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Study on Torsion Behaviour of Asymmetric Buildings Under Seismic Loads Using Etabs

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Abstract

Torsion of asymmetric building is one of the most frequent causes of structural damage and failure during strong ground motions. Torsion in buildings during earthquake shaking may be caused from a variety of reasons, the most common of which are irregular distributions of mass and stiffness. This paper deals with the understanding of behaviour of structure under asymmetric plan and hence study the influence of torsional moment effect on the behaviour of structure. The procedure involves the equivalent static analysis, time history analysis and response spectrum analysis as per IS 1893 (Part 1): 2002 for the asymmetric buildings of height G+9 and G+11 and an effort is made to study the effect of seismic loads on them to determine torsional moments, base shear, displacement and time period and their capacity and demand is evaluated using ETABS 9.7.4 version. Torsional irregularity check is done for both the buildings with varying heights. It is observed that the drift values for both the structures were within the permissible limits and are safe against torsion.

Keywords: Torsion, Base shear, Storey displacements, Torsional irregularity, Moment

Introduction

An earthquake is the vibration, now and then violent to the earth's surface that takes after the release of energy in the earth's crust.. This vitality can be produced by a sudden separation of portions of the earth's crust, by a volcanic ejection or even by a man made blast. The separation of the crust causes most damaging seismic tremors. Torsion reactions in structures arises from two sources i.e., Eccentricity in the mass and stiffness distributions, creating a torsion reaction combined with interpretation reaction and torsion emerging from accidental causes, incorporating instabilities in the masses and stiffness, the differences in coupling of the structural foundation with the supporting earth or rock underneath and wave propagation impacts in the seismic movements that give a torsion contribution to the ground, and also torsion movements in the earth itself during the earthquake [1].

Recent earthquakes have demonstrated that the irregularities in plan, elevation, distribution of mass, stiffness and strengths may cause serious damage in structural systems. However, an exact assessment of the seismic behaviour of irregular buildings is quite difficult and a complicated problem. Torsional methods of motions are transcendent in structures with L-, X-and Y-plan shapes, which ought to be avoided with suitable choice of structural configuration. Corner to corner interpretation methods of motions are transcendent in structures with L-and X-plan shapes, which ought to be stayed away from with appropriate changes in structural configuration [2].

Drift: Drift is the maximum lateral displacement of the structure with respect to total height or relative inner-storey displacement. The overall drifts index is the ratio of maximum roof displacement to the height of the structure, and inner-storey drift is the ratio of maximum difference of lateral displacements at top and bottom of the storey divided by the storey height.

Storey drift: Storey drift is the drift of one level of a multi-storey building relative to the level below. It is calculated by considering two storey levels.

Torsion irregularity: Torsional irregularity ought to be considered when most extreme story drift (or between story float) toward one side of the structure transverse to an axis (2 δ) is more than 1.2 times the normal of the story drift (or between story floats) at the two ends of the structure. Torsional irregularity is intended to reflect a broad behavioural issue encompassing not only drift, but distribution of forces.

Material properties

Property	Value
Young's modulus of (M30) concrete, E	27.386x106 KN/m²
Young's modulus of (M25) concrete, E	25x106 KN/m²
Density of Reinforced Concrete	25KN/m³

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Assumed Dead	1.5KN/m²
load intensities Dead load Live load (Rooms)	3 KN/ m²

Member properties

Member	**Value**
Length x Width	35m x 24m
No. of storeys	9 and 11
Storey height	3m
Beam dimensions	400x500m
Column dimensions	m 300x600m
Slab thickness	150mm
Thickness of main wall	200mm
Support conditions	Fixed

Load calculations

1. Self-weight comprises of the weight of beams, columns and slab of the building.

2. Dead load: Wall load, Parapet load and floor load (IS 875(Part1))

a) Wall load = (unit weight of brick masonry X wall thickness X wall height)

= 20 kN/m3 X 0.230m X 3m = 13.8 kN/m (acting on the beam)

b) Wall load (due to Parapet wall at top floor) = (unit weight of brick masonry X parapet wall thickness X wall height) = 20 kN/m3 X 0.115m X 0.90m

3. Live load:

Floor load: 4kN/m2 and Roof load: 2 kN/m2 (IS 875 (Part 2) acting on beams

4. Seismic Load: Seismic zone: IV (Z=0.36), Soil type:II,

Importance factor: 1,

Response reduction factor: 5,

Damping: 5%. IS 1893(Part-1):2002.

Here Seismic load is considered along two directions EQ-length and EQ-width.

Performed analysis in etabs

Two asymmetric L-shaped buildings with varying number of storeys are considered and are modelled using ETabs [3].

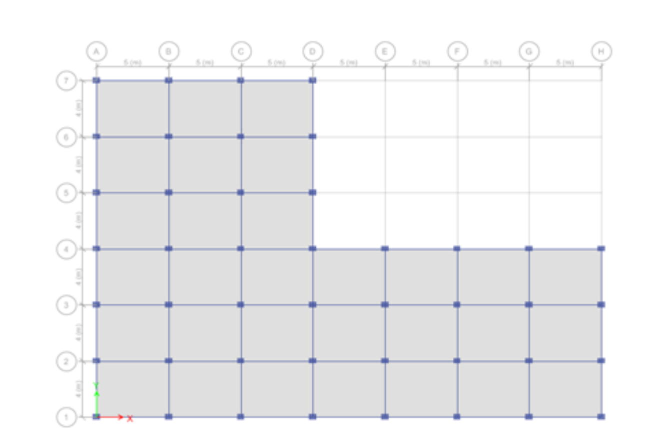

Figure1: ETABS Modelling plan view.

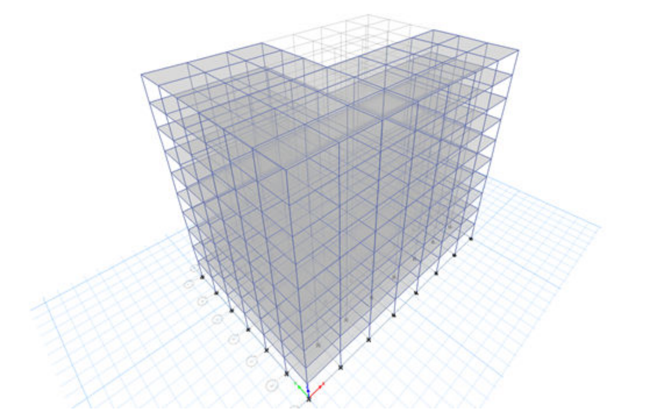

Figure 2: 3-D view of L-shaped building.

Storey Level	Wi (kN)	hi (m)	Wihi ^2/ (1000)	(Wihi^2)/(∑Wihi^2)
9	7200	32.4	6480.2	0.238
8	8100	27	5904.3	0.217
7	8100	24	4665.4	0.171
6	8100	21	3572.9	0.131
5	8100	18	2624.2	0.096
4	8100	15	1822.3	0.067
3	8100	12	1166.4	0.042
2	8100	9	656.1	0.024
1	8100	6	291.6	0.01
∑			27183	0.996

Table 1: Lateral Load Distribution with Height by the static method.

IS 1893 response spectrum curve and time history analysis curve for zone IV are obtained.. The damping value of 5% is specified to generate the response spectrum curve. The scale factor of 9.81 (i.e. g) is assigned.

Drift and storey drift calculation

MODEL-1

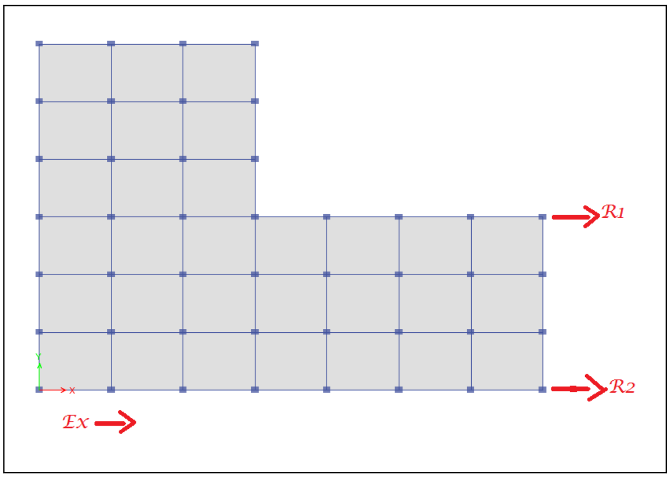

Figure 3: Earthquake force along X-Direction.

Drift: For the calculation of drift for earthquake force Ex acting along X- direction, R1 and R2 values are obtained from the ETABS analysis i.e.,

For top storey i.e., 9th storey, R1= 126.9 mm and

R2 = 125 mm

Similarly along Y-direction, R3 = 152.9 mm

R4 = 148.5 mm

According to code, the total drift is limited to H/250

Where, H = Height of the building = 32.4 m

Permissible drift value is 264 mm.

Similarly, the drift values for two models are noted for all the other storeys and are observed to be within the permissible limits. As the obtained drift values are within the permissible limits, the building is safe in both the directions [4].

From the obtained drift values maximum displacement i.e., maximum drift is noted in both X and Y directions. As the height of the building increases, the drift value increases and thus the top most storey undergoes maximum displacement and results in more torsionally irregular Table 2.

Storey	Drift in X-direction
	MODEL 1
G1	22
G2	38.4
G3	53.9
G4	69.1

G5	83.6
G6	92.1
G7	109.2
G8	119.3
G9	126.9

Table 2: Storey vs Drift in X- direction for EQX.

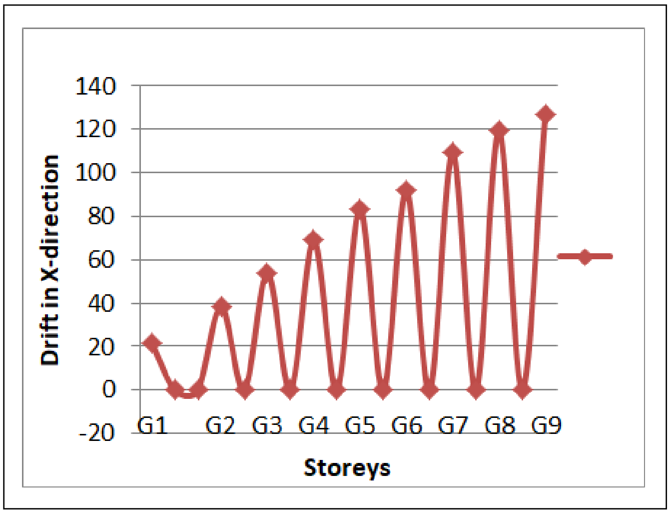

Figure 4: Storey Vs Drift graph.

Storey	Max. Displacement or Drift in Y-Direction Model-1
G1	26.5
G2	45.7
G3	64.1
G4	82.3
G5	99.7
G6	116.1
G7	130.8
G8	143.3
G9	152.9

Table 3: Storey vs Drift in Y- direction for EQY.

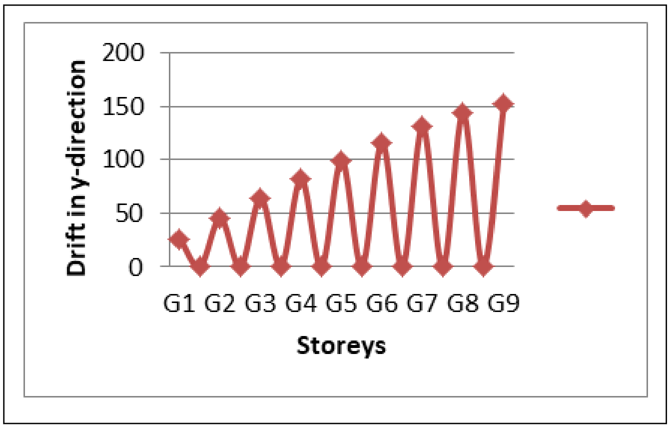

Figure 5: Storey Vs Drift graph.

Storey drift: Storey drift is the drift of one level of a multi-storey building relative to the level below. It is calculated by considering two storey levels.

For storey-9, the displacement values obtained are

R1= 126.9 mm and

R2 = 125 mm

For storey-8,

R1= 119.3 mm and

R2 = 117.6 mm

For seismic force acting along X-direction, storey drift for 9th floor = d1-d2

= 125 - 117.6

= 7.4 mm

Similarly storey drift values for both the models at each storey are calculated manually both for the seismic force acting along X and Y directions and are compared with E-tabs analysis values.

Torsional irregularity check

When an earthquake force Ex acts along X-direction, the maximum drift or displacements occur at R1 and R2 respectively [5]. Regarding the torsional irregularities, most of the codes have similar provisions essentially based on principles of the well-known standards of IBC06 (2006), UBC97 (1997) and ASCE7-10 (2010).According to ASCE7-10(2010),torsional irregularities are explained under type 1a and 1b irregularities in table 12.3-1 which is applicable for rigid and semi rigid structures.

Torsional irregularity exists if, dmax/davg> 1.2

Extreme torsional irregularity exists, if dmax/davg > 1.4

Results analysis

The G+9 and G+11 buildings of model-1 and model-2 are checked for their torsional irregularity and are safe in both the directions i.e., X and Y. Similarly the storey drift for each storey is calculated by considering two storeys. As the height of the building increases, the building experiences more torsion irregularity.

Conclusion

This work demonstrates that the torsional response in structures subjected to earthquake may be influenced by many parameters. Some of these effects as the ultimate top displacement, ductility. In terms of capacity the lateral yielding strength of the asymmetrical structure is higher than the one of the symmetrical structure in both directions. Time period and base shear calculation by using equivalent static method is approximately equal with response spectrum method in ETABS. As the height of the building increases, the building experiences more torsion irregularity. As the height of the building increases, the drift values increases and results in higher tosion irregularity. In general, top most floor undergoes maximum displacement. A comparison between two structures with increase in number of storeys is done and it is observed that as the number of storeys increases, building experiences more torsion.

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