spectrum analysis can be used to study the various types of response of a building. For the lateral stresses generated by the ETABS system, IS1893-2016 (part 1) specifies seismic zone IV and a 5 percent damped response spectrum. The eigenvalue problem of the model is used to derive the natural periods' basic values as part of ETABS. The total seismic load generated and its distribution along the height correspond to the mass and stiffness distribution simulated by ETABS. Based on the modal frequency and modal mass, respectively, they are then integrated to approximate the entire response of the structure.

Calculations as per IS 1893(part1) 2016, IS 13920: 1993 & ASCE 7-10. Modelling of the structure using ETABS. Analysis of the model for different cases. Observation, tabulation, and interpretation of the results.

2.1 Salient features and dimensions of the building

Building was modelled in ETABS for a G+10 storey. The Height is 3m and total height of building is 31.5m. Plan dimension of building is 48m × 24m. Building is assumed to be in Delhi.

The model was analyzed for four different shapes. Rectangle, L, T and U shape plans were used. And shear walls were placed in different positions. The results were observed for 42 models. Seismic zones is IV RCC frame is designed to be ductile as per code IS 13920:1993.

No.	Building description	
1	Seismic zone	IV
2	Importance factor	1.2
3	Soil type	II
4	Response reduction factor	5
5	Slab	150mm
6	Beam	230x500mm
7	Column	400x600mm
8	Shear wall	230mm
9	Dead load	1.5 KN/m^2
10	Live load	3 KN/m^2
11	Grade of concrete	M30

Table -1: Building description modelled in ETABS

3. RESULT AND DISCUSSIONS

- The maximum displacement at X and Y direction values are taken to calculate torsional irregularity coefficient (Ƞt)

$Ƞt=\delta max/ \delta avg$

- If the coefficient is greater than 1.2 than there is an existence of torsional irregularity.

If the value exceeds 1.4 than

3.1 Rectangle Shape

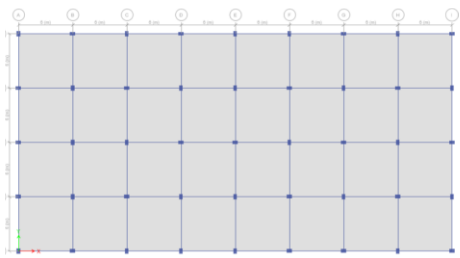

Fig -1: Rectangle Shape Model 1

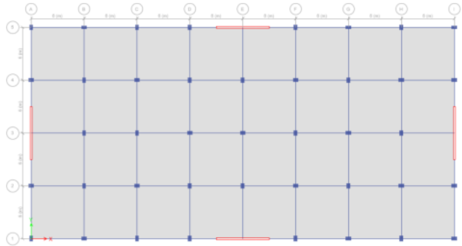

Fig -2: Rectangle Shape Model 2

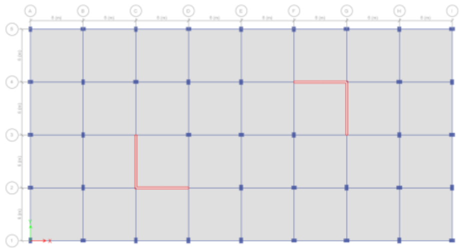

Fig -3: Rectangle Shape Model 3

Rectangle plan models (2) and (3) shear walls placed in different location.

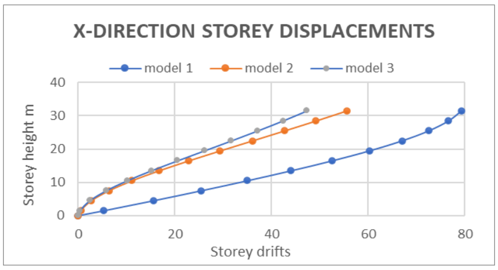

Chart -1: Storey Displacement is Highest in Model 1

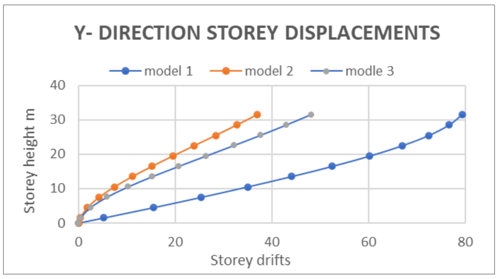

Chart-2: Storey Displacement is Highest In Model 1

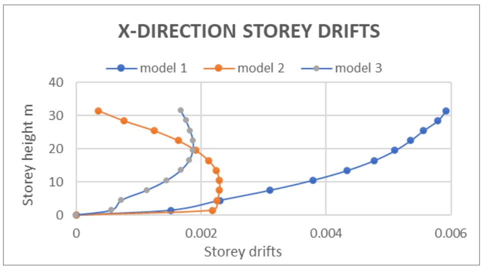

Chart-3: Storey Drifts Highest Model 1

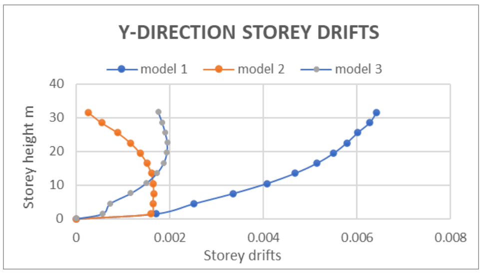

Chart -4: Storey Drifts Highest Model 1

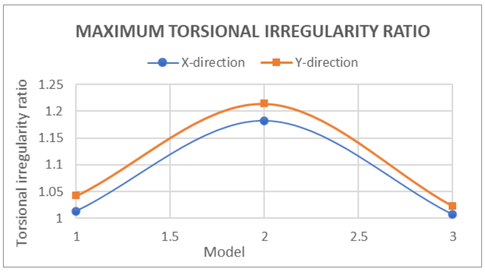

Chart-5: Maximum torsional irregularity ratio

The building height is 31.5m. The maximum displacements obtained from three models are 138mm, 50mm, and 48mm respectively. The displacement limit for a height of 31.5m is 63mm (H/500). The maximum story drifts obtained from three models are 0.0017, 0.0021 and 0.000162 respectively. The inter-story drift limit is set at 0.004 h. Figure 4.5 depicts the maximum torsional irregularity ratio. Model 3 performed better in the rectangular shape.

3.2 L Shape

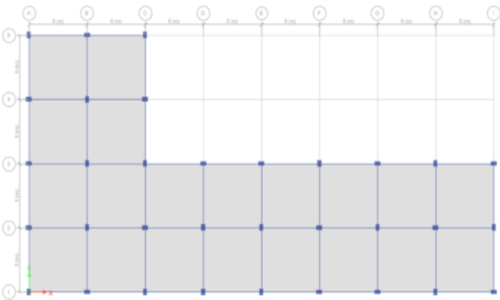

Fig -4: L Shape Model 1

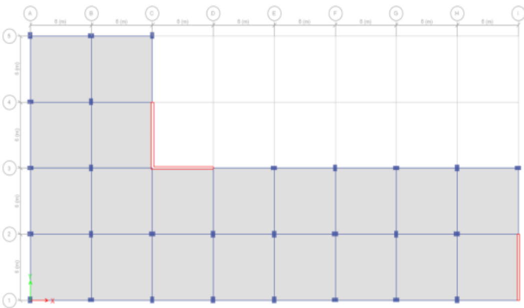

Fig -5: L Shape Model 2

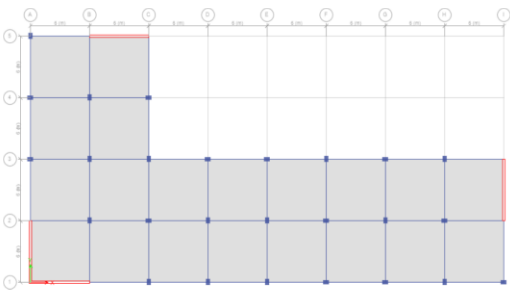

Fig -6: L Shape Model 3

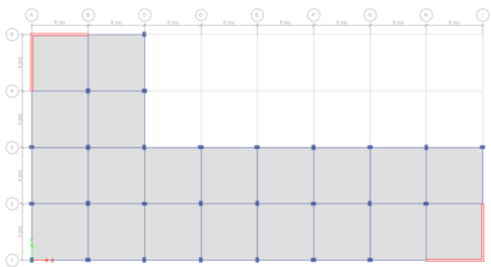

Fig -7: L Shape Model 4

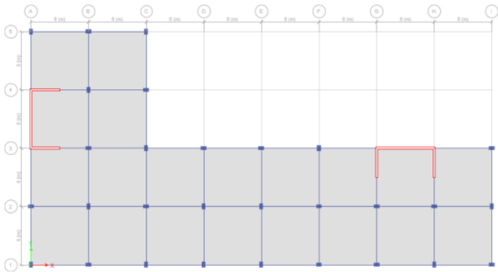

Fig -8: L Shape Model 5

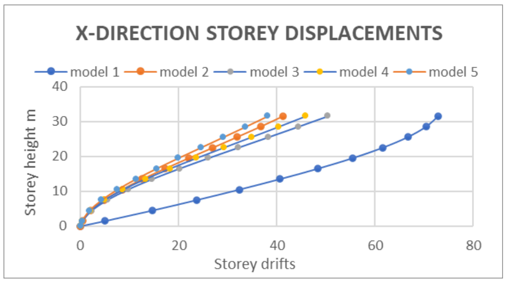

Chart -6: Storey Displacement is Highest in Model 1

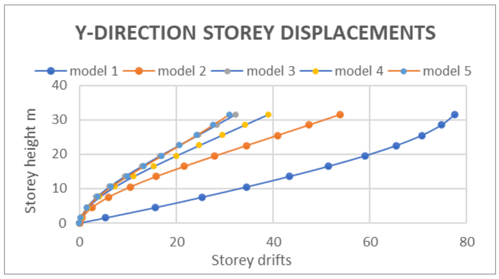

Chart -7: Storey Displacement is Highest in Model 1

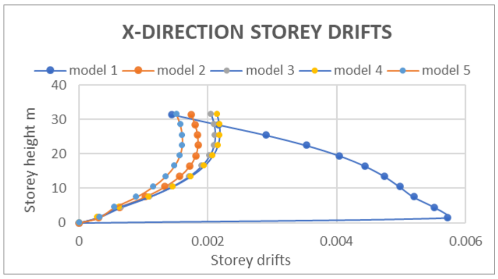

Chart -8: Storey Drifts is Highest in Model 1

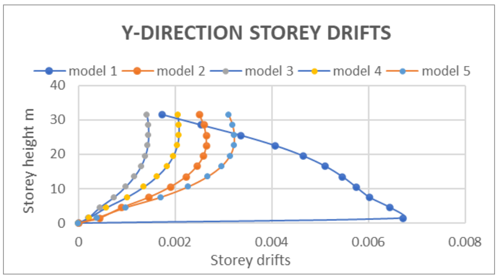

Chart -9: Storey drifts is Highest in Model 1

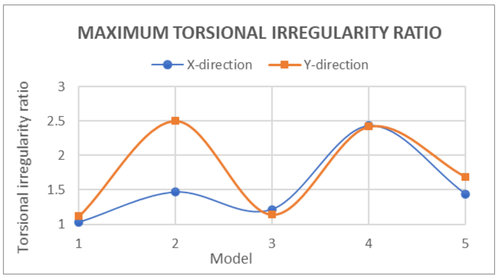

Chart -10: Maximum torsional irregularity ratio

The maximum displacements obtained from five models are 129mm, 53mm, 48mm, 45mm, and 38mm, respectively, for a building height of 31.5m. The displacement limit for a height of 31.5m is 63mm (H/500). All the maximum storey drifts obtained from the five models are within the limit. The inter-story drift limit is 0.004h. Figure 4.11(b) depicts the maximum torsional irregularity ratio. Model 3 performed better in the L shape. Though displacements in the shear wall models are within the limit, the torsional irregularity ratio in models 2, 4, and 5 exceeds the limit. As a result, the placement of the shear wall is critical.

3.3 T Shape

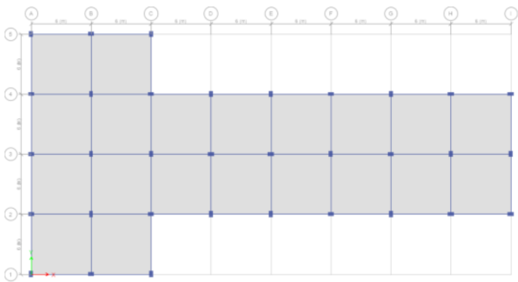

Fig -9: T Shape Model 1

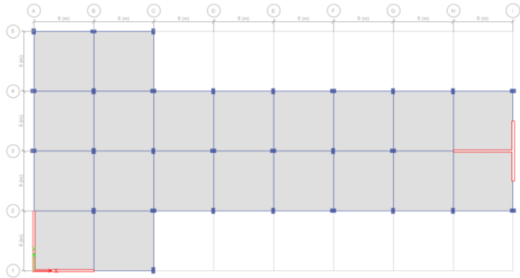

Fig -10: T Shape Model 2

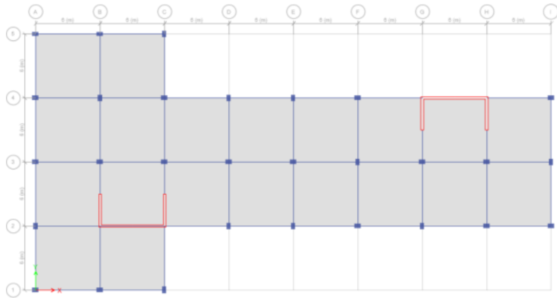

Fig -11: T Shape Model 3

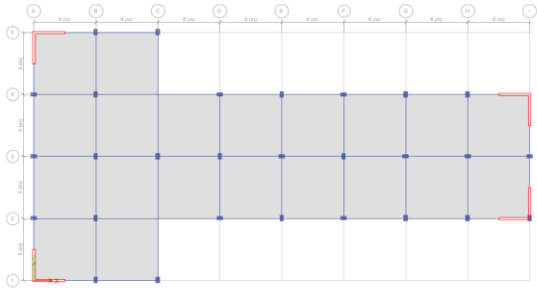

Fig -12: T Shape Model 5

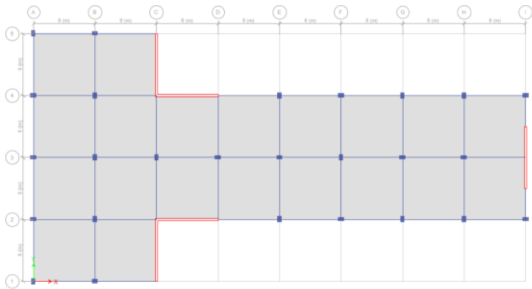

Fig -13: T Shape Model 5

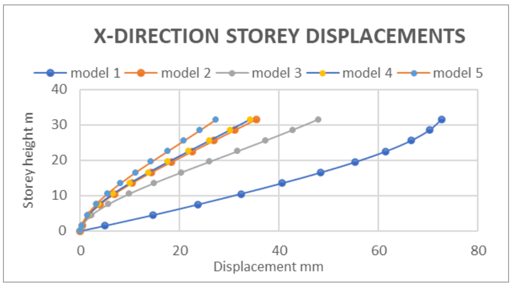

Chart -11: Storey Displacement is Highest in Model 1

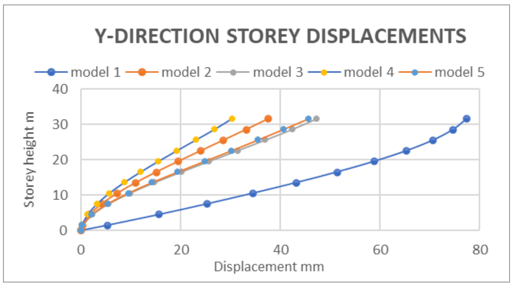

Chart -12: Storey Displacement is Highest in Model 1

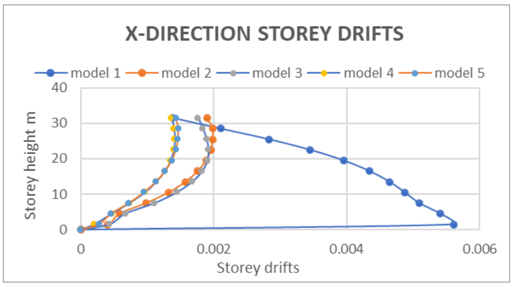

Chart-13: Storey Displacement is Highest in Model 1

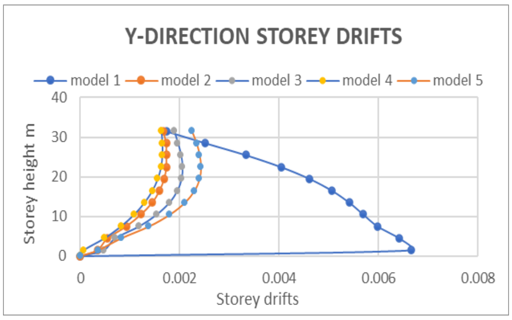

Chart-14: Storey Displacement is Highest in Model 1

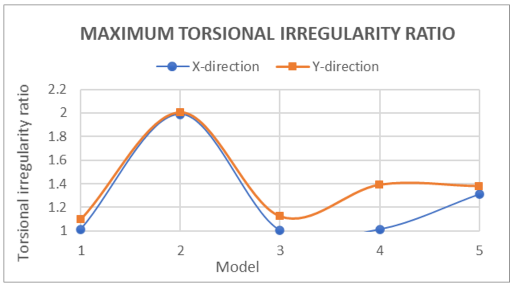

Chart-15: Maximum torsional irregularity ratio

Maximum displacements obtained from the five models are 128mm, 37mm, 47mm, 34mm, and 45mm, in that order. The displacement limit for a height of 31.5m is 63mm (H/500). All of the maximum storey drifts obtained from the five models are within the limit. The maximum amount of inter-story drift is 0.004h. Figure 4.16 depicts the maximum torsional irregularity ratio. The T shape model 3 produced better results. Only the y-direction torsional irregularity ratio exceeds the limit in model 4.

3.4 U Shape

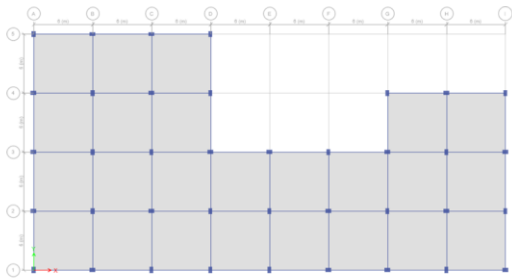

Fig -14: U Shape Model 1

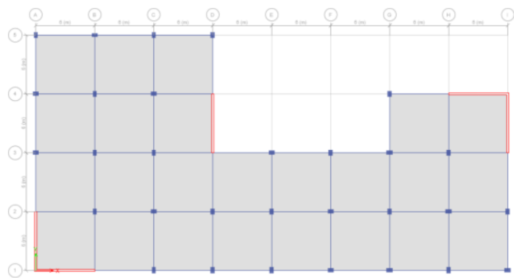

Fig -15: U Shape Model 2

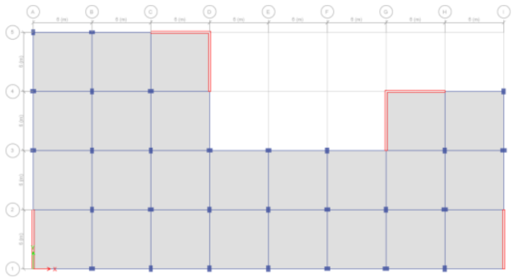

Fig -16: U Shape Model 3

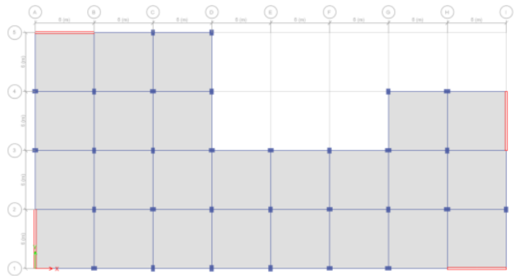

Fig -17: U Shape Model 4

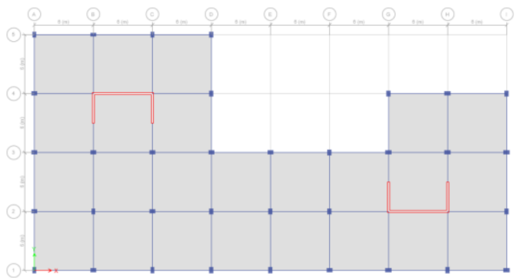

Fig -18: U Shape Model 5

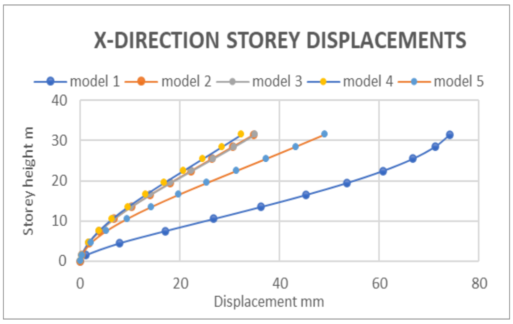

Chart -16: Storey Displacement is Highest in Model 1

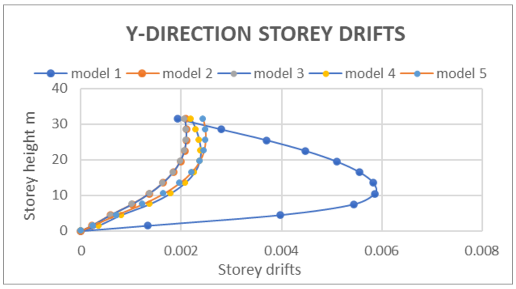

Chart -17: Storey Displacement is Highest in Model 1

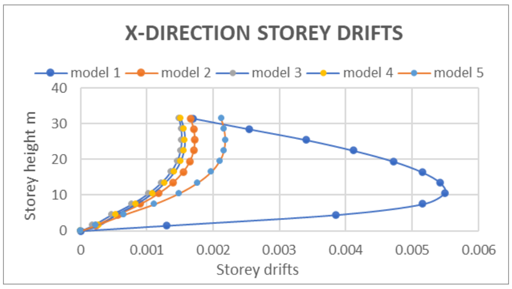

Chart -18: Storey Drift is Highest in Model 1

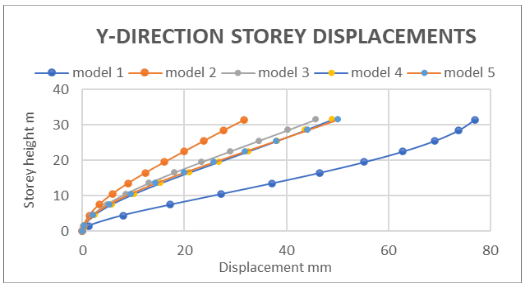

Chart -19: Storey Drift is Highest in Model 1

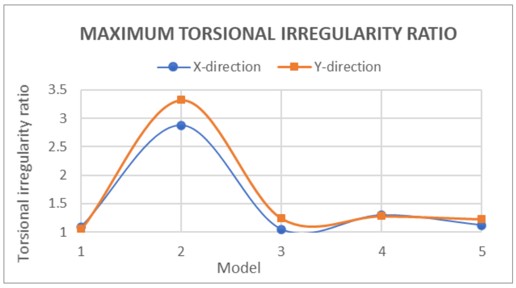

Chart -18 : Maximum torsional irregularity ratio

The maximum displacements obtained from the five models are 128mm, 34mm, 45mm, 48mm, and 50mm, in that order. The displacement limit for a height of 31.5m is 63mm (H/500). All five models' maximum storey drifts are within the limit. The maximum inter-story drift is 0.004h. Figure 4.22(b) shows the maximum torsional irregularity ratio". The U shape models 3, 4, and 5 performed better.

When shear walls are introduced into buildings, they play a significant role in inducing torsion. It is an iterative process to eliminate or reduce the torsional irregularity ratio. In the plan irregularity section, we can see and compare the results of various models. When the shear wall position is changed, the in torsional irregularity ratio increases and decreases dramatically.

4. CONCLUSION

The summary of the key points and conclusions from the analysis of multi-storey buildings with plan and elevation irregularities using response spectrum method:

- Plan configurations and elevation irregularities significantly affect the seismic response of multi-storey buildings.
- As irregularities increase, so does the inter-story drift response, with lower stories being more affected than upper stories.
- The increased plan and vertical irregularity of buildings lead to increased shear force demands on vertical resisting components, which can compromise the building's stability.
- Proper placement of shear walls is important for reducing displacement and increasing earthquake resistance.
- Irregularities in buildings cannot be fully accounted for by code-required load combination procedures, so designers must carefully study irregular and complex buildings in both directions to ensure their safety.
- Torsional irregularity ratio increases as plan or elevation irregularities grow, leading to higher torsional moments that must be taken into account when designing earthquake-resistant structures.
- Implementing earthquake-resistant model proposals into building codes can help ensure the safety of multi-storey buildings in seismic zones.

4.1 Scope of future study

- Consider other irregularities as per the IS code and add more shapes for the analysis.
- We can fix the percentage of vertical geometric irregularity and vary the discontinuity in different storey or by increasing the percentage of irregularity.
- Obtaining the best optimum position for the placement of shear walls for the various shapes considered.
- Since I fixed the building dimensions even after adding shear walls. Which tends to uneconomical design. So, we can alter the size of structural members based on the requirements.
- Similar studies can be taken up for buildings with infill walls, dampers, bracings and other load resisting structures and results obtained may be compared

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