Comparative Study of Symmetric & Asymmetric L- Shaped & T-Shaped Multi-Storey Frame Building Subjected to Gravity & Seismic Loads with Varying Stiffness

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Abstract

In present scenario, most of the buildings are often constructed with irregularities such as soft storey, torsional irregularity, unsymmetrical layout of in-fill walls, vertical and plan irregularity, etc. Past earthquake studies shows that the most of the RC buildings having such irregularities were severely damaged under the seismic ground motion. This paper presents an overview of performance of the torsion ally balanced and unbalanced buildings also called as symmetric and asymmetric buildings subjecting to seismic analysis. Three building models for L-shaped and T-shaped building are considered for study, which are constructed on medium soil in seismic zone Ш of India (as per IS: 1893-2002[9]), one symmetric and 3 asymmetric in stiffness distribution. Static analysis (for gravity and seismic loads). It is concluded that the performance of the models in which the stiffness of plan size considered is found better when compared with the models in which the stiffness of plan size ignored.
Keywords: Asymmetric Structure, Stiffness of plan size, storey displacement, Seismic Performance

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I. Introduction

Buildings may be considered as asymmetric in plan or in elevation based on the distribution of mass and stiffness along each storey, throughout the height of the buildings. Seismic Behavior of asymmetric building may cause interruption of force flow and stress concentration. Due to this, there is produce of torsion in the building which leads to increase in shear force, lateral deflection and ultimately causes failure. Asymmetry can be reason for a buildings poor performance under sever seismic loading. The building with vertical setbacks and L, H, U or T shaped in plans which built as unit are more affected during seismic event. There is horizontal torsional effect on each arm arising from the differential lateral displacement of two ends of each arm. In this paper, inelastic seismic behavior of multistoried building with vertical setbacks is analyzed by IS code approach. The effect of torsion on building are analyzed. Designs of asymmetric multistoried building are studied. Study shows that there is increase in shear force due to torsion in column and increase in area of steel reinforcement in column particularly at the edge member of the building. Traditional code torsional provisions are based on the assumption that the stiffness of lateral force resisting elements (LFREs) is independent from their strength. These provisions are mainly based on building linear responses and they distribute strength among LFRESs by static equilibrium based on predefined stiffness. An alternative approach for designing asymmetric buildings is using proper configuration of centers. Proper configuration of centers is a promising technique to control asymmetric buildings torsional responses. To use this method in seismic design, one has to find centers proper configuration and then distribute strength among LFREs such a way that results to that proper configuration. In this study a new methodology for designing asymmetric buildings is proposed. This method instead of using traditional static equilibrium, distributes the strength freely among LFREs, then strength of some LFRES are adjusted in a way to shift centers to their proper locations. To evaluate the method against traditional torsional provisions, some building models are designed by both traditional and proposed method. A comparison of nonlinear dynamic responses of these models displays the ability of proposed method for limiting building torsional responses. 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.

A. *Objective of This Paper:*

1) To evaluate the more suitable asymmetrical structure for resisting the seismic load efficiently.

2) To analyze the response of asymmetrical building with varying stiffness subjected to gravity loads and seismic loading using STAAD V8i.
3) To carry out analysis of different types L-shaped and T- shaped to find out significant change in parameters such as displacement, Bending moments, and shear forces.

II. Work carried out

A G+15 and G+20 L-Shaped & T- Shaped building analysis is carried out using STAAD Pro V8i software. The seismic loads to be applied on the buildings are based on the Indian Standard. Building is analyzed according to IS456-2008 and earthquake loading is applied as per the recommendation of IS1893-2002. Different configurations in plan of buildings are selected such as T-Shaped & L-Shaped analyzed. The study is performed for seismic zone III as per IS1893-2002

Table – 1
Details of model data of the symmetrical building G+15

Sr No.	*Description*	*Parameter*
1	*Depth of foundation*	*2.0 m*
2	*No. of stories*	*G + 15*
3	*Type of building use*	*Residential*
4	*Floor to Floor height*	*3.0m*
5	*Seismic zone*	*III*
6	*Unit wt. of masonry wall*	*14kN/m3*
7	*Beam size*	*0.3 m x 0.5 m*
8	*Column size*	*0.5 m x 0.8 m*
9	*Thickness of slab*	*120 mm*
10	*Thickness of wall*	*230mm*
11	*Type of steel*	*Fe-415*
12	*Grade of concrete*	*M-20*

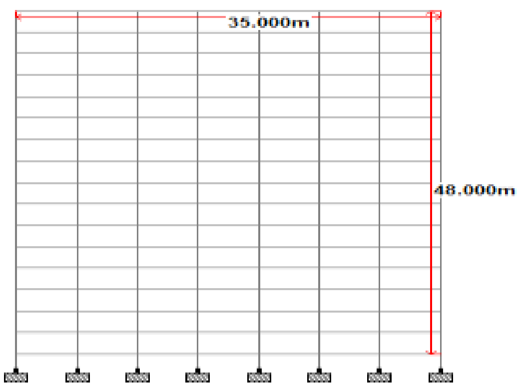


Fig. 1: Elevation of proposed structural frame

Table – 2
Details of model data of the symmetrical building G+20

Sr No.	*Description*	*Parameter*
1	*Depth of foundation*	*2.0 m*
2	*No. of stories*	*G + 20*
3	*Type of building use*	*Residential*
4	*Floor to Floor height*	*3.0m*
5	*Seismic zone*	*III*
6	*Unit wt. of masonry wall*	*14kN/m3*
7	*Beam size*	*0.3 m x 0.5 m*
8	*Column size*	*0.5 m x 0.8 m*
9	*Thickness of slab*	*120 mm*
10	*Thickness of wall*	*230mm*
11	*Type of steel*	*Fe-415*
12	*Grade of concrete*	*M-20*

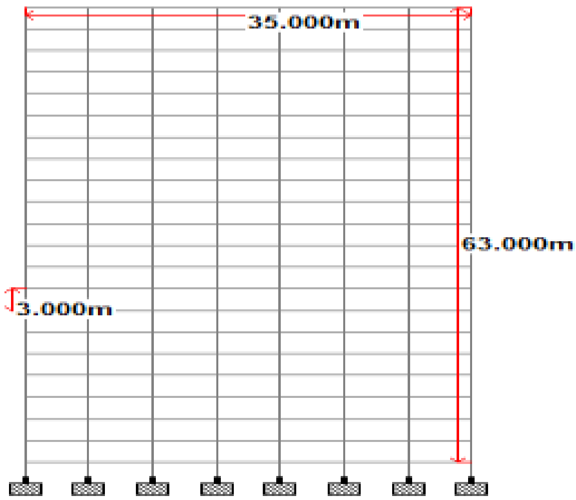


Fig. 2: Elevation of proposed structural frame

Table – 3
Details of model data of the symmetrical building

Sr No.	*Description*	*Parameter*
1	*Depth of foundation*	*2.0 m*
2	*No. of stories*	*G + 25*
3	*Type of building use*	*Residential*
4	*Floor to Floor height*	*3.0m*
5	*Seismic zone*	*III*
6	*Unit wt. of masonry wall*	*14kN/m3*
7	*Beam size*	*0.3 m x 0.5 m*
8	*Column size*	*0.5 m x 0.8 m*
9	*Thickness of slab*	*120 mm*
10	*Thickness of wall*	*230mm*
11	*Type of steel*	*Fe-415*
12	*Grade of concrete*	*M-20*

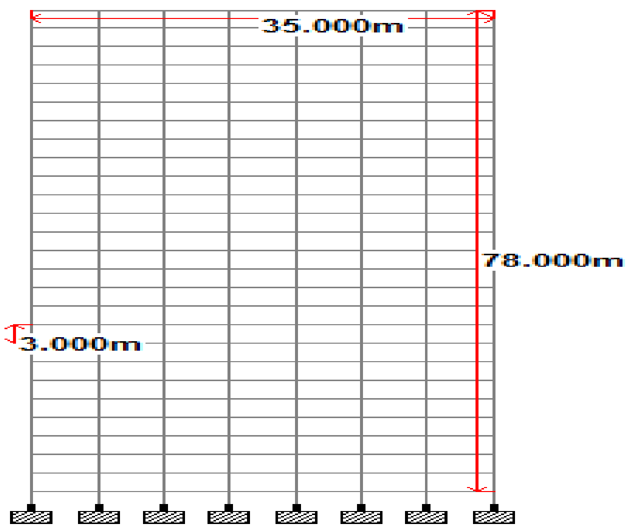


Fig. 3: Elevation of proposed structural frame

B. Modelling:

Building frame with the following geometrical types are considered for analysis in for seismic and gravity loading in each variation in plan size.

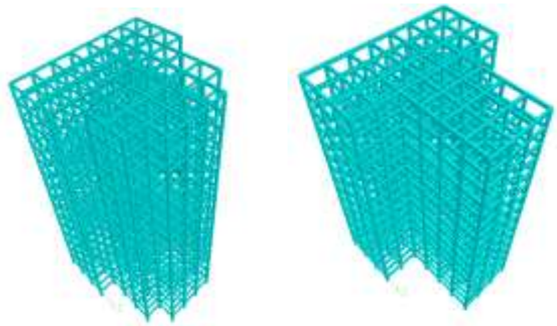


Fig. 4: Model 01- T-Shape 01 Model 02-T-Shape 02

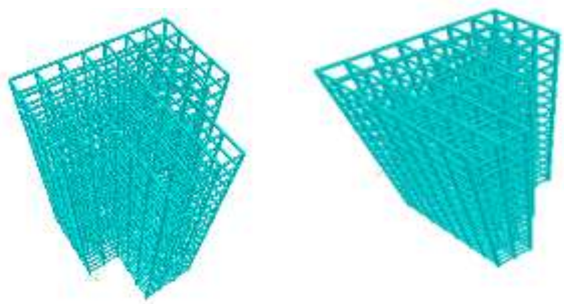


Fig. 5: Model 03 – T-Shape 03 Model 04 – L-Shape 01

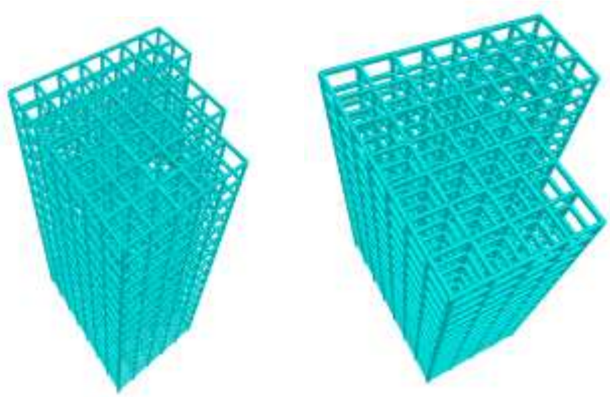


Fig. 6: Model 05- L-Shape 02 Model 06-L-Shape 03

III. RESULT

A. Maximum Lateral Displacements:

Table – 4
Maximum displacement in L-Shaped for G+15 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N*	*DISPLACEMENT IN Z-DIR^N*
Symmetrical	*247.638*	*270.383*
L-shape 1	*249.671*	*243.941*
L-shape 2	*255.694*	*262.549*
L-shape 3	*248.969*	*265.183*

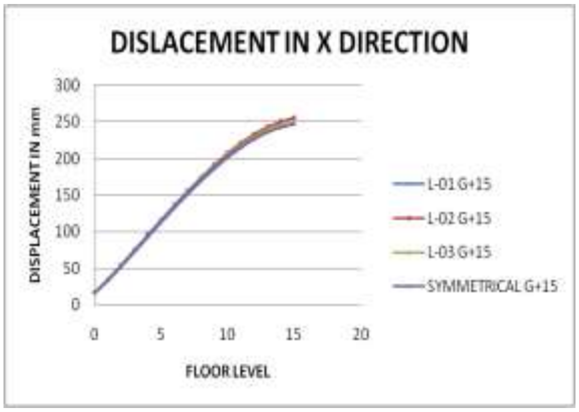


Fig. 7:

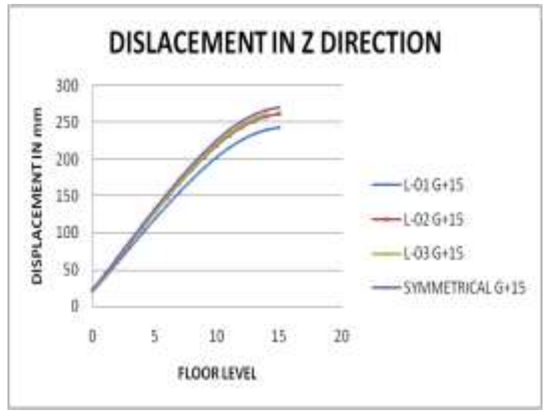
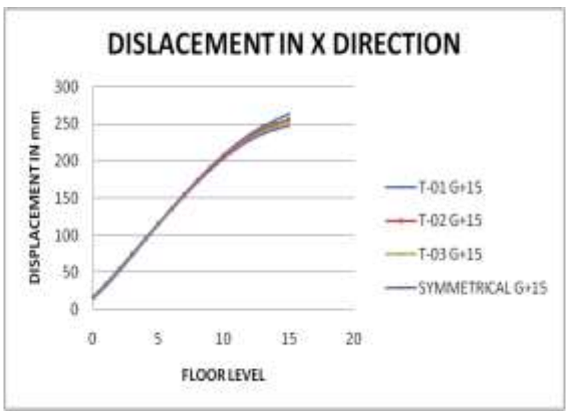


Fig. 8:

Table – 5
Maximum displacement in T-Shaped for G+15 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N^*	*DISPLACEMENT IN Z-DIR^N^*
Symmetrical	*247.638*	*270.383*
T-shape 1	*263.158*	*273.427*
T-shape 2	*255.348*	*273.727*
T-shape 3	*252.222*	*275.965*



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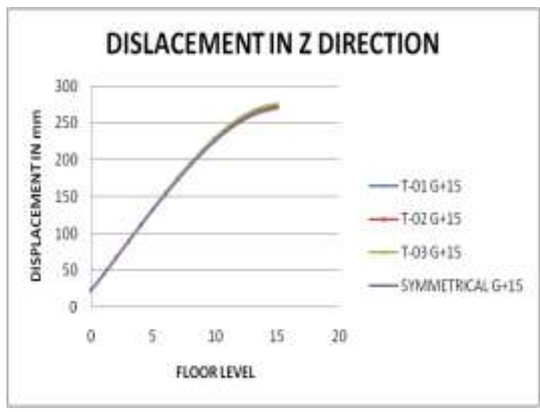
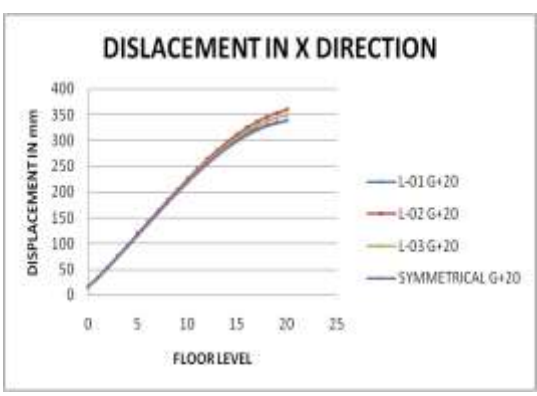


Fig. 10:

Table – 6
Maximum displacement in L-Shaped for G+20 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N^*	*DISPLACEMENT IN Z-DIR^N^*
Symmetrical	*339.013*	*371.983*
L-shape 1	*359.636*	*335.542*
L-shape 2	*349.097*	*359.636*
L-shape 3	*338.146*	*364.081*



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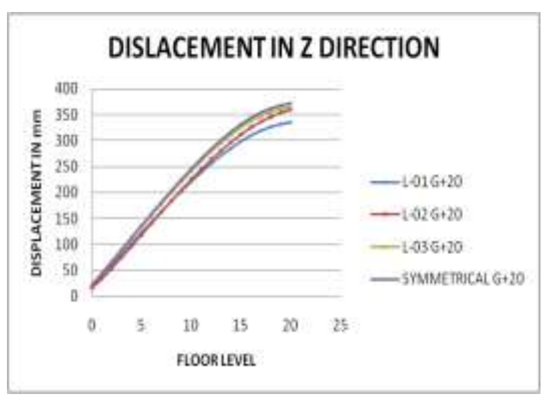


Fig. 12:

Table – 7
Maximum displacement in T-Shaped for G+20 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N*	*DISPLACEMENT IN Z-DIR^N*
Symmetrical	*338.146*	*371.983*
T-shape 1	*372.007*	*371.971*
T-shape 2	*357.821*	*373.901*
T-shape 3	*352.572*	*376.398*

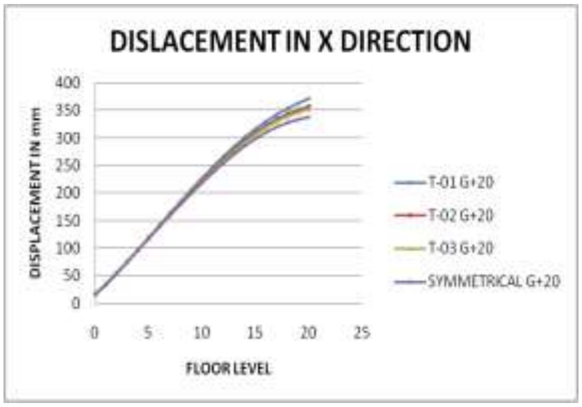


Fig. 13:

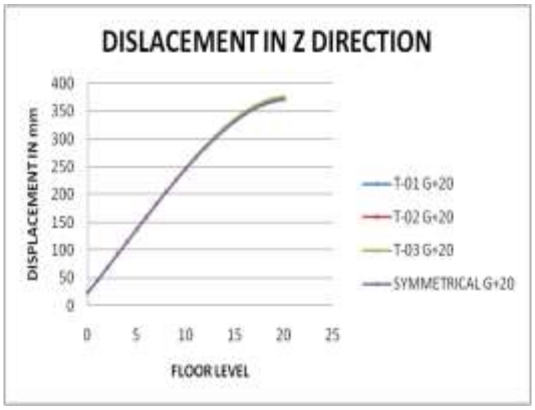


Fig. 14:

Table – 8
Maximum displacement in L-Shaped for G+25 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N*	*DISPLACEMENT IN Z-DIR^N*
Symmetrical	*434.761*	*479.589*
L-shape 1	*463.038*	*433.741*
L-shape 2	*477.127*	*464.127*
L-shape 3	*457.572*	*469.264*

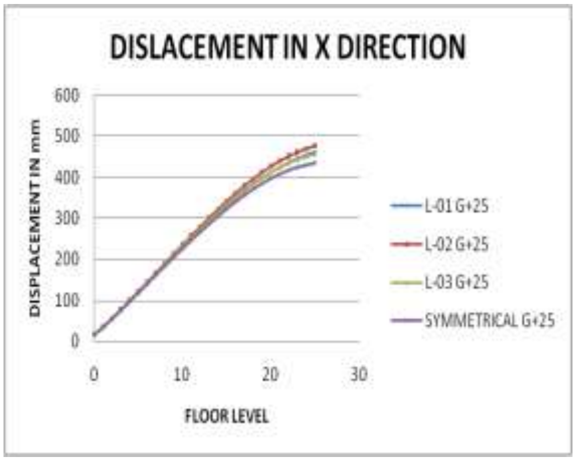


Fig. 15:

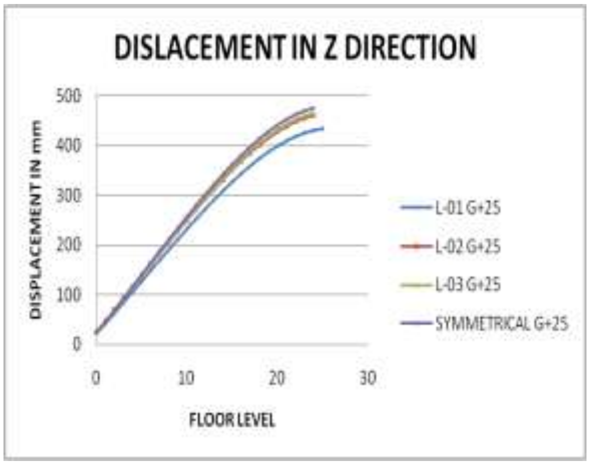
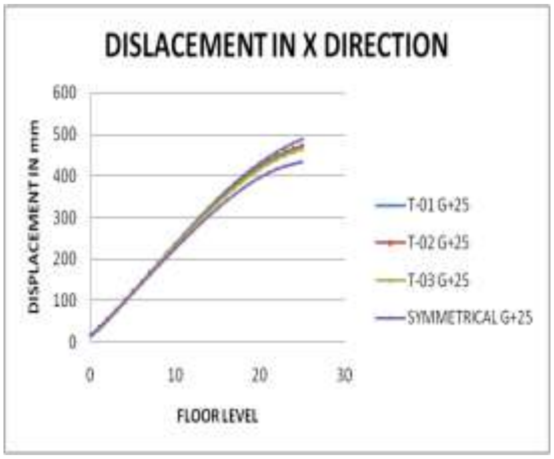


Fig. 16:

Table – 9
Maximum displacement in T-Shaped for G+25 building

STRUCTURE TYPE	*DISPLACEMENT IN X-DIR^N*	*DISPLACEMENT IN Z-DIR^N*
Symmetrical	*434.761*	*479.589*
T-shape 1	*489.895*	*477.224*
T-shape 2	*472.682*	*481.097*
T-shape 3	*465.671*	*483.888*



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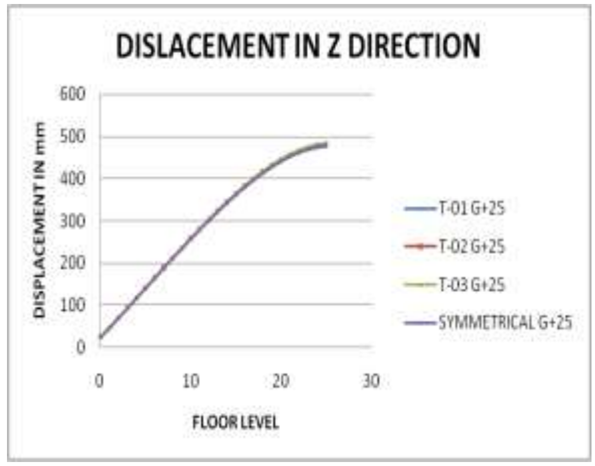

Fig. 18:

B. Maximum forces & Bending Moment in Column

Table – 10
Maximum Axial force in L-Shaped building

STRUCTURE TYPE	*G+15*	*G+20*	*G+25*
Symmetrical	*6144.051*	*8668.837*	*10745.41*
L-shape 1	*6474.799*	*8436.611*	*10319.37*
L-shape 2	*6522.28*	*8544.276*	*10506.74*
L-shape 3	*6495.72*	*8484.774*	*10401.92*

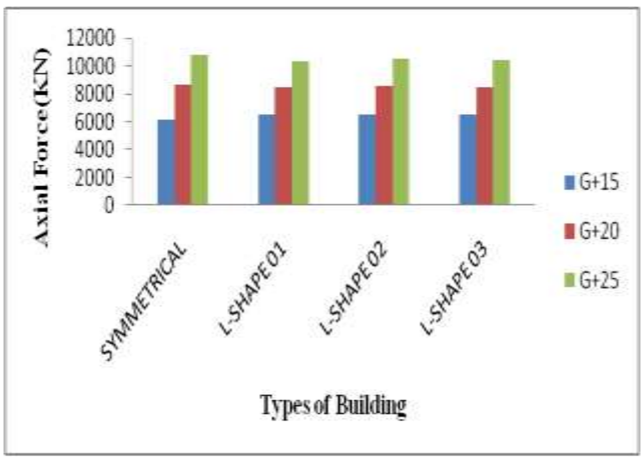

Fig. 19:

Table – 11
Maximum Axial force in T-Shaped building

STRUCTURE TYPE	*G+15*	*G+20*	*G+25*
Symmetrical	*6144.051*	*8668.837*	*10745.41*
T-shape 1	*6512.084*	*8509.902*	*10008.97*
T-shape 2	*6513.872*	*8510.167*	*10010.93*
T-shape 3	*6531.776*	*8556.357*	*10096.75*

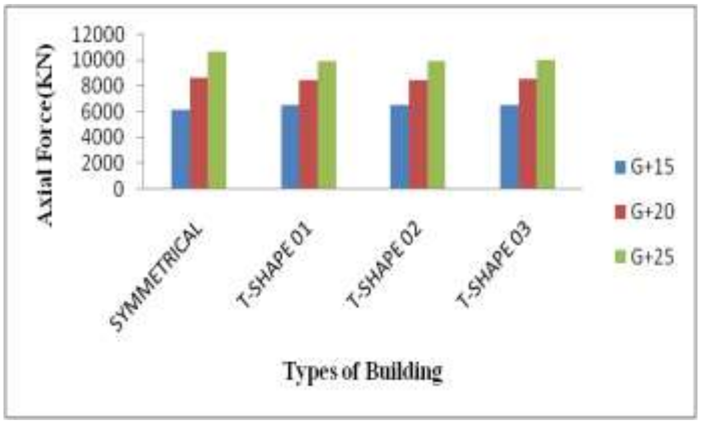

Fig. 20:

Table – 14
Maximum Bending Moment in L-Shaped building

STRUCTURE TYPE	G+15	G+20	G+25
Symmetrical	641.743	827.745	831.418
L-shape 1	795.402	802.34	807.726
L-shape 2	802.376	812.952	821.43
L-shape 3	815.336	823.25	829.656

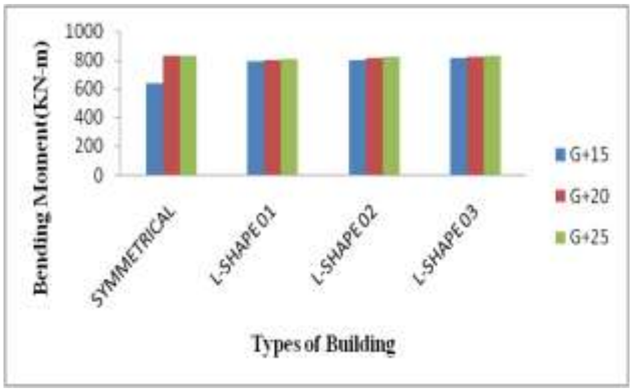

Fig. 21:

Table – 15
Maximum B.M in T-Shaped building

STRUCTURE TYPE	G+15	G+20	G+25
Symmetrical	641.743	827.745	831.418
T-shape 1	801.519	811.801	643.866
T-shape 2	802.478	812.349	644.232
T-shape 3	808.114	824.492	652.517

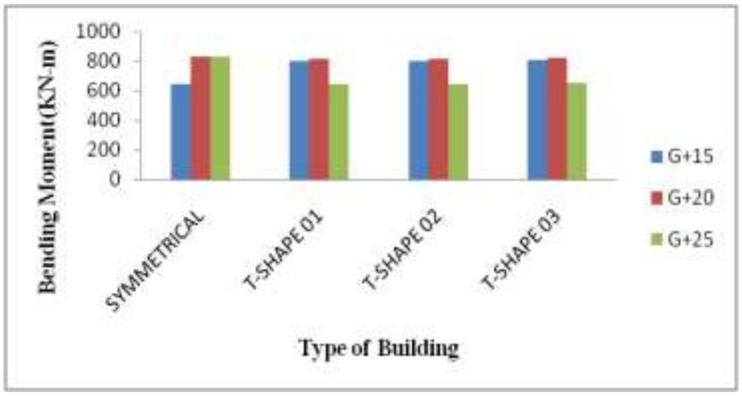

Fig. 22:

IV. RESULT & DISCUSSION

A. *For L-Shape Building:*

- Max. Bending Moment in column decreases from symmetrical to asymmetrical model. Model L-01 has less Bending moment compare to other models.
- Max. Axial Force in column decreases from symmetrical to asymmetrical model. Model L-01 has less axial force compare to other models.
- Compared to other models joint displacement is less in model L-01 in X-direction & in Y-direction for G+15 storey building.
- Compared to other models joint displacement is less in model L-02 in X-direction & in L-03 in Y-direction for G+20 storey building.
- Compared to other models joint displacement is less in model L-03 in X-direction & in Y-direction for G+25 storey building.

B. *For T-Shape Building*

- Max. Bending Moment in column decreases from symmetrical to asymmetrical model. Model T-02 has less Bending moment compare to other models.
- Max. Axial Force in column decreases from symmetrical to asymmetrical model. Model T-01 has less axial force compare to other models.
- Compared to other models joint displacement is less in model T-03 in X-direction & in Y-direction for G+15 storey building.
- Compared to other models joint displacement is less in model T-03 in X-direction & in Y-direction for G+20 storey building.
- Compared to other models joint displacement is less in model T-03 in X-direction & in Y-direction for G+25 storey building.

V. OBSERVATIONS & CONCLUSIONS

- Joint displacements are considerably decreases in asymmetric building compared to symmetric building.
- Symmetrical and asymmetrical building model show almost similar displacement against seismic load if the total mass is nearly constant.
- Considering the all criteria, it can be concluded that T-Shape and L-shape multistoried building are more susceptible to static and dynamic seismic load and gravity load compare to the symmetrical building, with constant mass symmetrical and asymmetrical shape building acts alike.

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