DYMIC ANALYSIS OF MULTI-STORY BUILDINGS FOR DIFFERENET SHAPES

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Abstract: *Earthquakes are caused generally by rupture of geological faults inside the earth, but also by other events such as volcanic movement, landslides, mine blasts, and atomic tests. Irregularities are characterized by vertical discontinuities in the geometry, distribution of mass, rigidity and strength. Different shapes of buildings leads to even inconsistency in the design of vertical parallel drive opposing components, in this way creating a difference between the focal point of mass and focus of Inflexibility, that ordinarily result in huge torsional requests on structure. A G+10 storey building is modeled in ETABS 2016 software and comparison is made between symmetric structure and other different shapes of structures like C, L & I in seismic zone V and soil type II, these models are analysed under response spectrum method. The comparison was made for base shear, storey drift, storey displacement, storey acceleration, storey force and storey stiffness. From the results and graphs it is clear that building with regular symmetric configuration gives a better resistance against earthquake forces and offer a stable structure.*

Key Word* – Analysis of response spectrum, *base shear, storey drift, storey displacement, storey acceleration, storey force and storey stiffness for High rise building Different Shapes.

1. INTRODUCTION

An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes are among the most powerful events on earth, and their results can be terrifying. A severe earthquake can release energy 10,000 times as great as that of the first atomic bomb. The force or intensity of an earthquake depends upon how much rock breaks and how far it shifts. Powerful earthquakes can shake firm ground violently for great distances. On an average, a powerful earthquake occurs less than once every two years. Scientists estimate that more than 8,000 minor earthquakes occur each day without causing any damage. Of those, only about 1,100 are strong enough to be felt. These earthquakes have clearly brought out that we need to have a comprehensive strategy for disaster mitigation which should include planning, design and construction of earthquake resistant buildings at a reasonably low cost.

In the event of an earthquake condition on a building, people can be evacuated safely before the building collapses. Major causalities in the earthquakes around the world are due to the structural collapses. The major structures that collapse are mainly due to their irregularities horizontally and vertically. If we start up with a good configuration and a reasonable framing system, even a poor design cannot harm its ultimate performance too much. In these modern days, most of the structures are involved with architectural importance and is highly impossible to plan with regular shapes. Hence, extensive research is required for achieving ultimate performance even with a poor configuration.

Indian standard codes give a recommended building configuration system for the better performance of RC building during earthquakes. The building configuration has been described as regular or irregular in terms of the size and shape of the building, arrangement of structural the elements and mass. IS 1893: 2002 (part1) has explained building configuration system for better performance of RC buildings during earthquakes.

2. OBJECTIVES

1. The analysis of a multi-storeyed RC building having G +10 Storey is analysed for earthquake intensity.
2. The Modelling of different shapes of building are modelled under E-tabs.
3. To analyse different shapes of building models for Response Spectrum.
4. To analyse different shapes of models for base shear, storey drift, storey displacement and storey stiffness.
5. To compare the responses for different shapes of models under seismic intensity zone V.

3. LITERATURE REVIEW

1. **Ramesh Konakalla et.al.** Study focused on 'Linear Behaviour of the Buildings with Plan Irregularities under Earthquake and Wind Loads'. Method of analysis adopted is Linear Static Analysis. There are 4 models of 20- Storied, 3-D framed structures

are considered for the study i.e., a symmetrical plan configuration and 3 other model with unsymmetrical plan configuration of L, inverted U and T-shape. It was observed that in the regular frame, there was no torsional effect in the frame because of symmetry i.e., due to the centre of mass coincides with the centre of rigidity and also the lateral displacements are same in the direction of earthquake force. The same was observed in the case of wind loads. The responses for an irregular building are different for the columns which are located in the plane perpendicular to the action of force.

2. **M.R.Wakchaure et.al.** The paper aims in studying description of different plan irregularity by analytical method under seismic events. Analysis carried to estimate the seismic performance of high rise building and the effects of structural irregularity in stiffness, strength, mass and combination of these factors are considered. Study is carried on an irregular plan geometrical forms which are more common in the metro city areas such as Mumbai. The irregular plans are modelled in ETABS 9.7v having 35 and 39 storied building, to determine the effect of the plan geometrical form on the seismic behaviour of structures with elastic analysis. Also, the effects of gust factor are considered in T-shape and Oval Shape plans. In structural configuration shear wall positions located in the form of core and columns are considered as gravity as well as lateral columns. There are 2-types of model that are to be developed (strength & serviceability models). In strength model all the lateral resisting systems (i.e. shear walls and coupling beams) are analysed.
3. **Raul Gonzalez Herrera et.al.** This article show analytical description of the damages caused by different plan irregularities, during seismic events of different magnitudes. The effects of commented irregularities are studied with qualitative analyses of important and recent investigations, in Mexico. The work describes to the geometric forms that are repeated more in the urban areas of Mexico (squared, rectangular, section U, section L and section T). The architectonic plants were modelled in SAP2000 considering one, two and four levels to determine the effect of the geometric form in the seismic behaviour of structures with elastic analyses. Also, effects of the extension in rectangular plants and the inclusion of projections in sections with architectonic plants U, L and T are studied. In all the studied systems, effects of different irregularities are analysed on the variation of displacements, with respect to regular systems.
4. **Milind V. Mohod et.al**. This paper studies the effects of plan and shape configuration on irregular shaped structures. The effect of irregularity (plan and shape) on structure was carried out using STAAD Pro. V8i. Storey drift and lateral displacement play an important role in understanding the behaviour of structure are compared. It has been observed from the research that simple plan and configuration must be adopted at the planning stage to minimize the effect of earthquake.
5. **Satyaveni Allipilli et.al.** This paper investigate on significance of plan irregularity in the selection of suitable structural moment resisting framing system for the analysis and design of multi-storied buildings. Functional use of the structures, zones and height of the building are taken into consideration. Nodal displacements and drifts are determined by performing the linear static analysis. From the design results amount of reinforcement are determined and compared. Frame wise observations from the analysis and design are observed in detail. Number of 20 storied moment resisting frame both regular and irregular in plan are analysed and designed in the present study. It is observed that there was no impact of plan irregularity to opt a suitable moment resisting structural framing system for the analysis and design.

4. METHODOLOGY

The step by step procedure followed to achieve the above objectives is;

1. An extensive literature review is carried out to establish the above objectives for the project work.
2. G+10 storey structure is chosen for the present investigation.
3. ETABS software is chosen for modelling and analysis of the selected structure.
4. To understand the behaviour of structure, four models are considered with regular and irregular configuration.

5. DISCUSSIONS ARE MADE BASED ON FOLLOWING PARAMETERS

1. Storey Displacement
2. Storey drift
3. Storey acceleration
4. Storey forces
5. Storey Stiffness
6. Base shear

6. BUILDING DETAILS

- Number of stories = G+10
- C/C distance between columns in X-direction = 5m
- C/C distance between columns in Y-direction = 5m
- Foundation level to ground level = 3m
- Floor to floor height = 3m
- Live load on all floors = 3kN/m2
- Live Load on Roof = 1.5kN/m2
- Floor Finish = 1.5kN/m2
- Concrete = M25
- Steel = Fe415 and Fe500
- Size of column = 500x500mm
- Size of beam = 230x500mm
- Depth of slab = 150mm
- Seismic zone V = 0.36
- Soil Type = II

7. PLAN AND ELEVATION OF MODELS

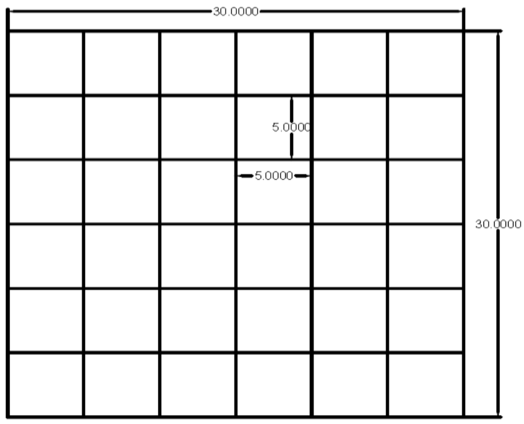


Fig 7.1: Plan of Symmetric Structure

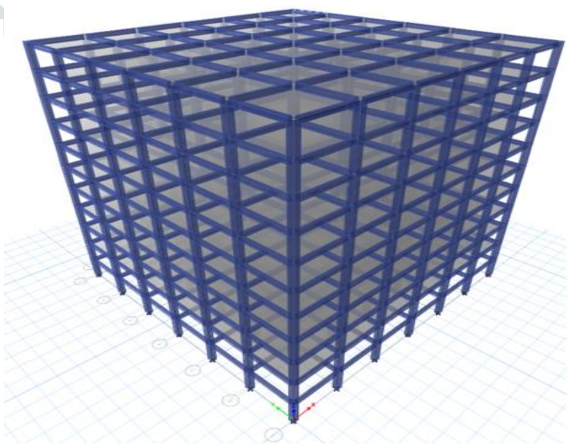


Fig 7.2: 3D Elevation of Symmetric Structure

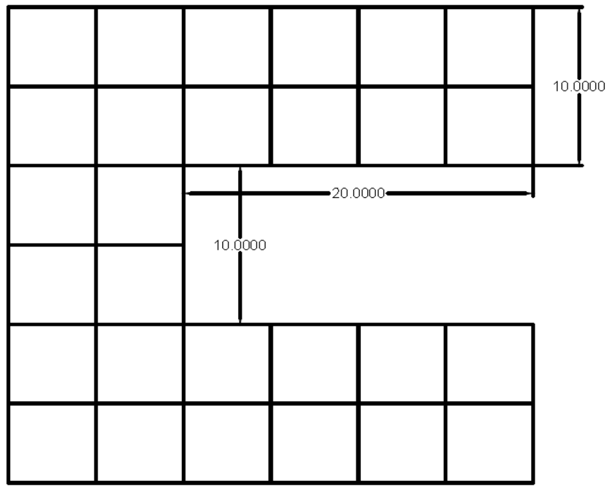


Fig 7.3: Plan of C Shaped Structure

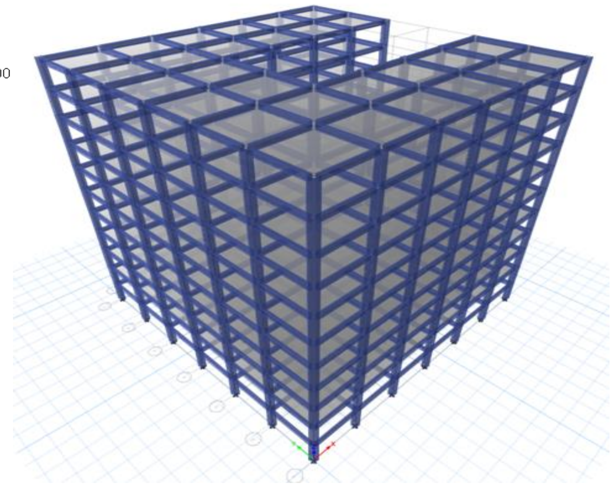


Fig 7.4: 3D Fig Elevation of C Shaped Structure

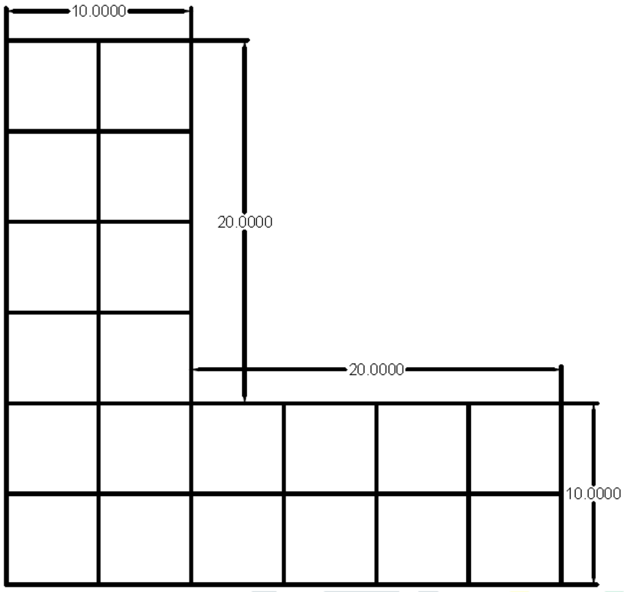


Fig 7.5: Plan of L Shaped Structure

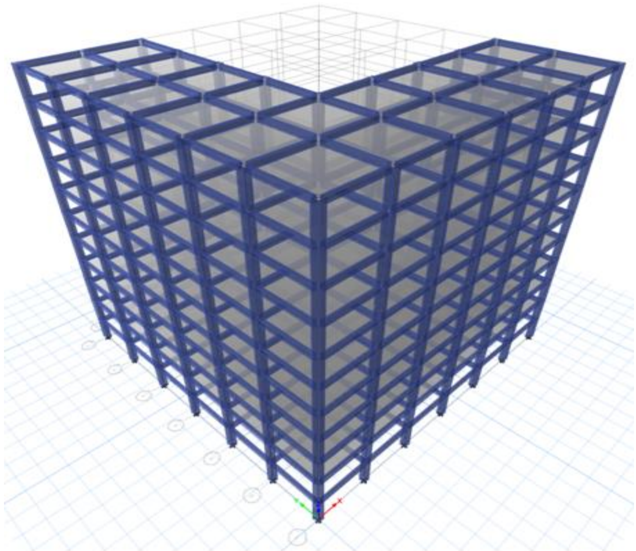


Fig 7.6: 3D Elevation of L Shaped Structure

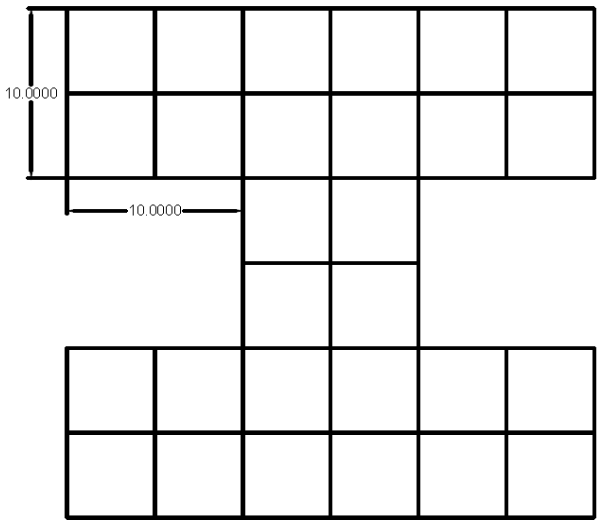


Fig 7.7: Plan of I Shaped Structure

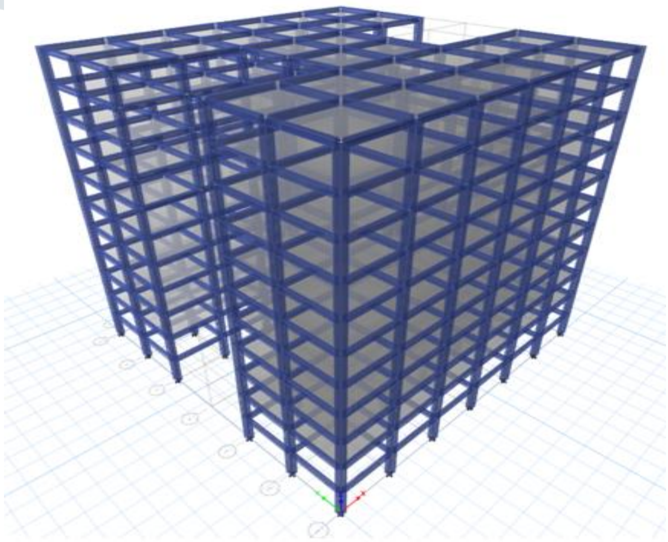


Fig 7.8: 3D Elevation of I Shaped Structure

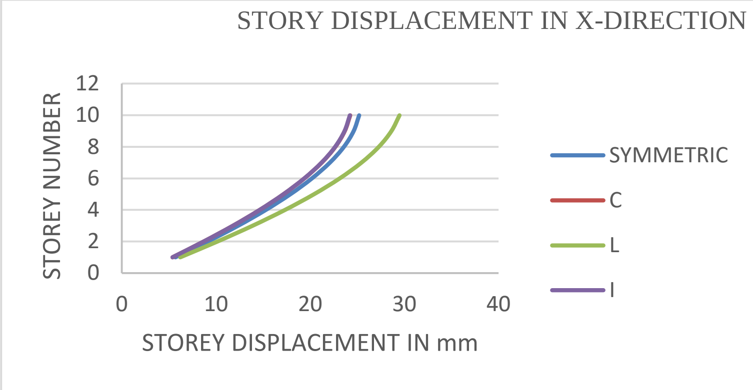
8. RESULTS AND DISCUSSIONS

8.1 Storey Displacement

The floor level versus displacement graph is been plotted for the models with regular symmetric and C, L, I - shaped irregular configured structures in both X and Y directions.

Table 8.1: Storey Displacement in X Direction

Storey	Symmetric	C	L	I
10	26.21	25.249	30.501	25.215
9	25.623	24.672	29.641	24.645
8	24.589	23.669	28.302	23.647
7	23.099	22.226	26.458	22.209
6	21.194	20.382	24.152	20.368
5	18.916	18.175	21.433	18.165
4	16.298	15.64	18.341	15.632
3	13.366	12.805	14.91	12.799
2	10.151	9.703	11.182	9.7
1	6.712	6.398	7.23	6.397

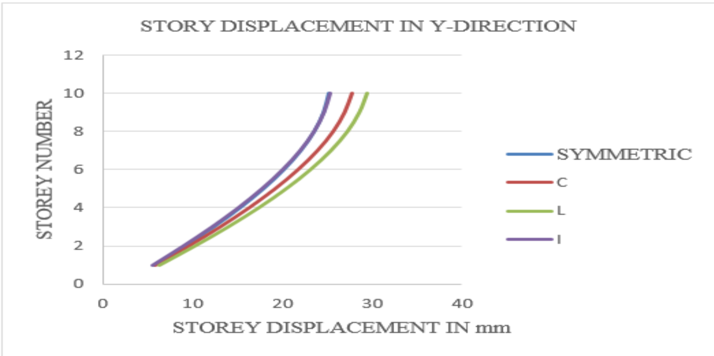


Graph 8.1: Storey Displacement in X Direction

From the graph it shows that for the building models with C, I shaped models have a lesser displacement values than that for the symmetric and L shaped configured building.

Table 8.2: Storey Displacement in Y Direction

Story	Symmetric	C	L	I
10	26.21	28.721	30.501	26.391
9	25.623	27.899	29.641	25.712
8	24.589	26.628	28.302	24.597
7	23.099	24.885	26.458	23.038
6	21.194	22.711	24.152	21.075
5	18.916	20.154	21.433	18.751
4	16.298	17.252	18.341	16.1
3	13.366	14.037	14.91	13.15
2	10.151	10.544	11.182	9.935
1	6.712	6.842	7.23	6.529



Graph 8.2: Storey Displacement in Y Direction

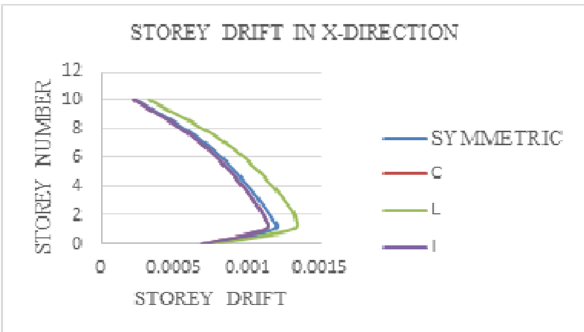
From the graph it shows that for the building models with Symmetric and I shaped models have a lesser displacement values than that for the C and L shaped configured building.

8.2 Storey Drift

The floor level versus Storey drift graph is been plotted for the models with regular symmetric and C, L, I - shaped irregular configured structures in both X and Y directions

Table 8.3: Storey Drift in X Direction

Storey	Symmetric	C	L	I
10	0.000288	0.000278	0.000381	0.000278
9	0.000464	0.000445	0.00057	0.000445
8	0.000628	0.000604	0.000753	0.000602
7	0.000764	0.000735	0.000905	0.000734
6	0.000876	0.000844	0.001029	0.000843
5	0.00097	0.000937	0.001132	0.000936
4	0.001056	0.00102	0.001224	0.001019
3	0.001134	0.001095	0.001306	0.001094
2	0.001202	0.001155	0.001371	0.001155
1	0.001234	0.001176	0.001364	0.001175
0	0.000785	0.000742	0.000815	0.000742

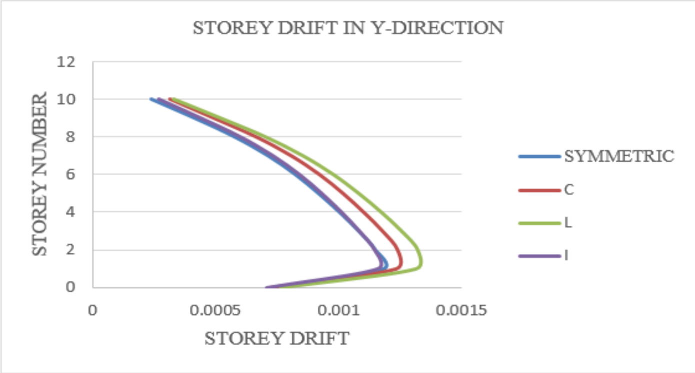


Graph 8.3: Storey Drift in X Direction

From the graph it shows that for the building models with C, I shaped models have a lesser Storey drift values than that for the symmetric and L shaped configured building.

Table 8.4: Storey Drift in Y Direction

Storey	Symmetric	C	L	I
10	0.000288	0.000366	0.000381	0.00032
9	0.000464	0.000543	0.00057	0.00049
8	0.000628	0.000715	0.000753	0.000651
7	0.000764	0.000857	0.000905	0.000783
6	0.000876	0.000972	0.001029	0.000891
5	0.00097	0.001067	0.001132	0.000981
4	0.001056	0.001151	0.001224	0.001062
3	0.001134	0.001227	0.001306	0.001134
2	0.001202	0.001288	0.001371	0.001196
1	0.001234	0.001282	0.001364	0.001208
0	0.000785	0.000767	0.000815	0.000758



Graph 8.4: Storey Drift in Y Direction

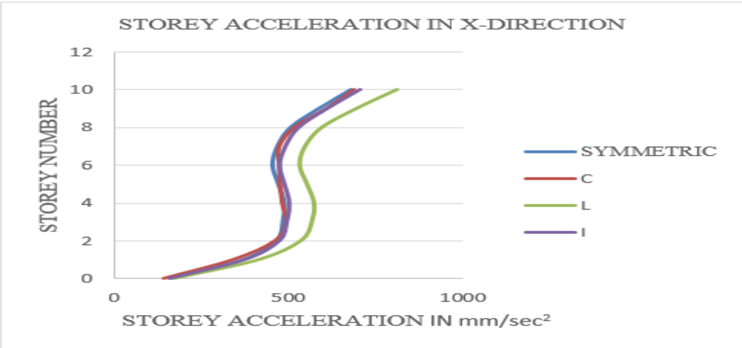
From the graph it shows that for the building models with Symmetric and I shaped models have a lesser Storey drift values than that for the C and L shaped configured building.

8.3 Storey Acceleration

The floor level versus Storey acceleration graph is been plotted for the models with regular symmetric and C, L, I - shaped irregular configured structures in both X and Y directions.

Table 8.5: Storey Acceleration in X Direction

Storey	Symmetric	C	L	I
10	682.69	695.61	816.23	709.06
9	591.48	615.96	700.52	615.7
8	510.12	523.92	600.93	534.27
7	472.5	479.71	552.84	496.27
6	458.21	479.47	537.23	479.53
5	474.63	481.93	557.95	493.16
4	491.68	488.07	578.29	507.17
3	487.84	499.25	572.18	499.97
2	468.98	468.1	540.8	479.16
1	374.14	346.99	420.47	381.52
0	164.73	146.52	178.3	167.1

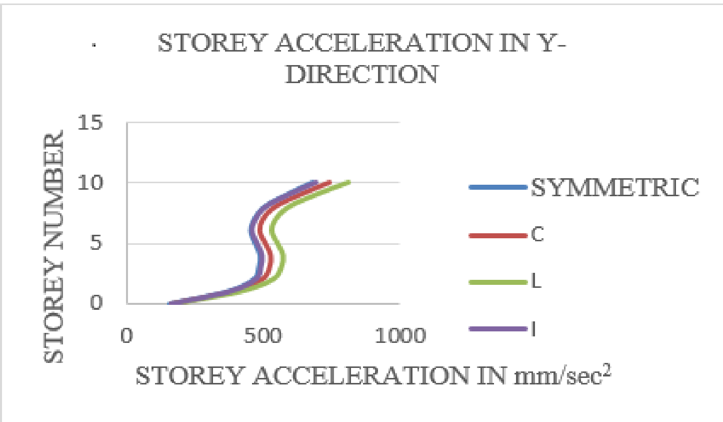


Graph 8.5: Storey Acceleration in X Direction

From the graph it shows that for the building models with Symmetric building model is having a lower Storey acceleration values than other building models with irregular configuration.

Table 8.6: Storey Acceleration in Y Direction

Story	Symmetric	C	L	I
10	682.69	746.9	816.23	700.64
9	591.48	640.39	700.52	600.96
8	510.12	548.09	600.93	515.9
7	472.5	503.35	552.84	477.91
6	458.21	490.15	537.23	464.36
5	474.63	510.84	557.95	483.32
4	491.68	530.82	578.29	501.73
3	487.84	526.66	572.18	497.43
2	468.98	498.59	540.8	477.59
1	374.14	387.67	420.47	380.05
0	164.73	166.79	178.3	167.37



Graph 8.6: Storey Acceleration in Y Direction

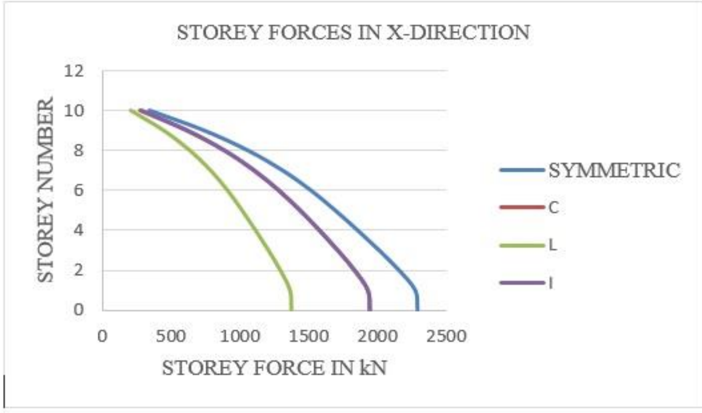
From the graph it shows that for the building models with Symmetric building model is having a lower Storey acceleration values than other building models with irregular configuration.

8.4 Storey Forces

The floor level versus Storey Force graph is been plotted for the models with regular symmetric and C, L, I - shaped irregular configured structures in both X and Y directions.

Table 8.7: Storey Forces in X Direction

Storey	Symmetric	C	L	I
10	345.3318	285.0902	211.1577	290.5398
9	742.8699	622.3533	450.1347	625.504
8	1060.327	895.9958	640.0222	895.2689
7	1313.514	1112.251	791.4287	1113.023
6	1519.511	1290.983	914.7814	1292.212
5	1695.64	1446.932	1020.442	1446.162
4	1859.169	1587.701	1118.685	1588.065
3	2015.048	1720.133	1212.127	1721.235
2	2159.955	1843.547	1298.629	1842.711
1	2276.611	1938.945	1367.902	1938.804
0	2291.879	1952.088	1377.859	1952.427

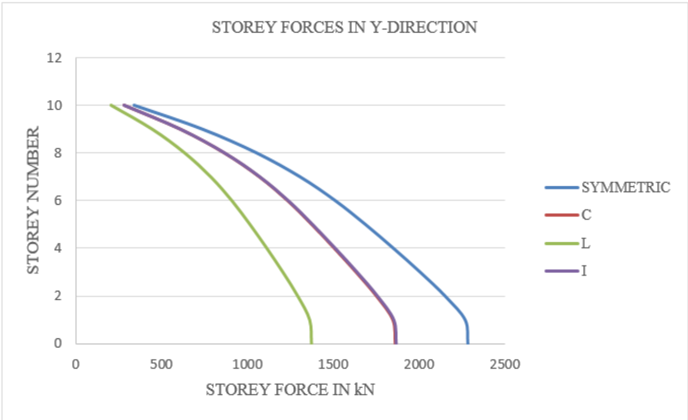


Graph 8.7: Storey Forces in X Direction

From the graph it shows that for the building models with irregular configuration have a lower Storey Force values than symmetric building model.

Table 8.8: Storey Forces in Y Direction

Storey	Symmetric	C	L	I
10	345.3315	287.8681	211.1577	287.5058
9	742.8699	614.4216	450.1348	614.158
8	1060.327	872.3134	640.0222	872.6571
7	1313.514	1076.241	791.4287	1077.432
6	1519.511	1241.08	914.7814	1243.16
5	1695.64	1381.912	1020.442	1384.79
4	1859.169	1513.624	1118.685	1517.089
3	2015.049	1640.195	1212.127	1643.999
2	2159.956	1758.499	1298.629	1762.353
1	2276.611	1853.752	1367.902	1857.431
0	2291.88	1867.265	1377.859	1870.9



Graph 8.8: Storey Forces in Y Direction

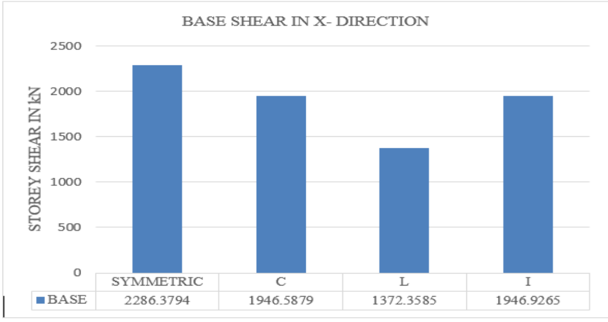
From the graph it shows that for the building models with irregular configuration have a lower Storey Force values than symmetric building model.

8.5 Base Shear

The Shear force at base of the structure is compared for symmetric and C, L, I - shaped irregular configured structures in both X and Y directions.

Table 8.9: Storey Shear Force in X Direction

MODEL (X-DIR)	SYMMETRIC	C	L	I
BASE	2286.3794	1946.588	1372.359	1946.927

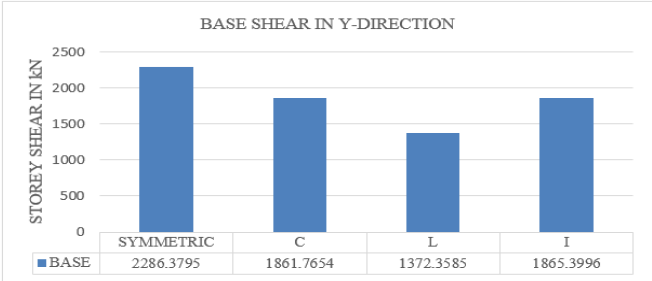


Graph 8.9: Storey Shear Force in X Direction

From the graph it shows that for the building models with irregular configuration have a lower Base shear values than symmetric building mode

Table 8.6: Storey Shear Force in Y Direction

MODEL (Y-DIR)	SYMMETRIC	C	L	I
BASE	2286.3795	1861.765	1372.359	1865.4



Graph 8.10: Storey Shear Force in Y Direction

From the graph it shows that for the building models with irregular configuration have a lower Base shear values than symmetric building model.

9. CONCLUSION

In the thesis a structural model is considered wherein different shapes of building models are subjected to earthquake Zone V. Their effects on models have been shown in the form of graph in successive part of results and discussions, by comparing various parameters such as displacements, storey drifts, storey acceleration, storey force, storey Stiffness, and base shear.

Hence from the obtained results the following conclusions are made,

1. Considering the effect of displacement for different shapes on the structure. It is been observed that, Symmetric and I – shaped structure give better resistance against to displacement in comparison to C, L–shape structures.
2. The storey drifts being the important parameter to understand the drift demand of the structure. Symmetric and I shape structure have a lower drift values to that of C and L-shape models showed larger drift values.
3. The storey acceleration was compared between symmetric and non-symmetric building in both direction i.e., in X and Y directions, the both graph show that symmetric building is more stable building model.
4. The storey force in both directions showed that regular building model has a high storey force than that for the building with irregular configuration.
5. The storey stiffness in both directions showed that regular building model has grater stiffness than that for the building with irregular configuration.
6. The graphs of base shear in both directions show a greater shear values for the symmetric building than that for irregular configured building.
7. It is observed that, there are no torsional effects in the frame because of symmetry that is the Centre of mass that coincides with the Centre of rigidity, hence symmetric structure perform better in resisting earthquake force.
8. An increase in storey stiffness and base shear for the symmetric building, which give a clear indication that symmetric configured building perform better then that the irregular structure and is compatible than other form of building.
9. From the above results so obtained from all the graphs is clear that building with symmetric configuration give a better resistance against earthquake forces and offer a stable structure.

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