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Effect of Torsional Irregularity on Seismic Response of L-Shaped RCC Buildings as per IS 1893 (Part 1): 2016

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Abstract **- Torsional irregularity is a critical factor affecting the seismic performance of reinforced cement concrete (RCC) buildings, particularly those with irregular plan configurations such as L-shaped structures. The presence of re-entrant corners in such buildings leads to non-uniform distribution of mass and stiffness, resulting in significant torsional effects during earthquake excitation. This study examines the influence of torsional irregularity on the earthquake response of an L-shaped RCC (G+11) building by considering different levels of eccentricity. The structural models are developed and analyzed using ETABS, and earthquake analysis is carried out using the response spectrum method in accordance with the provisions of IS 1893 (Part 1): 2016. Multiple models are created with varying eccentricity ratios to simulate different degrees of torsional irregularity. Key response parameters such as storey displacement, drift, base shear, and torsional asymmetric ratio are evaluated to understand the behavior of the structure under seismic loading. The results indicate that an increase in torsional irregularity leads to a substantial rise in displacement and drift, particularly at the corner regions of the building. The investigation highlights the importance of considering torsional effects in the design of irregular structures to ensure safety and improved dynamic performance.**

Keywords - Torsional irregularity; L-shaped building; seismic analysis; RCC; ETABS; response spectrum

1. INTRODUCTION

The increasing demand for modern architectural designs has led to the construction of buildings with complex and irregular plan configurations. Among these, L-shaped buildings are widely adopted due to their functional advantages and aesthetic appeal. However, such configurations introduce significant structural discontinuity that influence the behavior of buildings under earthquake loading. Unlike regular structures, irregular buildings exhibit non-uniform distribution of mass and stiffness, resulting in complex dynamic responses during earthquake excitation.

One of the most critical forms of irregularity observed in such structures is torsional discontinuity. This phenomenon occurs due to the eccentricity between the center of mass and the center of rigidity of the building. When subjected to lateral dynamic forces, this eccentricity causes the structure to undergo rotational motion in addition to translational displacement. In L-shaped buildings, the presence of re-entrant corners further intensifies this behavior by creating zones of stress concentration and increased deformation demand, particularly at the inner corners of the structure.

According to IS 1893 (Part 1): 2016, torsional asymmetry is identified when the ratio of maximum storey displacement to the average storey displacement exceeds the specified limit. This criterion highlights the importance of evaluating displacement variations within the structure to ensure stability and safety. As the degree of eccentricity increases, the torsional response becomes more pronounced, substantially affecting key ground-motion response parameters such as storey displacement, storey drift, and internal force distribution.

In this context, the present analysis focuses on evaluating the seismic response of an L-shaped reinforced cement concrete (RCC) G+11 building with varying levels of torsional irregularity. The structural models are developed and analyzed using ETABS, and ground-motion analysis is performed using the response spectrum method in accordance with the provisions of IS 1893 (Part 1): 2016. The work aims to understand the influence of torsional discontinuity on the overall structural performance and to provide insights for improved seismic design of irregular buildings.

1.1 CHALLENGES CAUSED BY STRUCTURAL IRREGULARITIES

- Uneven displacement across building
- Higher storey drift at corners
- Stress concentration at re-entrant corners
- Additional torsional moments in members
- Non-uniform load distribution
- Increased earthquake damage risk
- Damage to non-structural elements
- Complex analysis in ETABS
- Possibility of local structural failure
- Reduced overall stability+

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2. OBJECTIVES

- To evaluate the seismic response of L-shaped RCC (G+11) buildings
- To explore the effect of torsional irregularity on structural behavior
- To analyze the influence of varying eccentricity levels
- To determine storey displacement and storey drift
- To evaluate base shear variation
- To calculate torsional irregularity ratio as per IS 1893 (Part 1): 2016
- To identify critical regions prone to higher seismic effects
- To perform analysis using ETABS.

3.METHODOLOGY

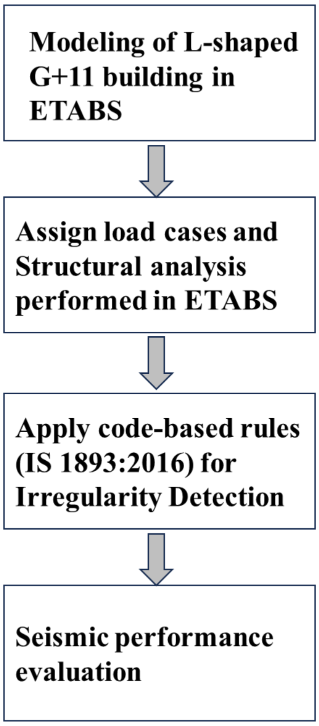

Chart 1: Methodology Workflow

The present study investigates the seismic response of an L-shaped reinforced cement concrete (RCC) G+11 building with particular emphasis on torsional irregularity. The analysis is carried out using ETABS by adopting a systematic modeling and evaluation approach in accordance with the provisions of IS 1893 (Part 1): 2016.

Initially, the geometric configuration of the structure is defined as an L-shaped plan with ground plus eleven storeys. A uniform storey height is considered throughout the building. Structural components including beams, columns, and slabs are modeled using appropriate sectional dimensions. The material properties for concrete and reinforcing steel are assigned based on standard design values, ensuring realistic representation of structural behavior.

The boundary conditions are defined by assuming fixed supports at the base of the structure. The diaphragm action of floor slabs is considered to ensure proper distribution of lateral loads. The structural model is then checked for connectivity and stability before proceeding with the analysis.

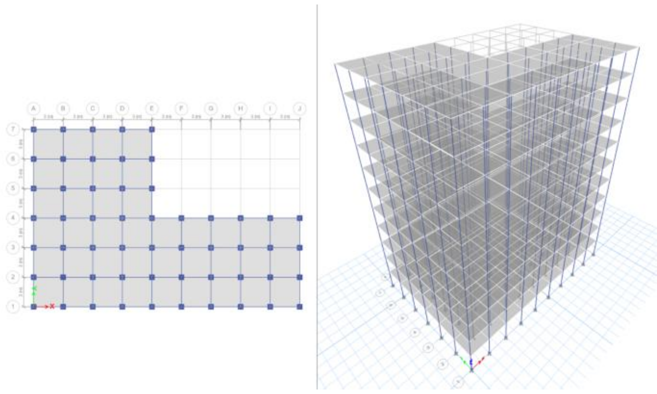

Fig 1: Plan layout of L-shaped structure

Table 1: L-shaped RC building model details

Particulars	Data
Type of structure	L-Shaped RCC building
Number of stories	11
Height of one floor	3m
Total height of the building	34.1m
Seismic zone	4
Importance factor	1.0
Shape & Size of column	Rectangular 500X500
Shape & Size of beams	Rectangular 350X450
Length & Width of the building	21 m x 27m

Table 2: Material Properties

Particulars	Data
Grade of concrete	M30
Grade of steel	Fe500
Grade of Rebar steel	Fe450
Modulus of elasticity, E	210000Mpa
Poisson’s ratio	0.3

Table 3: Load patterns as per IS 1893:2016

Load Cases	
Dead load	DL
Live load	LL
Earthquake in X direction	EQ X
Earthquake in Y direction	EQ Y
Wind in X direction	W X
Wind in Y direction	W Y

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4. RESULTS

The seismic analysis of the L-shaped G+11 RCC building was carried out using the response spectrum method. The structural response was evaluated in terms of storey displacement, storey drift, base shear, and torsional irregularity ratio. The results obtained from the analysis provide insight into the behavior of the structure under seismic loading, with particular emphasis on torsional effects caused by the L-shaped configuration.

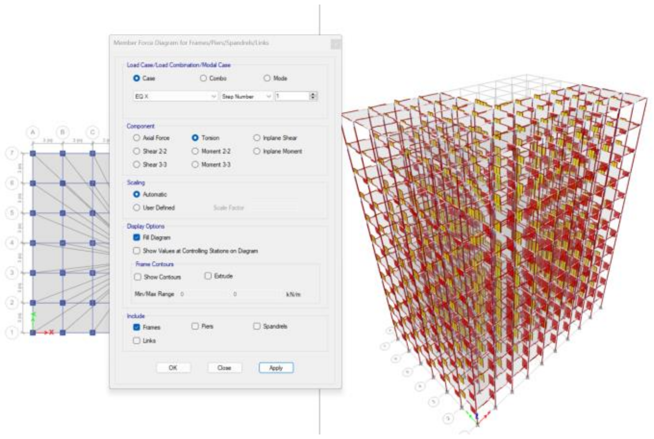

Fig 2: torsional force diagram for the building

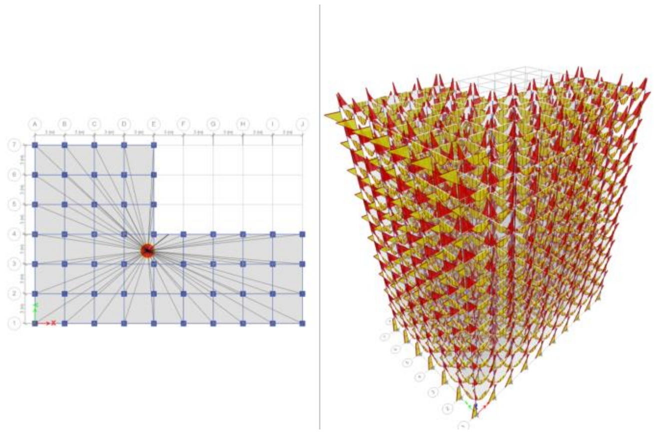

Fig 3: Bending moment diagram for the building

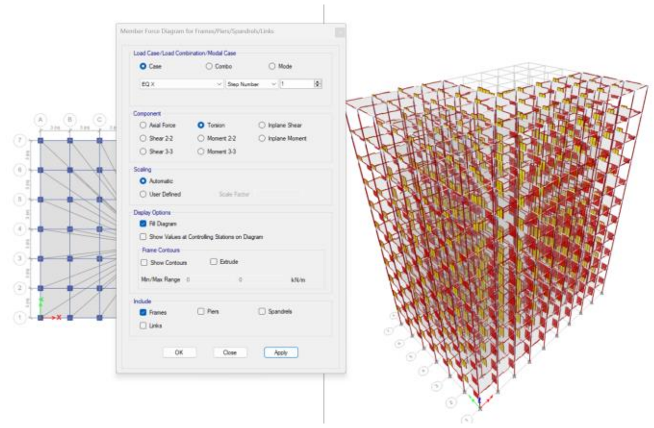

Fig 4: Bending moment diagram (EQ X) for the building

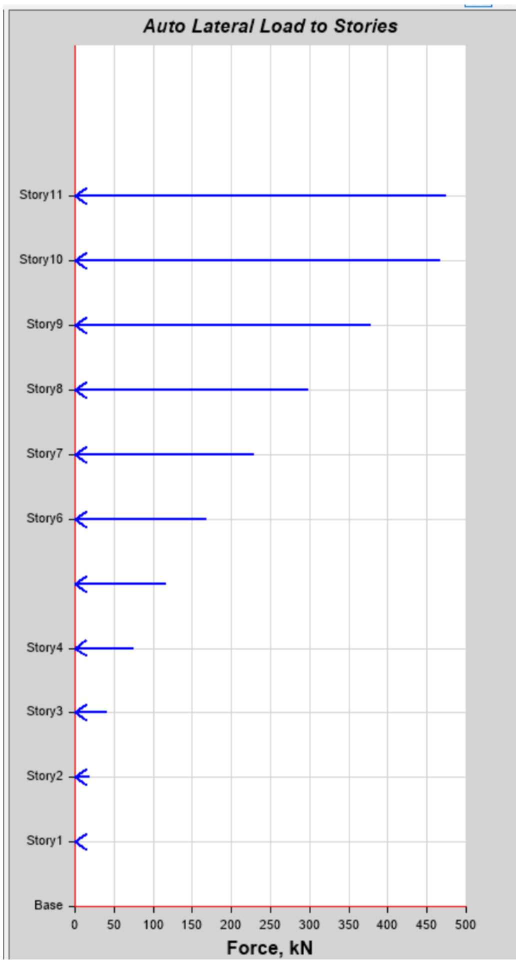

Fig 5: Auto Lateral Load under EQ X condition

Table 4: Auto Lateral Load under EQ X

Storey	Elevation (m)	X direction	Y direction
Storey 11	33	475.2671	0
Storey 10	30	467.6892	0
Storey 9	27	378.8283	0
Storey 8	24	299.3211	0
Storey 7	21	229.1677	0
Storey 6	18	168.3681	0
Storey 5	15	116.9223	0
Storey 4	12	74.8303	0
Storey 3	9	42.092	0
Storey 2	6	18.7076	0
Storey 1	3	4.6769	0
Base	0	0	0

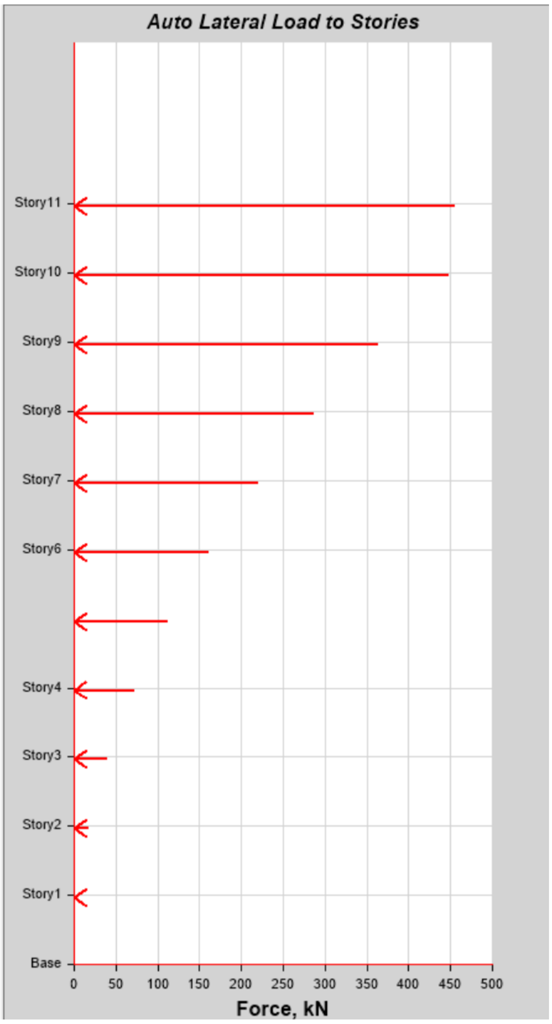

Fig 6: Auto Lateral Load under EQ Y condition

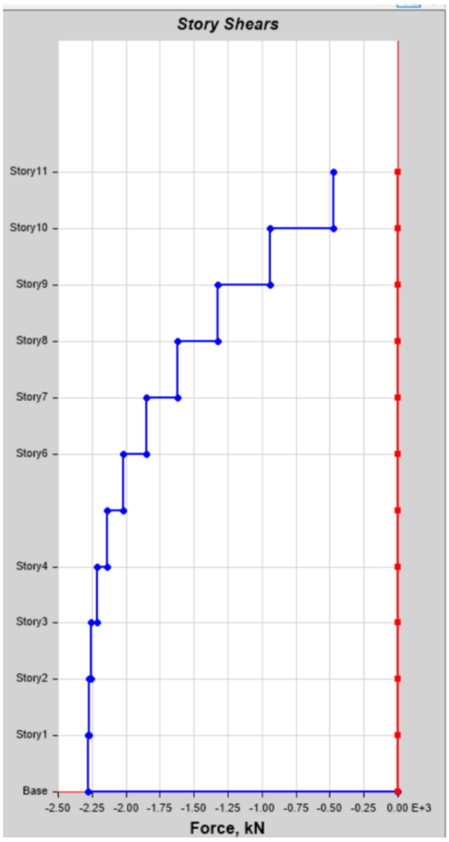

Fig 7: Storey Shear under EQ-X Load Conditions

Table 5: Auto Lateral Load under EQ Y

Storey	Elevation (m)	X direction	Y direction
Storey 11	33	0	456.0925
Storey 10	30	0	448.8204
Storey 9	27	0	363.5445
Storey 8	24	0	287.2451
Storey 7	21	0	219.922
Storey 6	18	0	161.5753
Storey 5	15	0	112.2051
Storey 4	12	0	71.8113
Storey 3	9	0	40.3938
Storey 2	6	0	17.9528
Storey 1	3	0	4.4882
Base	0	0	0

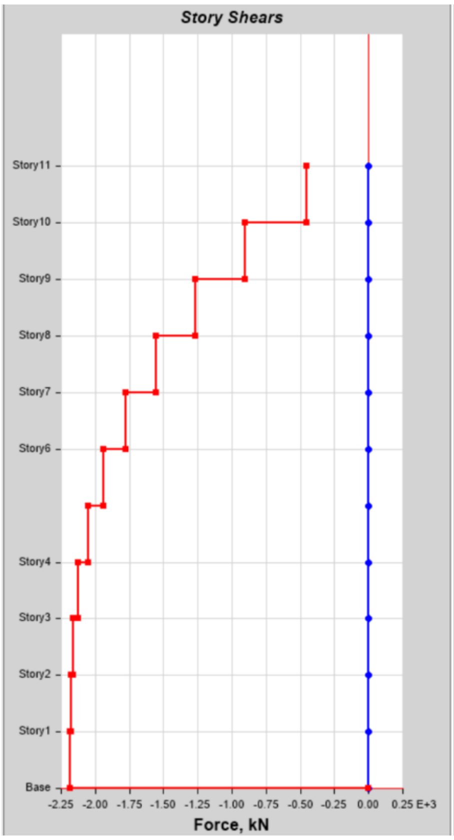

Fig 8: Storey Shear under EQ-Y Load Conditions

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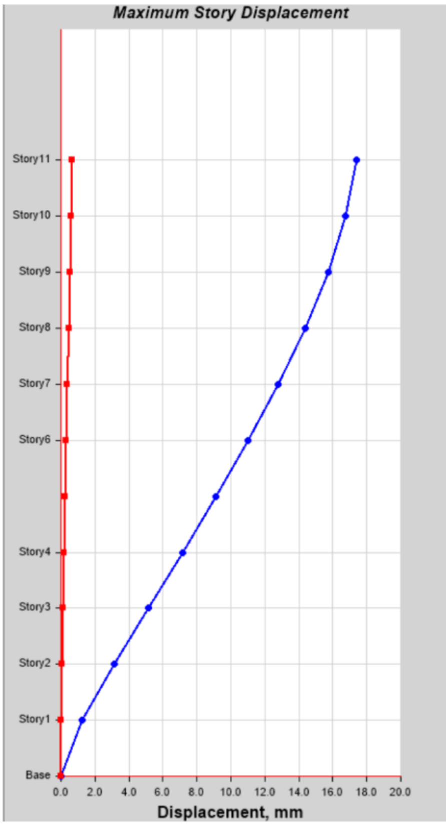

Fig 9: Storey Displacement under EQ-X Load Conditions

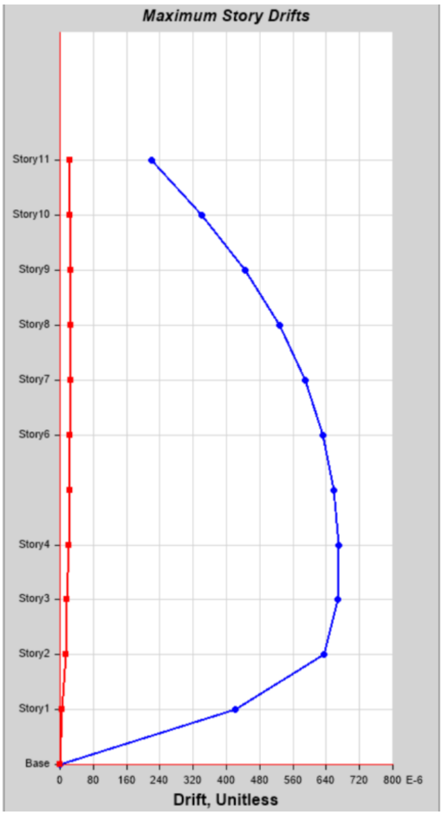

Fig 11: Storey Drift under EQ-X Load Conditions

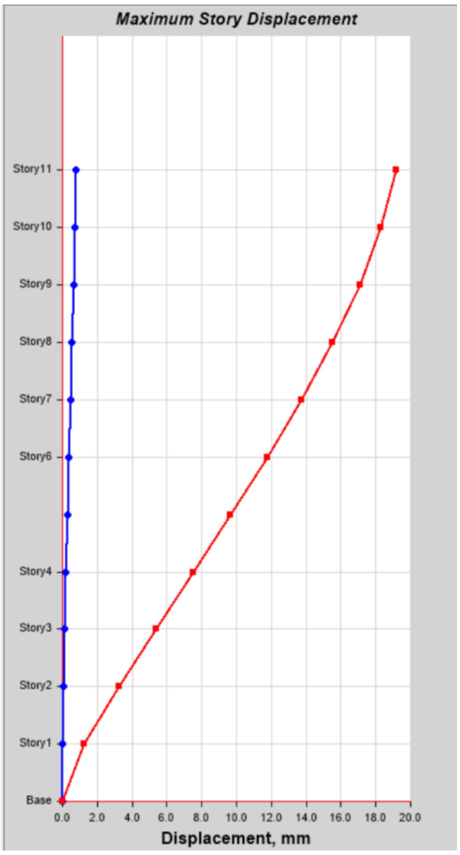

Fig 10: Storey Displacement under EQ-Y Load Conditions

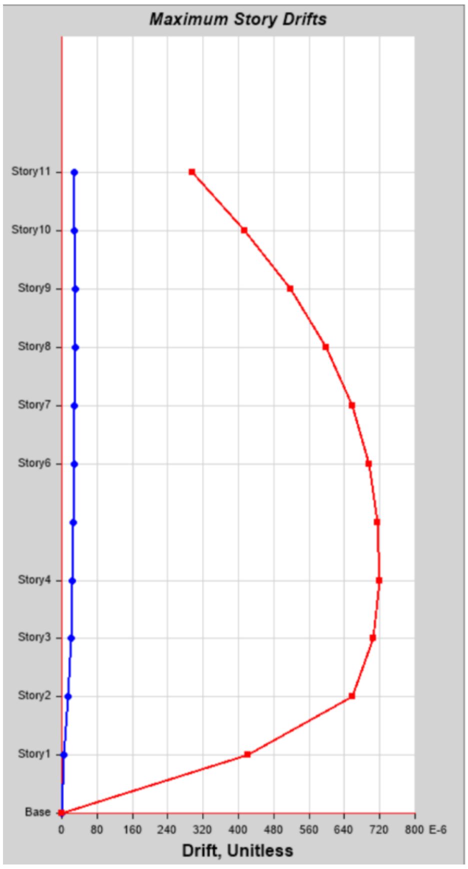

Fig 12: Storey Drift under EQ-Y Load Conditions

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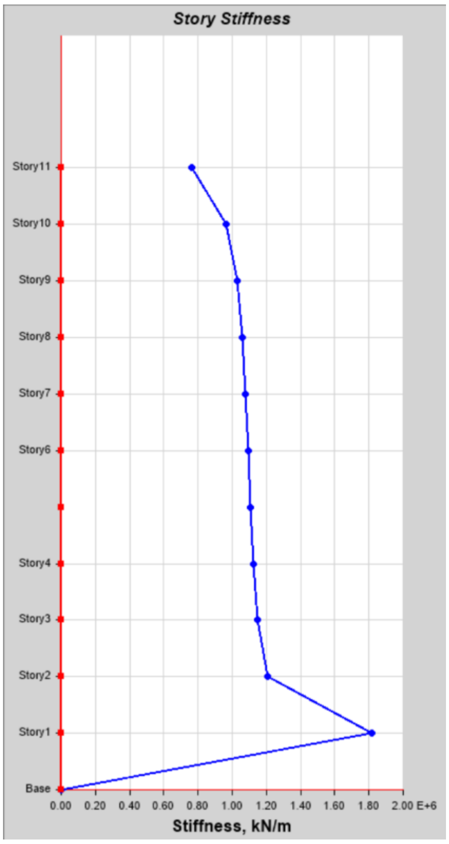

Fig 13: Storey Stiffness under EQ-X Load Conditions

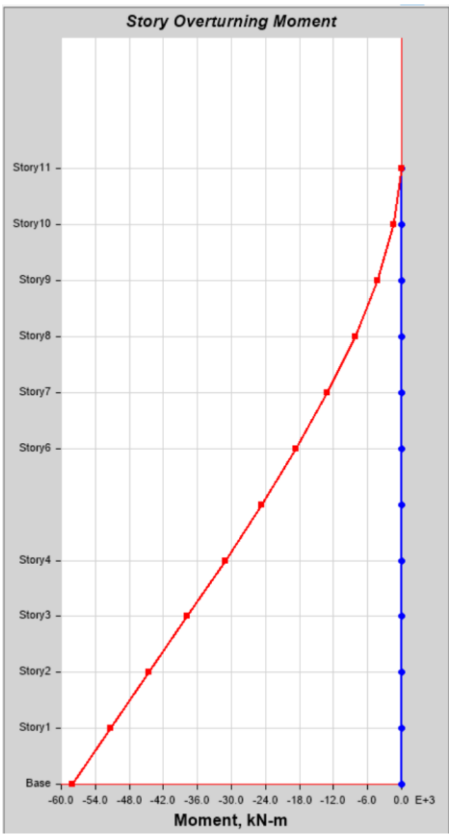

Fig 15: Storey Overturning Moment under EQ-X Load Conditions

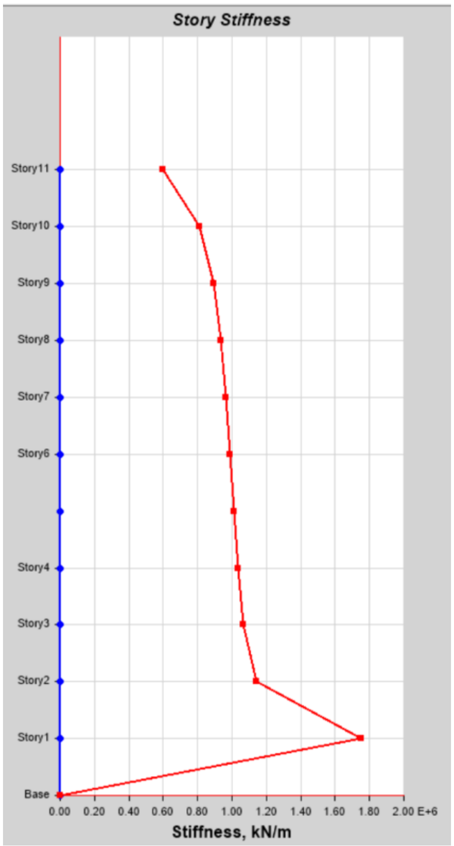

Fig 14: Storey Stiffness under EQ-Y Load Conditions

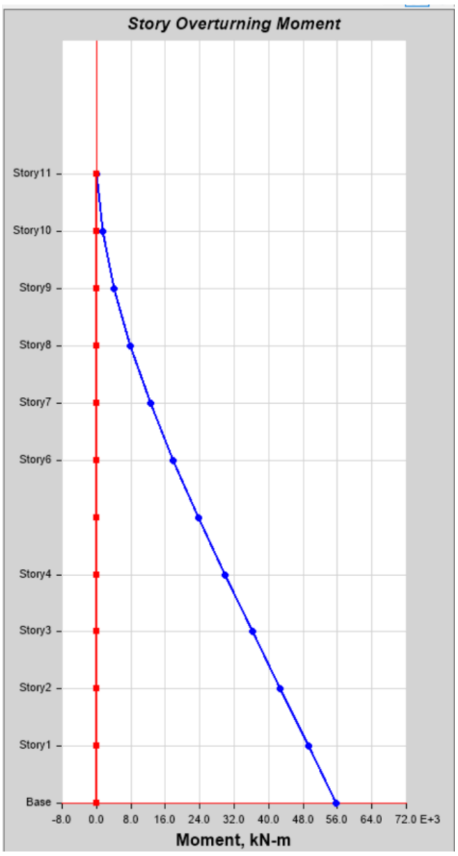

Fig 16: Storey Overturning Moment under EQ-Y Load Conditions

Structural analysis is performed to determine, how the building responds to the assigned load cases. The software calculates forces, stiffness, displacements, shear, drifts and other important parameters.

Table 6: Plan Irregularity detection

Irregularity	IS 1893 Limit	Irregularity presence
Torsional Irregularity	Max storey displacement > 1.2 × average storey displacement	present
Re-entrant Corner	Projection > 15% of plan	present
Diaphragm Discontinuity	Opening >50% stiffness change	Not present
Out-of-Plane Offset	Elements not in same plane	Not present
Non-Parallel Systems	Not parallel to main axes	Not present

CONCLUSION

The present study evaluates the seismic response of an L-shaped G+11 reinforced cement concrete (RCC) building with particular emphasis on torsional irregularity. The analysis carried out using ETABS, in accordance with IS 1893 (Part 1): 2016, indicates that torsional irregularity is present in the structure due to the asymmetric distribution of mass and stiffness. The results show non-uniform displacement and storey drift across the plan, with higher values observed at edge regions, confirming the existence of significant torsional effects under seismic loading.

Furthermore, the L-shaped configuration introduces re-entrant corners, which act as critical zones of stress concentration and increased deformation. These regions exhibit higher displacement and drift compared to other parts of the structure, making them more vulnerable during seismic excitation. The combined effect of torsional irregularity and re-entrant corner presence significantly influences the overall structural performance. Therefore, careful consideration of these factors is essential in the analysis and design of irregular buildings to ensure safety and improved seismic resistance.

FUTURE SCOPE

- Study effect of vertical irregularities in L-shaped buildings
- Perform time history analysis for more realistic seismic response
- Investigate behavior under different soil conditions
- Analyze effect of increasing building height (G+15, G+20, etc.)
- Study impact of shear walls and bracing systems on torsional response
- Evaluate performance with different material grades.

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