SEISMIC RESPONSE OF ASYMMETRIC BUILDING IN TORSION

[1]Darshan J.Parmar , [2]Prof. K. C. Koradia

[1] PG student, [2] Assistant Prof

Structural Engineering,Civil Department

Darshan Institute of Engineering and Technology , Rajkot,India.

Abstract— Structural asymmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to the potential for translational-torsional coupling in the structures dynamic behavior which can lead to increased lateral deflections, increased member forces and ultimately the buildings collapse. In this paper the inelastic seismic behavior and design of asymmetric multistoried buildings are studied. The effects of torsion on buildings are investigated. The buildings with setbacks are analyzed for torsion. Study also shows that there is increase in shear, in columns and the columns at outer frame need some special attention**.** and to calculate the eccentricity and torsion in the asymmetric building like a C,T,L and I shape Building. And compare with the symmetric building. To perform Response spectrum Analysis ,Torsion Moment ,time period ,story displacement and story Drift.

Key Words: Centre of mass, Centre of stiffness, Eccentricity, Torsion, Time Period, Story Displacement, Story drift, Response Spectrum Analysis.

I.INTRODUCTION:

At present scenario many buildings are asymmetric in plan and/or in elevation based on the distribution of mass and stiffness along each storey throughout the height of the building. However an accurate evaluation of the seismic behaviour of irregular buildings is quite difficult and a complicated problem Due to the variety of parameters and the choice of possible models for torsionally unbalanced systems, there is as yet no common agreement or any accurate procedure advised by researchers on common practice in order to evaluate the torsional effects. Seismic damage surveys and analyses conducted on modes of failure of building structures during past severe earthquakes concluded that most vulnerable building structures are those, which are asymmetric in nature. Asymmetric building structures are almost unavoidable in modern construction due to various types of functional and architectural requirements.

Torsion in buildings during earthquake shaking may be caused from a variety of reasons, the most common of which are non-symmetric distributions of mass and stiffness Modern codes deal with torsion by placing restrictions on the design of buildings with irregular layouts and also through the introduction of an accidental eccentricity that must be considered in design.

The lateral-torsional coupling due to eccentricity between centre of mass (CM) and centre of rigidity (CR) in asymmetric building structure generates torsional vibration even under purely translational ground shaking during seismic shaking of the structural systems, inertia force acts through the centre of mass while the resistive force acts through the centre of rigidity as shown in Fig.1

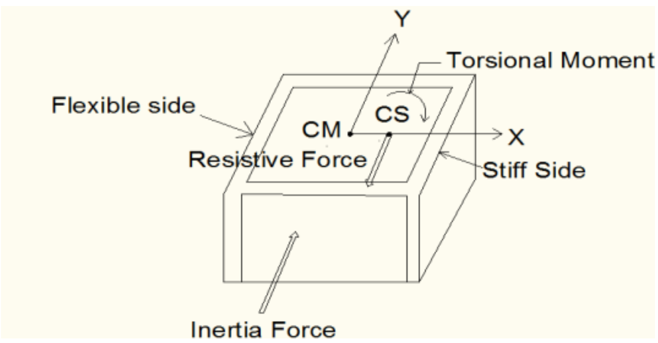
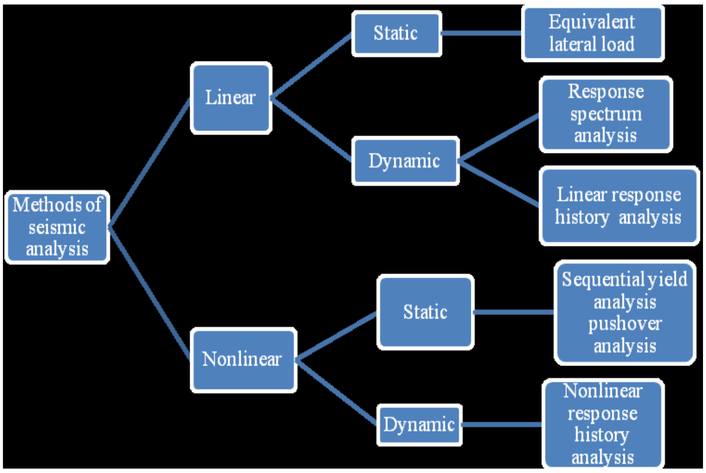


Figure 1.1 Eccentricity System

METHODS OF SEISMIC ANALYSIS



Equivalent Static Analysis

Along any principal direction, the total design lateral force or design base shear is given in terms of design horizontal seismic coefficient and seismic weight of the structure. Design horizontal seismic coefficient depends on the zone factor of the site, importance of the structure, response reduction factor of the lateral load resisting elements and the fundamental period of the structure. Following procedure is generally used for the Equivalent Static Analysis

Determination of base shear (VB) of the building-

VB= Ah x W (1.1)

Where, Ah = the seismic response coefficient

$A_h = (Z * I * S_a) / (2 * R * g)$ (1.2)

Vertical Distribution of Seismic Forces

$Q_i = V_b \, (W_i H_i^2) / \Sigma^n_{j=1} W_j H_j^2$ (1.3)

The lateral force, F (kip or KN), induced at any level shall be determined from the following equations

Response Spectrum Method

This is required in many building codes for all except for very simple for very complex structures. The structural response can be defined as a combination of many modes computer analysis can be used these modes for a structure For each mode, and then they are combined to estimate the total response of the structure. In this the magnitude of forces in all directions is calculated and then effects on the building is observed.

Following are the types of combination methods:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

II. Modeling of Asymmetric building.

In this study G+5, G+10, G+15 and G + 20 reinforced concrete building with selected for performing linear dynamic analysis. This reinforced concrete frame is a real building with slight modification to simplify the analysis and design process. I Will Perform the response spectrum analysis for different models like a symmetric building and asymmetric building like a T,L,I and C .Both Side X-direction & Y-Direction both side 3m * 3m c Bay frame considered. And same way here we have to created totally 20 building model are designed..

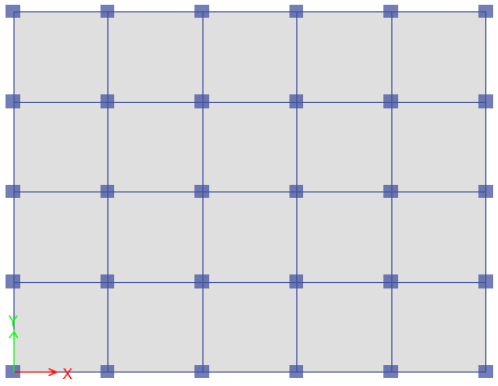


Figure: 1..1 Modeling of Frame

And to analysis and design a different building model in such fixed condition and to design a building model and calculate the torsion moment, Response spectrum load ,Time Period ,Story Displacement ,Story Drift and Eccentricity.

Types of Irregularities: These irregularities are categorized in two types: 1. Vertical Irregularity a)Stiffness Irregularities – Soft Story b)Mass Irregularities: c)Vertical Geometric Irregularity 2.Horizontal/Plan Irregularity.

In order to design buildings in earthquake prone regions, seismic codes present different torsional provisions according to the seismicity of the region. Seismic provisions introduce design eccentricity to estimate the value of the torsion in buildings as accurately as possible. The dynamic eccentricity results from the irregular mass, resistance or stiffness distribution of the system, while the accidental eccentricity is expected to account for factors not explicitly considered, such as uncertain estimation of the mass, stiffness and rotational component, which is believed to play a highly important role. This accidental eccentricity, which is a fraction of the plan dimension, b, is considered in design to be on either side of the center of stiffness. The coefficient, proposed by different seismic building codes is equal to 0.05 or 0.1. The design eccentricity ed1 is generally presented as; ed1 = α esi + βbi, ed2 = esi – βbi.

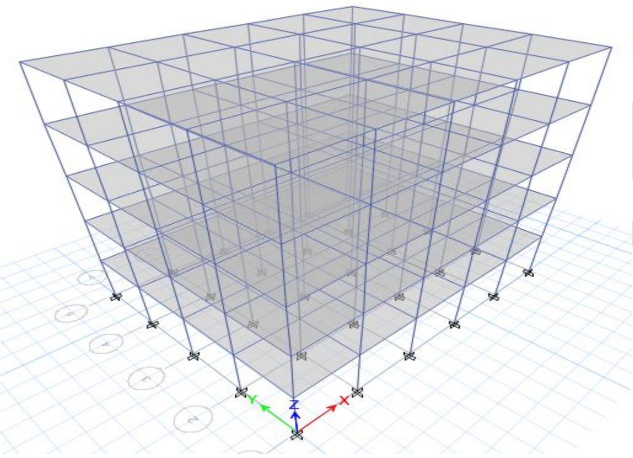
Table: 2.1 Data for building Analysis

Grade of concrete	M 25
Grade of steel	Fe 415
Soil type	Hard
Support Condition	Fixed
Beam(mm)	230 * 600
Column(mm)	600 * 600
Slab thickness	200 mm
Wall thicknes	230 mm

Bay Dimension	3 m * 3 m
Location	Rajkot
Live Load	2 Kn/m2
Floor finish	1 Kn/m2
Response Reduction Factor	5
Importance factor	1
Damping	5 %
Zone Factor (z)	IV(0.24)

Load Combinations

(1)1.5(DL+IL)
(2)1.2(DL+IL+ELX)
(3)1.2(DL+IL-ELX)
(4)1.2(DL+IL+ELY)
(5)1.2(DL+IL-ELY)
(6)1.5(DL+ELX)
(7)1.5(DL-ELX)
(8)1.5(DL+ELY)
(9)1.5(DL-ELX)
(10)0.9DL + 1.5 ELX
(11) 0.9DL - 1.5 ELX
(12) 0.9DL + 1.5 ELY
(13) 0.9DL -1.5 ELY



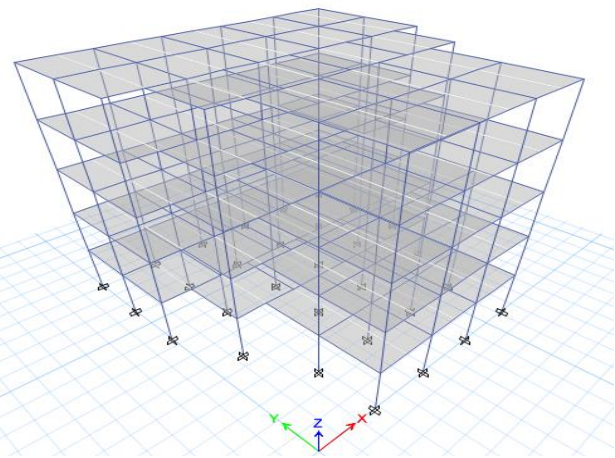


Figure: 2.2 3-D view of G + 5 Symmetric building

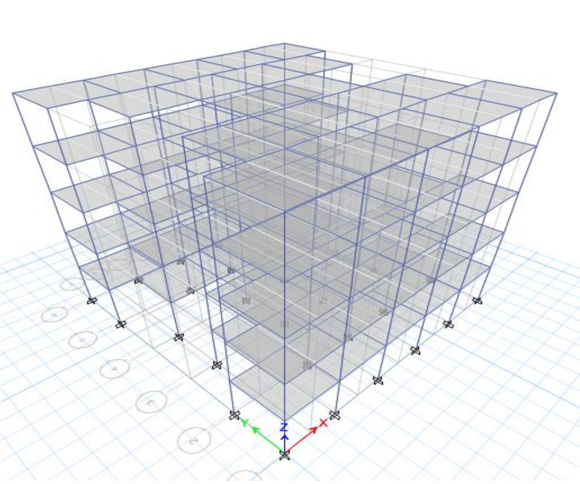


Figure: 2.3 3-D view of G + 5 T shape building

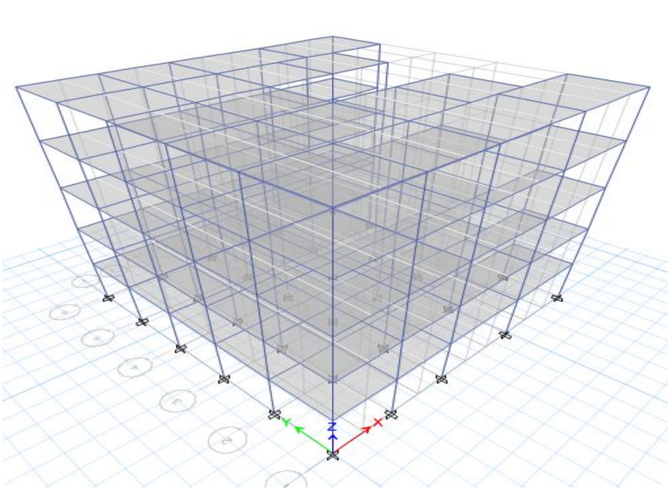


Figure: 2.4 3-D view of G + 5 I shape building

Figure: 2.5 3-D view of G + 5 C shape building

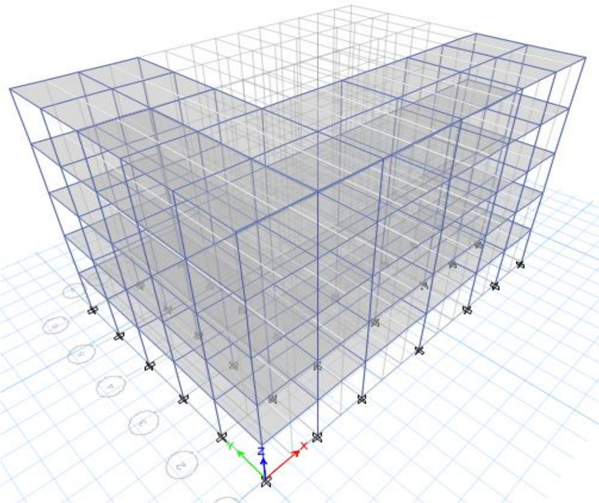


Figure: 2.6 3-D view of G + 5 L shape building

III. Result Discussion.

(1)Response Spectrum Base Shear.

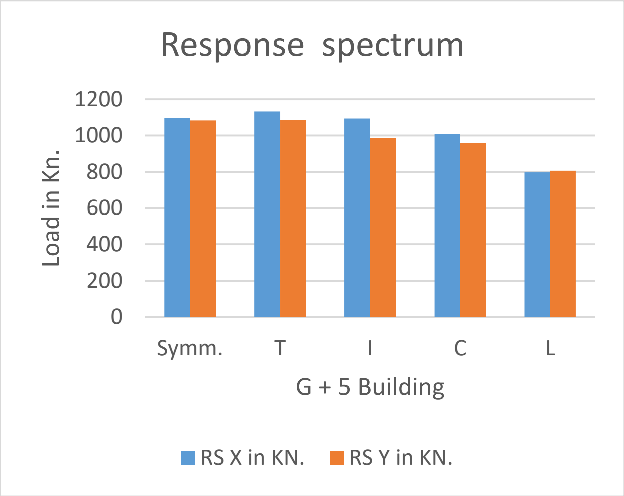


Fig. 3.1 RS Load in X- Dir and Y-Dir. For G + 5 Story

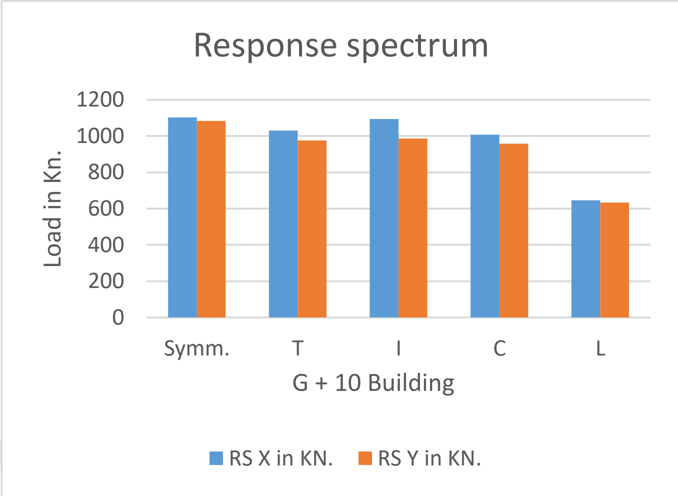


Fig. 3.2 RS Load in X- Dir and Y-Dir. For G + 10 Story

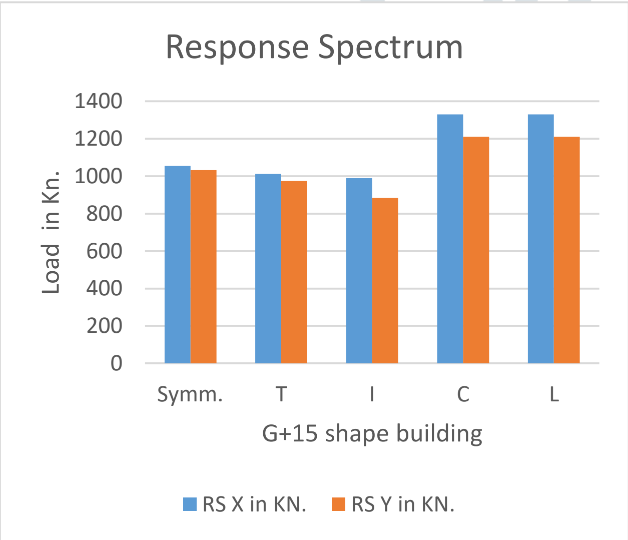


Fig. 3.3 RS Load in X- Dir and Y-Dir. For G + 15 Story

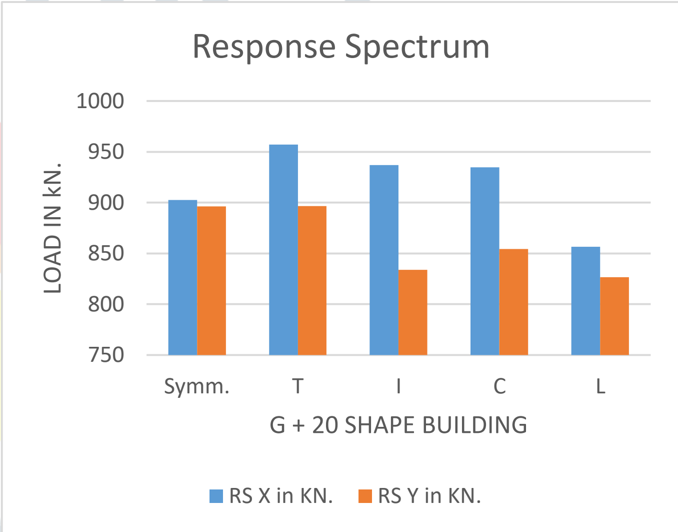


Fig. 3.4 RS Load in X- Dir and Y-Dir. For G + 20 Story

(2)Torsion Moment.

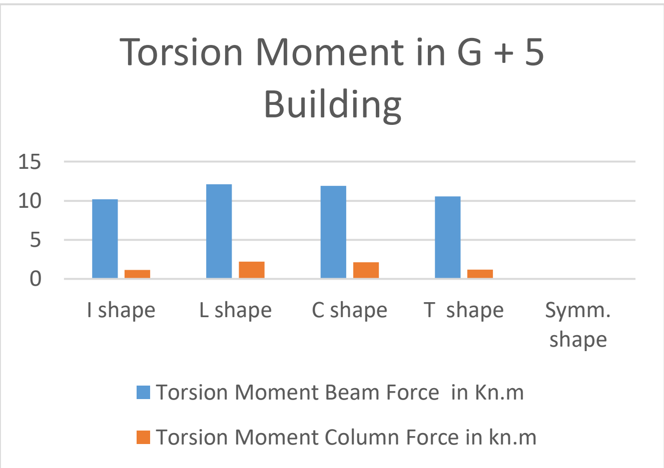


Fig. 3.5 Torsion Moment in G + 5 Building

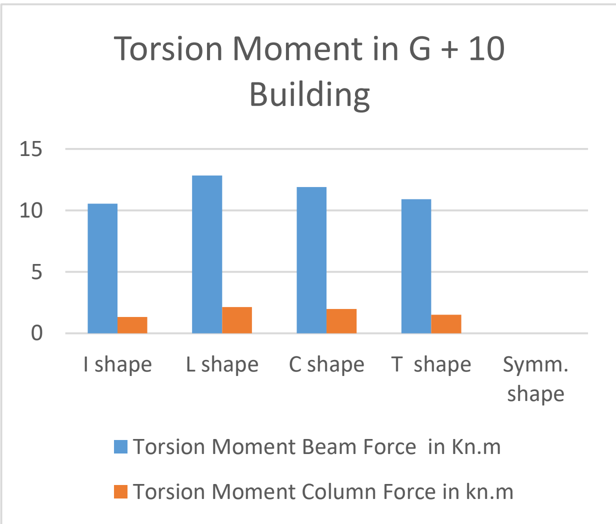


Fig. 3.6 Torsion Moment in G + 10 Building

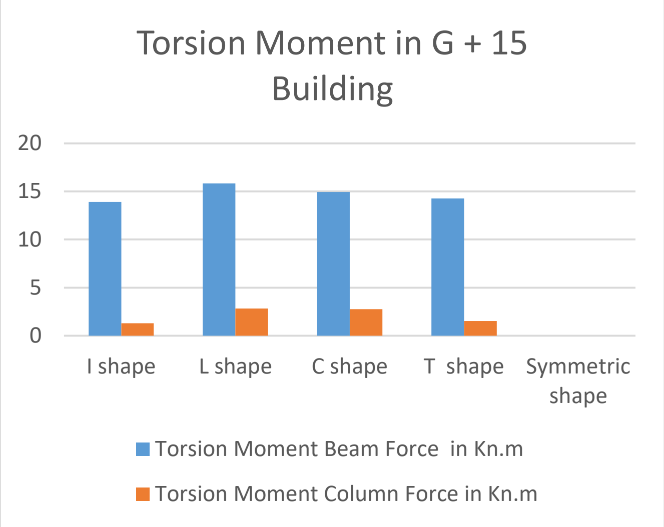


Fig. 3.7 Torsion Moment in G + 15 Building

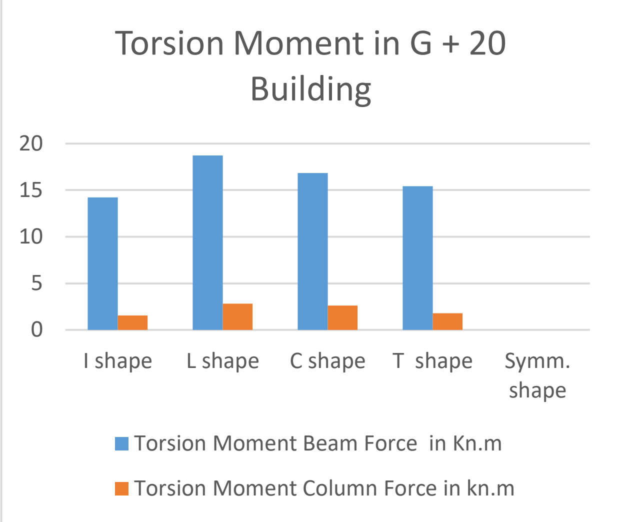


Fig. 3.8 Torsion Moment in G + 20 Building

(3) Time Period

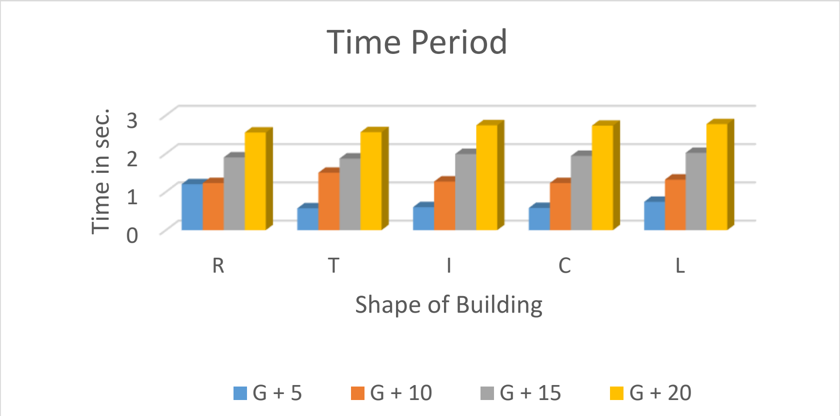


Fig. 3.9 Time Period for All Building

(4) Story Displacement

In Asymmetric structural system total displacement is due to displacement due to bending + displacement due to shear.

$\delta_{total} = \delta_{bending} + \delta_{shear}$.

$$\delta_{total} = \frac{qH^4}{8EI} + \frac{qH^2}{2GA}\zeta$$

Where, H = Beam length (i.e. Building height)
A = Area of the tall building c/s
I = Moment of inertia of the building
E = Axial moduli of the section
G = Shear moduli of the section
ζ = shear modification factor

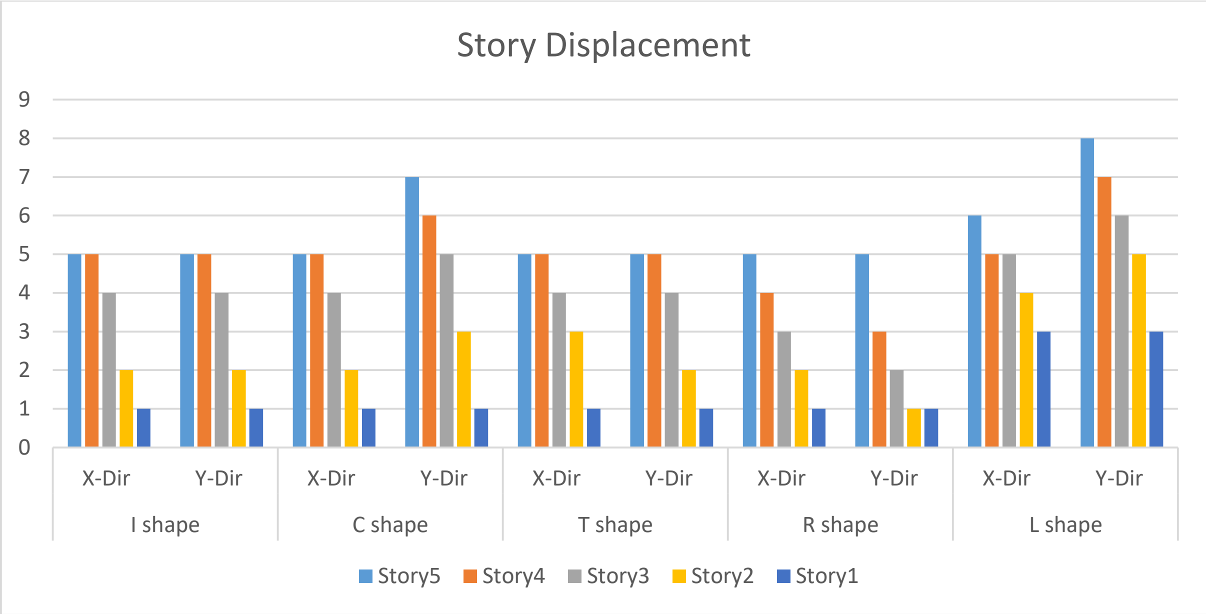


Fig. 3.10 G + 5 Story Displacement

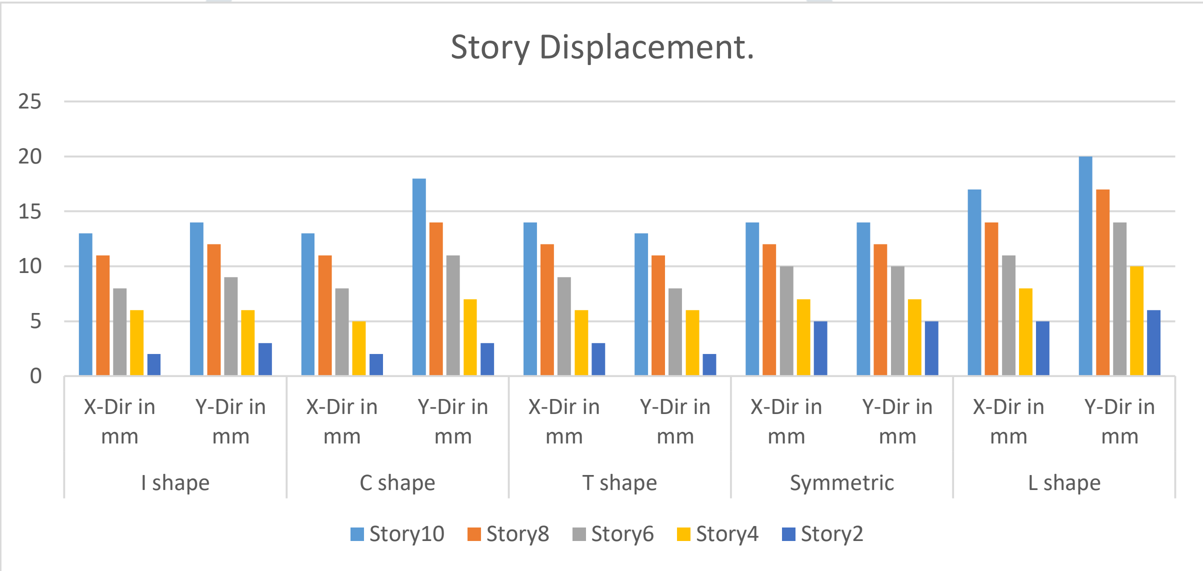


Fig. 3.11 G + 10 Story Displacement

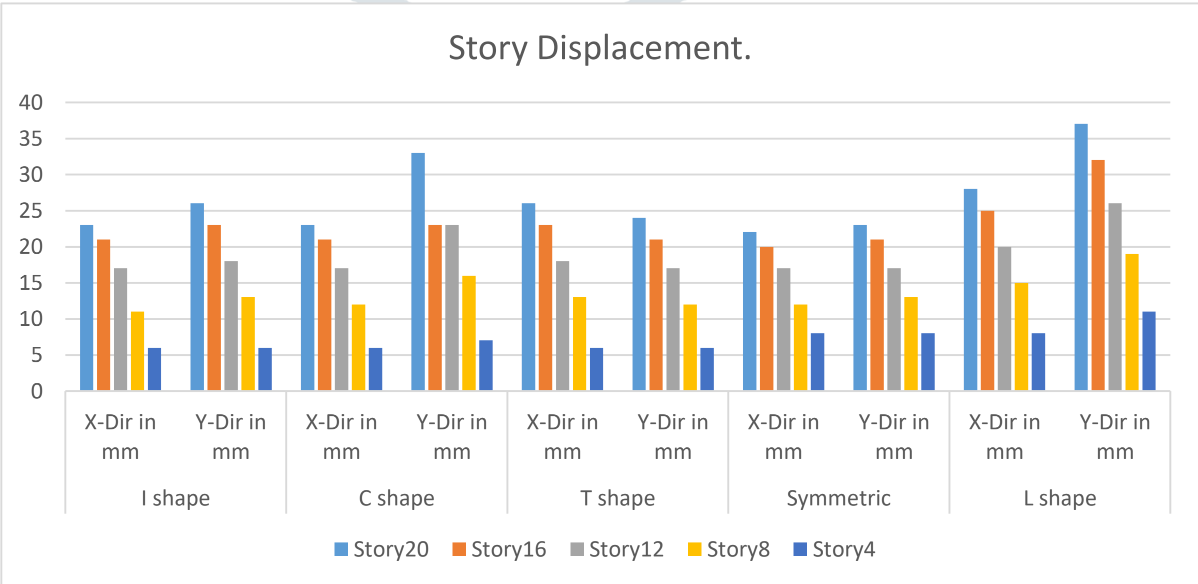


Fig. 3.12 G + 15 Story Displacement

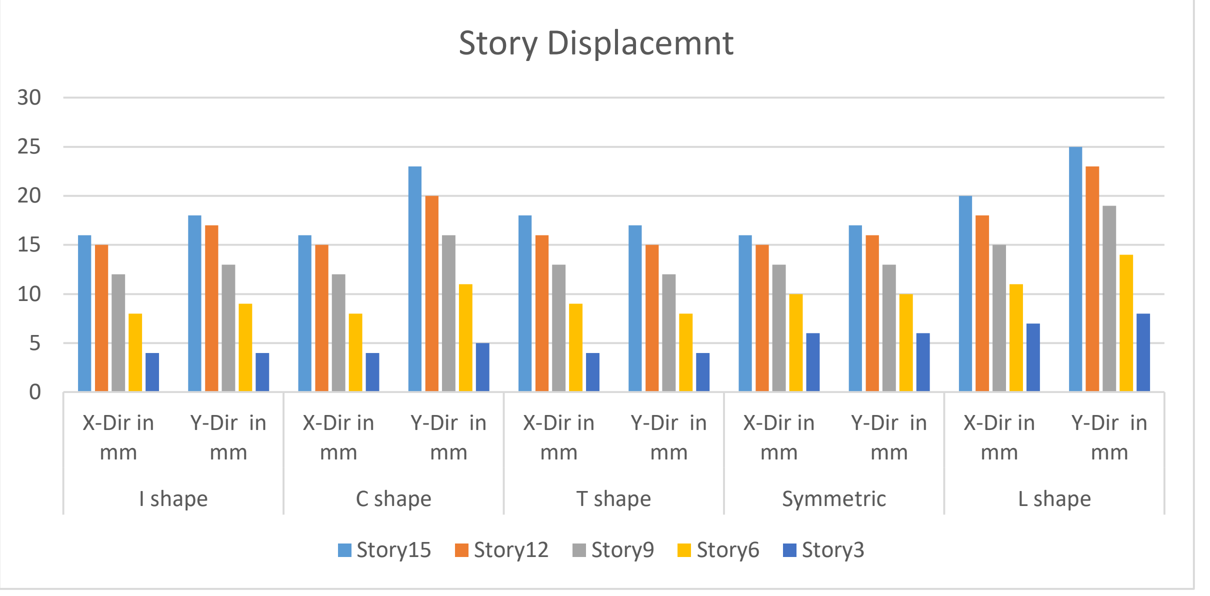


Fig. 3.13 G + 20 Story Displacement

(5) ECCENTRICITY

The dynamic eccentricity results from the irregular mass, resistance or stiffness distribution of the system, while the accidental eccentricity is expected to account for factors not explicitly considered, such as uncertain estimation of the mass, stiffness and rotational component, which is believed to play a highly important role. This accidental eccentricity, ea, which is a fraction of the plan dimension, b, is considered in design to be on either side of the center of stiffness. The coefficient, proposed by different seismic building codes is equal to 0.05 or 0.1. The design eccentricity ed1 is generally presented as;

ed1 = α esi + βbi ,ed2 = δ_{esi} – βbi.

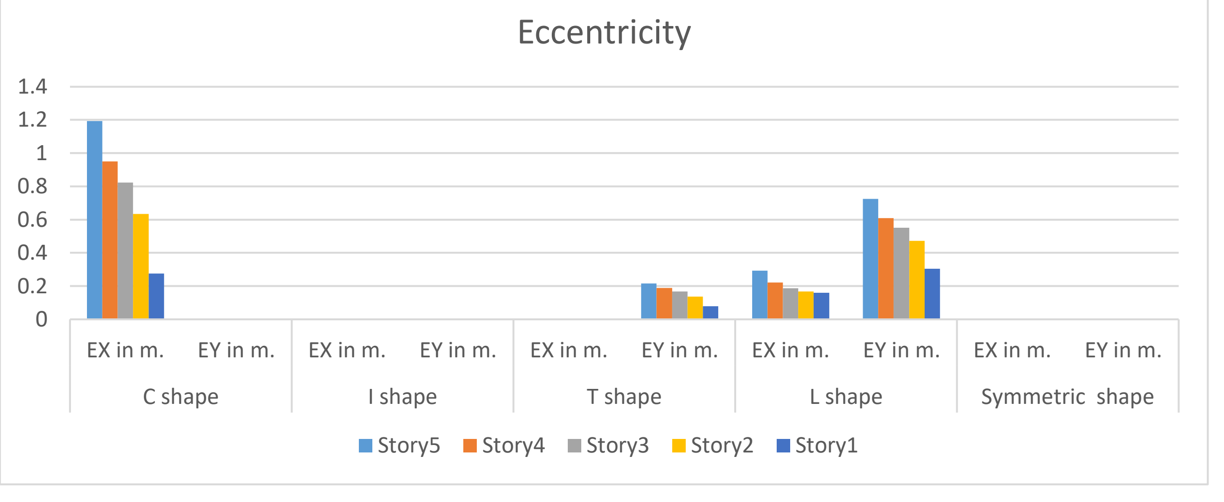


Fig. 3.14 G + 5 Story Eccentricity

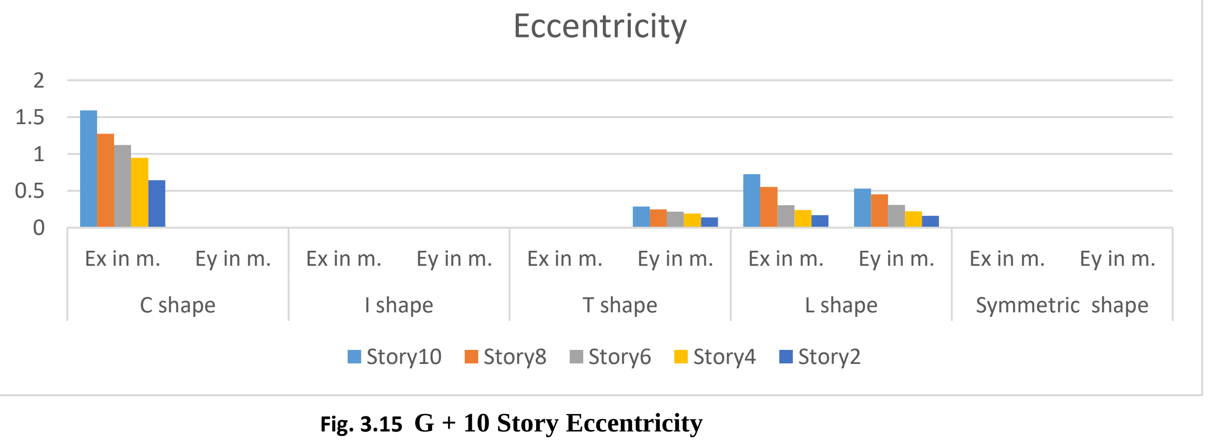


Fig. 3.15 G + 10 Story Eccentricity

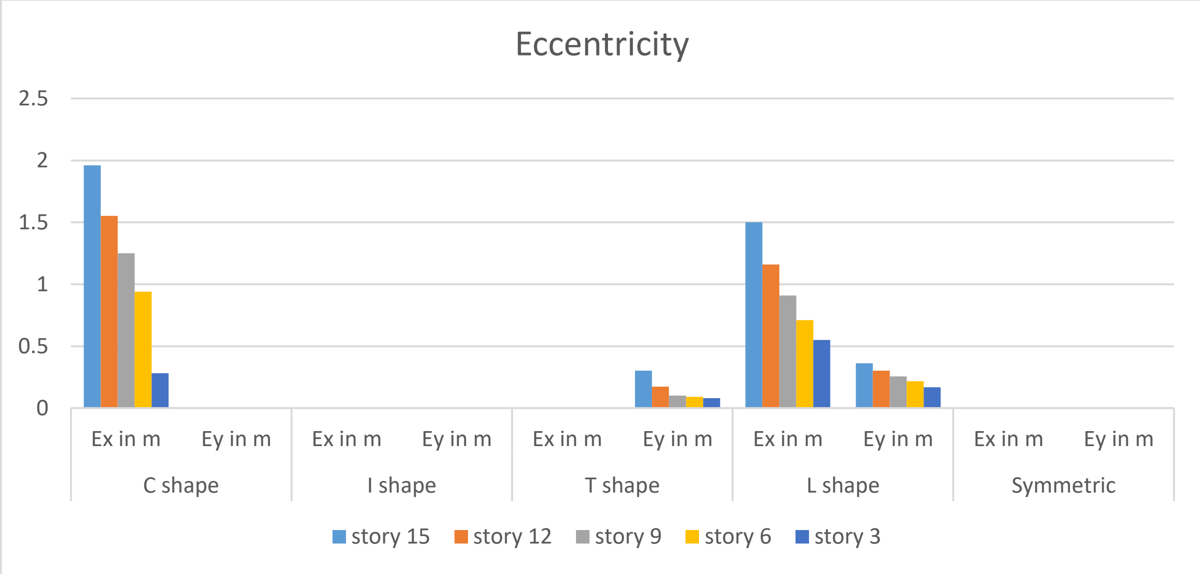


Fig. 3.16 G + 15 Story Eccentricity

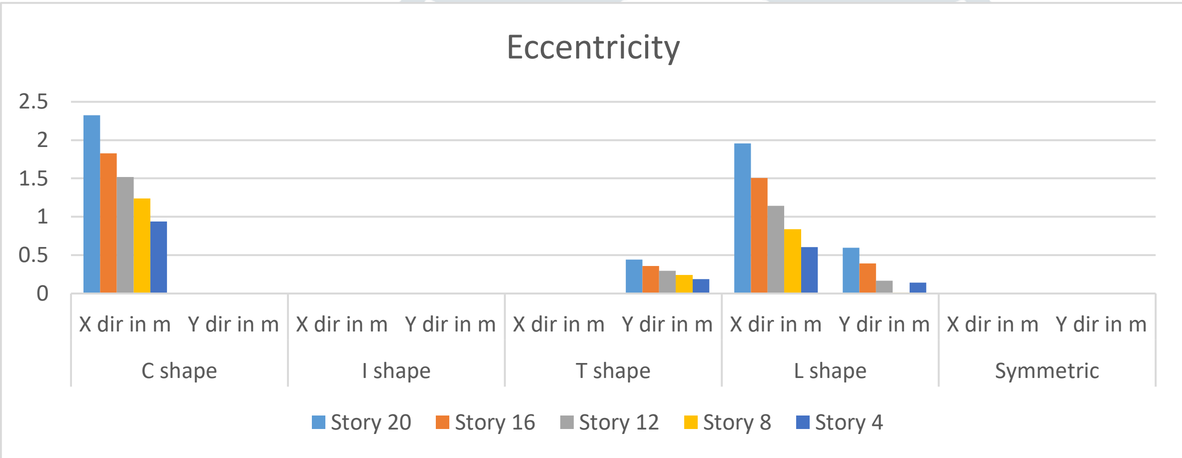


Fig. 3.17 G + 20 Story Eccentricity

(6) story drift

Drift is the relative story displacement due to acting of lateral load. Story drift may be defined as a "Drift of one level of multi storey building relative to the level below.

As per the Indian standards IS 1893:2002 drift limit is set to 0.004 times height of the structure. Drift ratios are calculated for the maximum displacement response. From results it is observed that in all cases storey drift is less the IS 1893:2002 code specified permissible limit.

$$\text{(Story Drift)} = \frac{\text{Lateral Displacement at } (i+1)^{th} \text{ level - Lateral Displacement at } (i)^{th} \text{ level of story}}{\text{Height of story between } (i+1)^{th} \text{ and } (i)^{th} \text{ level.}}$$

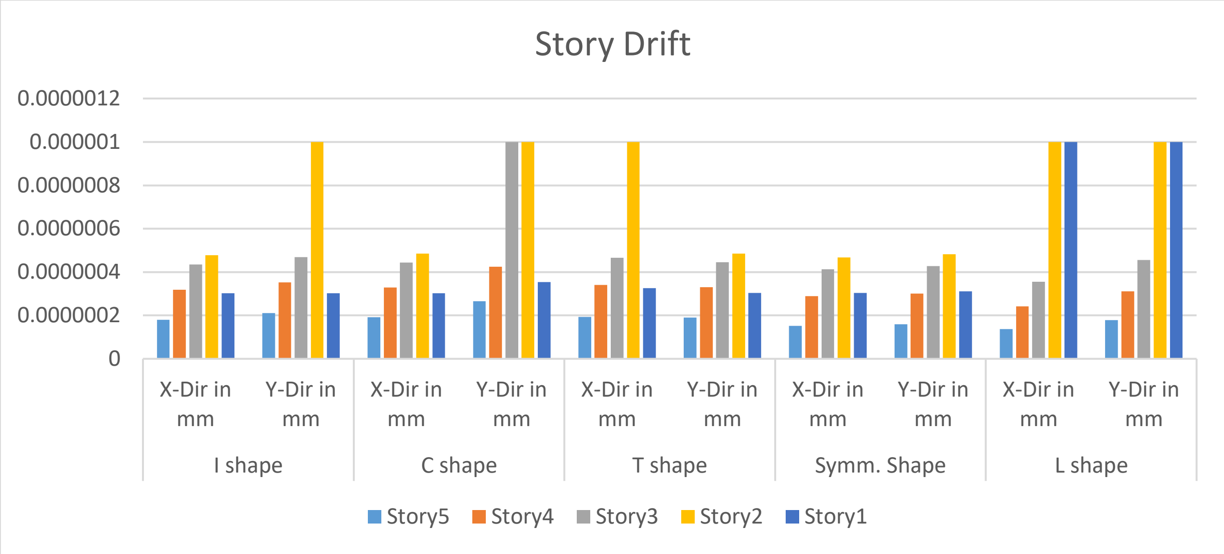


Fig. 3.18 G + 5 STORY DRIFT

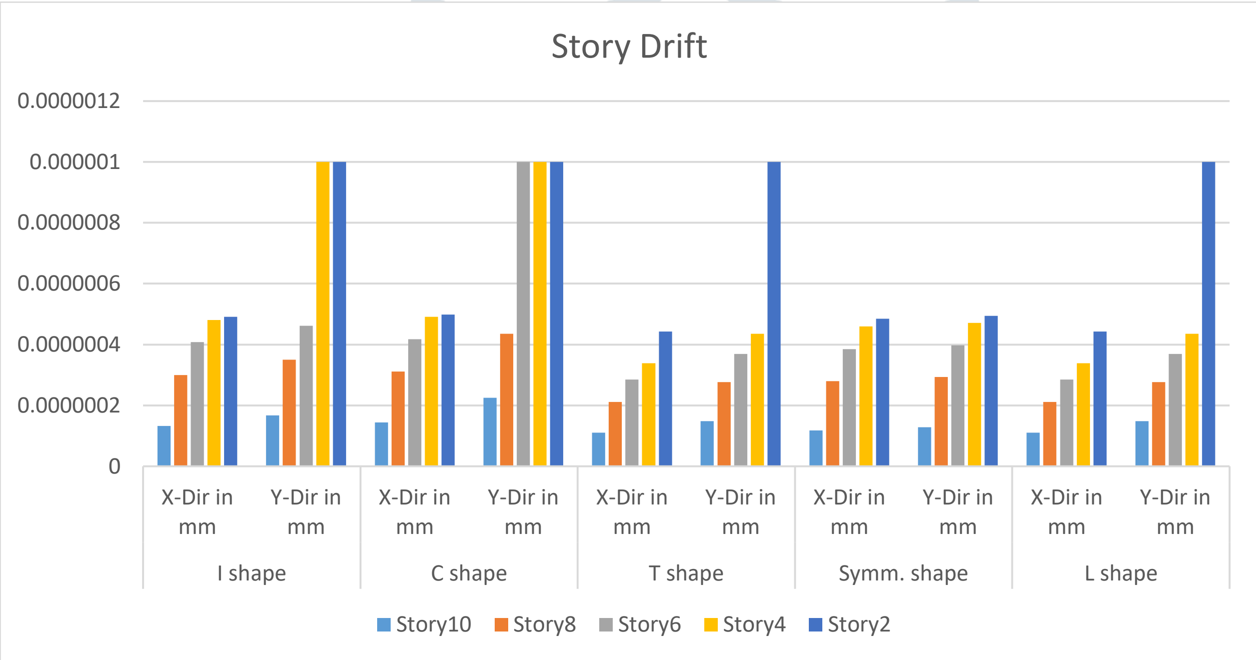


Fig. 3.19 G + 10 STORY DRIFT

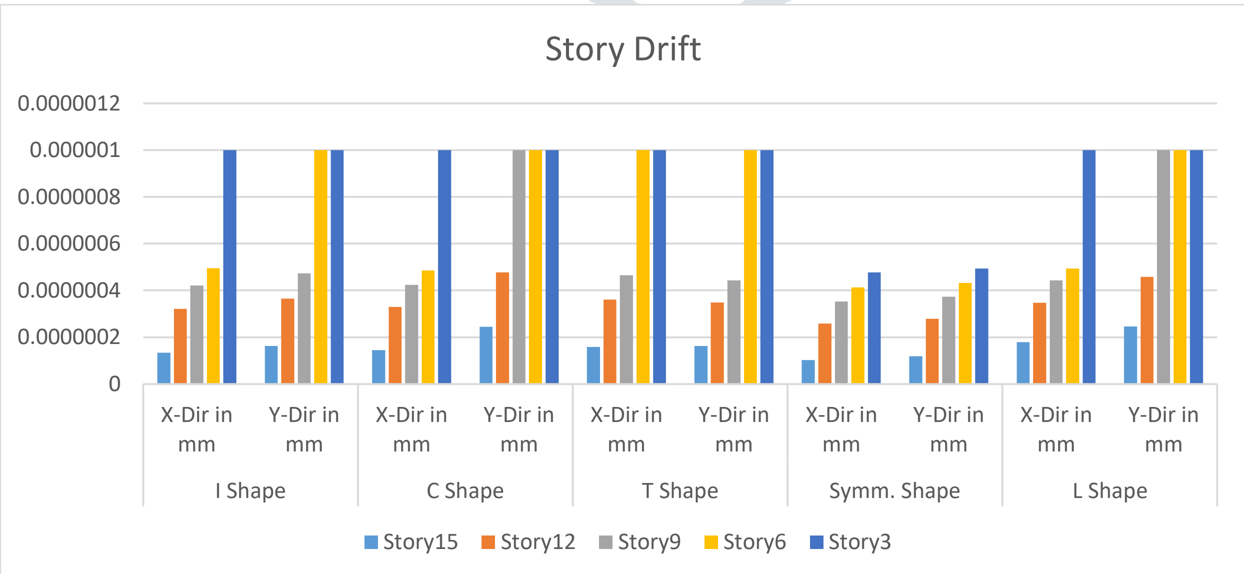


Fig. 3.20 G + 15 STORY DRIFT

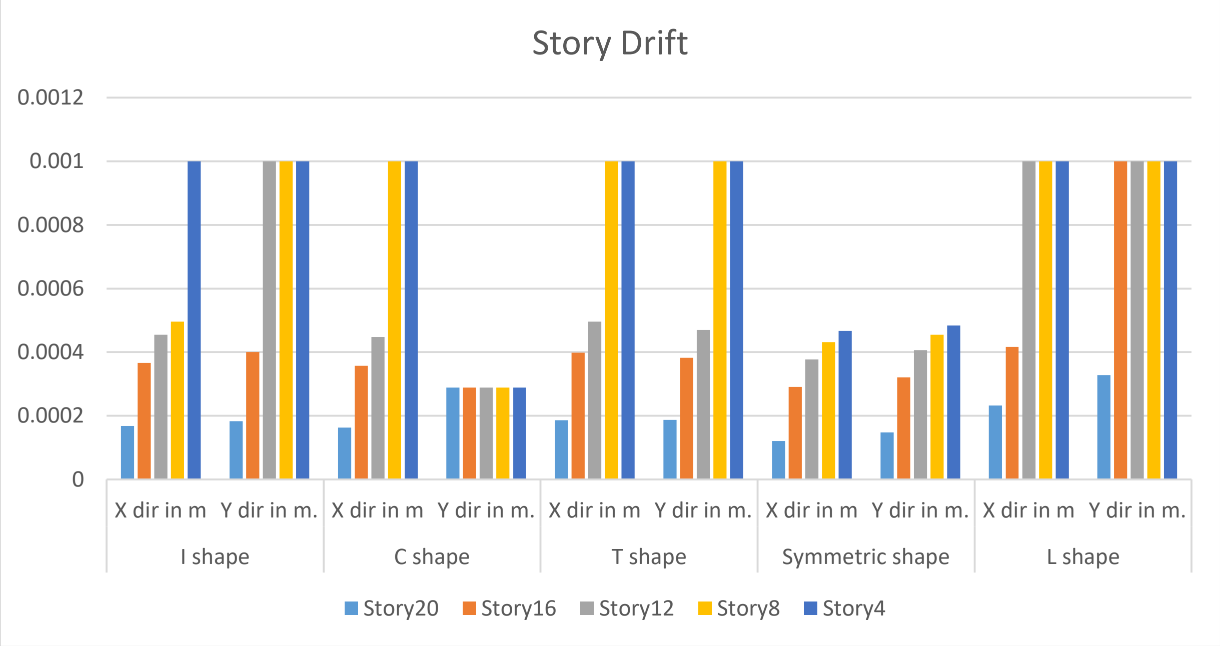


Fig. 3.21 G + 20 STORY DRIFT

IV. Conclusion

1. Asymmetric Building L shape Building generate more torsion moment as compared to other asymmetric Building.

2. The columns at plinth level are not affected much due to torsion than the columns above the plinth.

3. Time period and base shear calculation by using equivalent static method is approximately equal with response spectrum method in E tabs.

4. While comparing the Torsional Moment (TM) in beam the result shows that for asymmetrical building TM is more than symmetrical, therefore it is necessary to design the beam and column for torsional moment.

5. By using equivalent static method and Response spectrum method in Etabs it shows that base shear and roof displacement for asymmetrical building is more than symmetrical building.

References

[1] Rakesh K. Goel "seismic Response of Asymmetric systems: Energy-Based Approach ", Journal Of Structural Engineering. ASCE November (1997) vol- 123 No.11 pp.1444-1453.

[2] S. N. Tande, J. S. Dali and S. C. Potnis , "Seismic Behavior of Torsion Susceptible Irregular Building Frames",ICESE2012.

[3] Sekhar Chandra Dutta and Rana Roy "Seismic Demand of Low-Rise Multistory Systems with general Asymmetry",Journal of Engineering Mechanics,January(2012) ,vol38,No-7 pp.311-318. Earthquake Resistance Design of Structures,- Dr.S.K.Duggal.

[4] Sekhar Chandra Dutta and Rana Roy "Seismic Demand of Low-Rise Multistory Systems with general Asymmetry",Journal of Engineering Mechanics,January(2012) ,vol38,No-7 pp.311-318.

[5]R. Tabatabaei and H. Saffari ,"Evaluation of the Torsional Response of Multi story Buildings using Equivalent Static Eccentricity ", Journal Of Structural Engineering ,ASCE, vol-137 , (2011).pp.862-868.

[6] Wai K. Tso "Static Eccentricity Concept For Torsional Moment Estimations ", Journal Of Structural Engineering .ASCE vol-117 No-3, march(1990).pp.1199-1212.

[7] Young-Soo and Bryan Stafford Smith " Assessment of Translational-Torsional coupling in Asymmetric Uniform Wall-frame Structures".Journal Of Structural Engineering (1995),vol-121 ,No-10, pp.1488-1496.

[8] Explanatory handbook on codes for Earthquake Engineering,SP-22.

[9] IS 1893 Part 1 (2002) Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.

[10] **Dynamics of structure theory and applications to Earthquake Engineering,- A.K.Chopra.**