SEISMIC ANALYSIS OF MULTISTORIED BUILDING FOR DIFFERENT PLANS USING ETABS 2015

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Abstract - *Seismic analysis of any type of structure is an important consideration while working in high earthquake prone areas. With the help of seismic analysis, the structure can be designed and constructed to withstand the high lateral movement of earth's crust during an earthquake. Any type of basic or a highly advanced structure which maybe under static or dynamic conditions can be evaluated by using ETABS. ETABS is a co-ordinated and productive tool for analysis and designs, which range from a simple 2D frames to modern high-rises which makes it one of the best structural software for building systems.*

Key Words: **Seismic Analysis, ETABS, Storey Stiffness, Centre of Mass Displacement, Modal Analysis, Indian Code IS 456 (2000).**

1. INTRODUCTION

The main aim is to generate and perform dynamic analysis of 4 different shapes of structure: Rectangular, T-Shaped, I-Shaped, L-Shaped and to compare their results for various types of forces, moments and displacements. It is expected that these structures will sustain all the loads and deformations of normal construction and have adequate durability and resistance to seismic effects.

Earthquake engineering has developed a lot since the early days. Due to emergence of earthquake prone areas, earthquake engineering is becoming one of the key aspects in the analysis and designing of any structure. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.

Structural analysis methods can be divided into the following five categories.

1. Equivalent static analysis
2. Response spectrum analysis
3. Linear dynamic analysis
4. Nonlinear static analysis

2. TYPES OF RCC FRAMES

We have considered a 3D RCC frame with the dimensions for 4 different shapes. These shapes have same area. The 4 shapes are as follows:

1. Rectangular plan
2. I-shaped plan
3. T-shaped plan
4. L-shaped plan

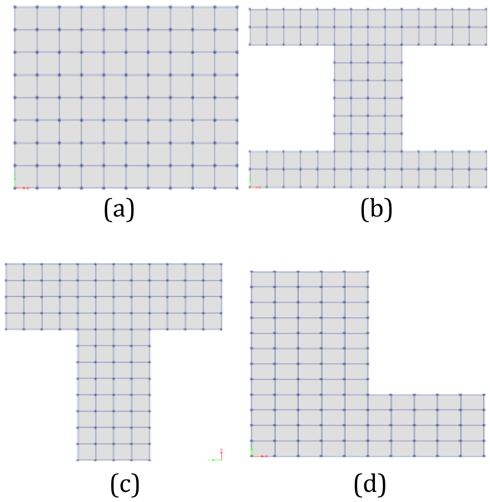


Fig 1: Plan (a) Rectangular shaped (b) I-shaped (c) T- shaped (d) L-shaped of the building.

Table 1

Building Description And Material Specification	
Number of storey	15
Support condition	Fixed
Storey height	3m
Grade of concrete	30MPa
Grade of steel	Fe415
Size of column(floor 1-5)	650mm X 650mm
Size of column(floor 6-15)	500mm X 500mm
Size of beam	450mm X 300mm
Thickness of main wall	230mm
Density of concrete	25KN/m3
Density of brick walls consider	20KN/m3

3. LOADING

The structures are acted upon by different loads such as dead load, live load, earthquake load.

1. Self-weight of structure comprises of weight of the beam, column and slab of the structure.
2. Dead load of the structure consists of wall load, parapet wall load and floor load according to IS 875 – part 1.
   I. Wall load: weight unit of brick masonry * thickness of wall * height of wall = 20kN/m3 * 0.23m * 3m = 13.8kN/m3.
   II. Wall load (parapet wall at top floor): weight unit of brick masonry * thickness of wall * height of wall = 20kN/m3 * 0.115m * 0.9m = 2.07KN/m.
3. Live load: It consists of floor load which is taken as 4KN/m2 and roof load as 2kN/m2 according to IS 875 part 2.
4. Seismic load: The different seismic parameters are taken as follows, IS 1893 part 1 : 2002
   1. Seismic zone : V (Z=0.36)

2. Soil type : II
3. Importance factor : 1
4. Response reduction factor : 5
5. Dumping : 5%

4. RESULTS & DISCUSSION

1. **Storey Shear:** It is defined as the ratio of storey shear force when storey collapse occurs to the storey shear force when total collapse occurs. Comparison of storey shear for 1st, 5th, 10th & 15th storey are given below.

Table 2

Storey	Rectangular shaped (KN)	I-Shaped (KN)	T-Shaped (KN)	L-Shaped (KN)
Storey 15	891.79	1025.70	787.46	860.05
Storey 10	4193.82	4805.51	3736.94	4078.13
Storey5	5352.18	6131.67	4772.11	5207.5
Storey1	5500.63	6302.03	4905.95	5353.32

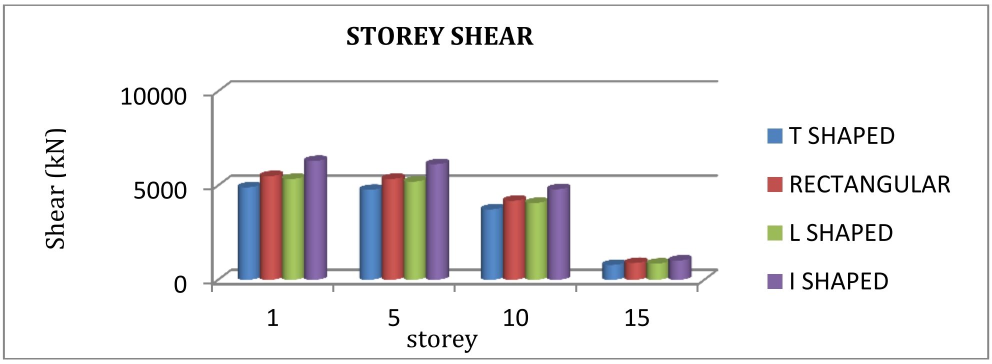


Chart 1: Storey Shear

If we compare the values of 15th floor, storey shear decreases with increase in storey height which is 12% less in T-shaped structure and 15% more in I-shaped when compared to rectangular shaped structure.

2. **Storey Stiffness:** The storey stiffness of a storey is generally defined as ratio of storey shear to storey drift. Storey stiffness of a storey is not a stationary property but an apparent one that depends on the lateral load distribution. In the analysis of frame building subjected to wind or earthquake loads, it is generally assumed that lateral loads are distributed in a 'regular' manner. Regular means that loads act in same direction on all floors and that lateral loads vary from floor to floor in a controlled manner.

Table 3

Storey	Rectangular shaped (N/m)	I-Shaped (N/m)	T-Shaped (N/m)	L-Shaped (N/m)
Storey15	0.9	0.9	0.8	0.9
Storey14	1.4	1.4	1.3	1.5
Storey13	2	2	1.8	2
Storey12	2.4	2.4	2.2	2.5

Storey11	2.8	2.8	2.5	2.9
Storey10	3.2	3.1	2.8	3.2
Storey9	3.4	3.4	3	3.5
Storey8	3.6	3.6	3.2	3.7
Storey7	3.8	3.8	3.3	3.8
Storey6	3.9	3.9	3.4	3.9
Storey5	3.3	3.3	3	3.4
Storey4	3.3	3.3	3.1	3.4
Storey3	3.2	3.1	3.2	3.2
Storey2	2.7	2.7	2.8	2.7
Storey1	1.3	1.3	1.4	1.3

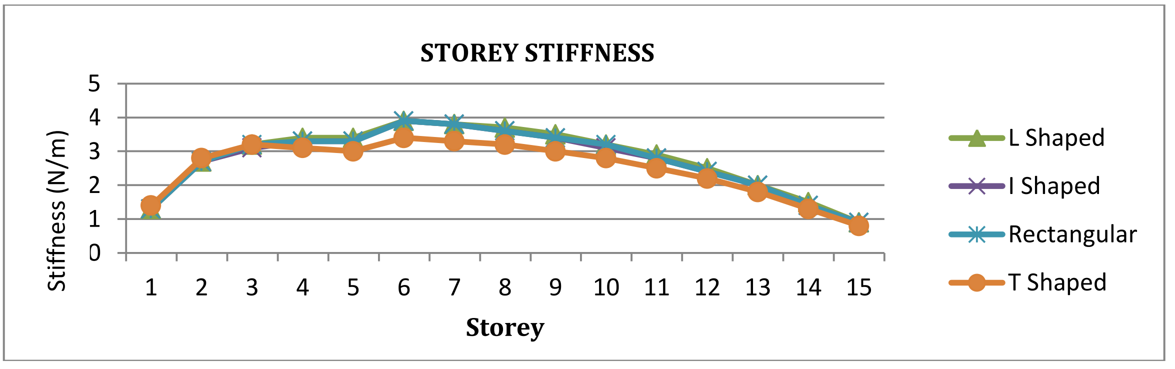


Chart 2: Storey Stiffness

Storey stiffness for T-shaped structure is les as compared to all other shapes. Other three almost show similar results. T-shaped is 9% less then rectangular shaped.

3. **Joint Displacement:** It is the displacement of joints in a structure due to application of wind or seismic loads. This displacement is measured in 'mm'.

Table 4

Storey	Rectangular Shaped (mm)	I-Shaped (mm)	T-Shaped (mm)	L-Shaped (mm)
Storey15	13.8	14.9	24.8	28.3
Storey14	13.6	14.7	24.5	28
Storey13	13.4	14.4	24.1	27.4
Storey12	12.9	14	23.4	26.4
Storey11	12.4	13.4	22.6	25.2
Storey10	11.6	12.6	21.5	23.7
Storey9	10.8	11.7	20.2	21.9

Storey8	9.8	10.6	18.7	19.8
Storey7	8.6	9.3	17	17.5
Storey6	7.3	7.9	15.1	14.8
Storey5	5.9	6.4	13	12
Storey4	4.6	5	11.1	9.3
Storey3	3.3	3.5	8.9	6.5
Storey2	1.9	2	6.5	3.7
Storey1	0.6	0.7	3.7	1.3
Base	0	0	0	0

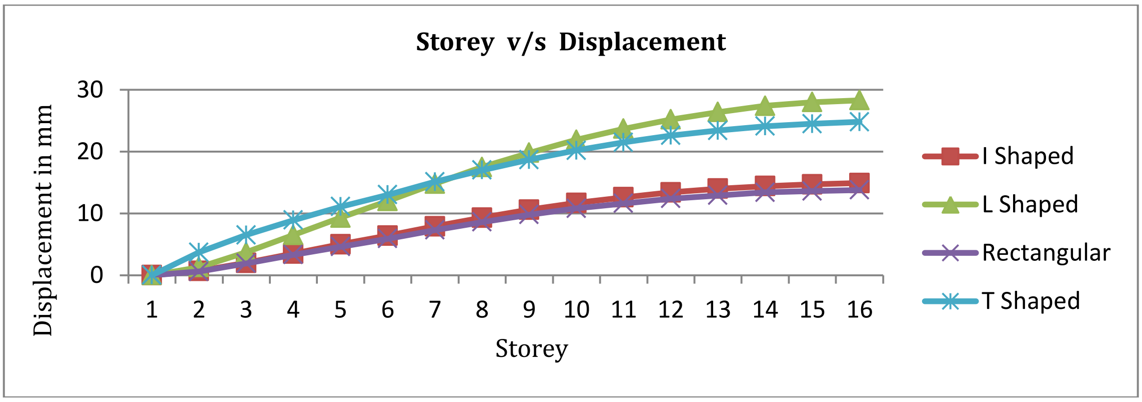


Chart 3: Joint Displacement

L-shaped structure is having value 105% greater than rectangular shaped structure.

4. **Centre of Mass Displacement:** Centre of mass of the structure is displaced due to dynamic forces such as wind and earthquake. This displacement is known as Centre of Mass Displacement and it is measured in 'mm'.
Table 5

Storey	Rectangular shaped (mm)	I-Shaped (mm)	T-Shaped (mm)	L-Shaped (mm)
Storey15	17.7	24.8	25.1	17
Storey14	17.5	24.4	24.9	16.8
Storey13	17.1	23.8	24.4	16.5
Storey12	16.6	23	23.8	15.9
Storey11	15.8	21.9	22.9	15.2
Storey10	14.9	20.5	21.8	14.3
Storey9	13.8	18.9	20.5	13.2
Storey8	12.5	17.1	19	12
Storey7	11	15	17.2	10.6
Storey6	9.4	12.8	15.3	9

Storey5	7.6	10.3	13.2	7.3
Storey4	5.9	7.9	11.2	5.7
Storey3	4.1	5.5	9	4
Storey2	2.4	3.1	6.6	2.3
Storey1	0.8	1.1	3.8	0.8

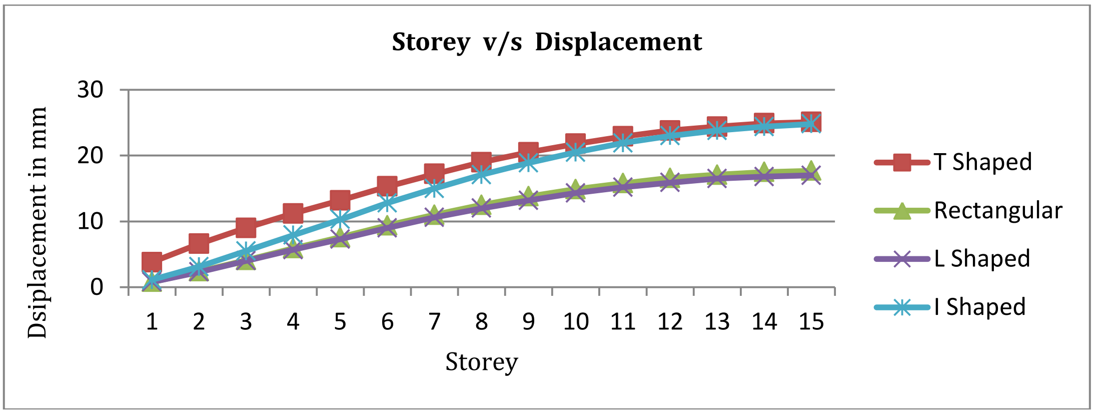


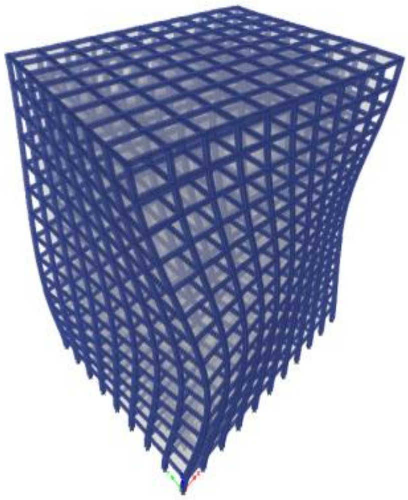
Chart 4: Centre of Mass Displacement

Centre of mass displacement is observed maximum in T-shaped structure. It is 43% greater than rectangular shaped structure, I shaped structure have intermediate values.

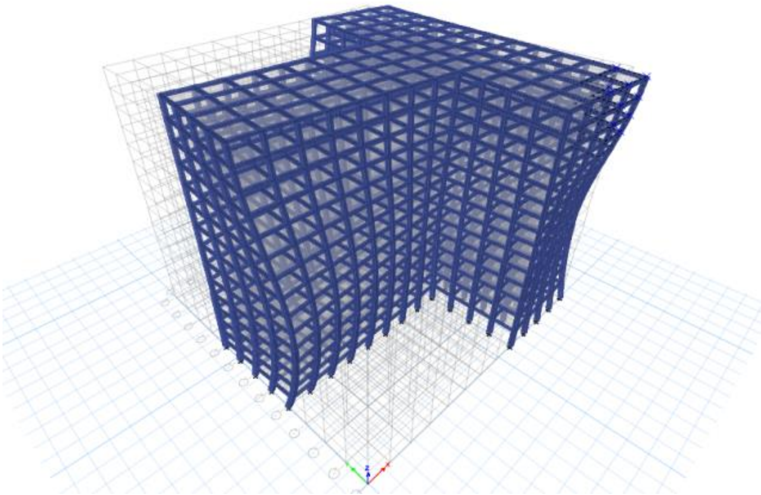
5. MODAL ANALYSIS

Modal analysis or mode superposition method is a linear dynamic response procedure which evaluates and superimposes free vibration mode shapes to characterize displacement patterns. Mode shapes describe the configuration into which a structure will naturally displace.

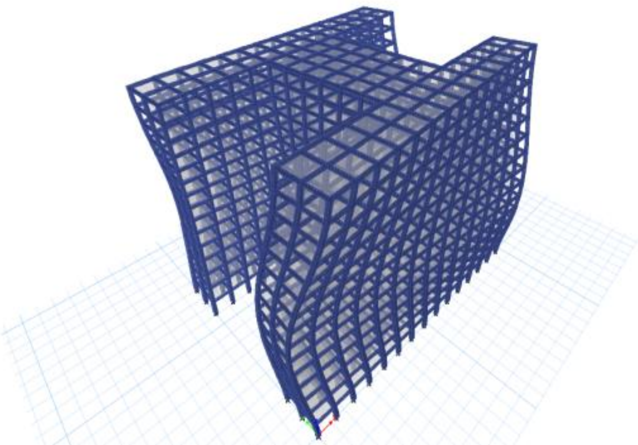
The mode shaped for 5th mode for (a) Rectangular shaped (b) T-shaped (c) I-shaped (d) L-shaped of the building are as follows:



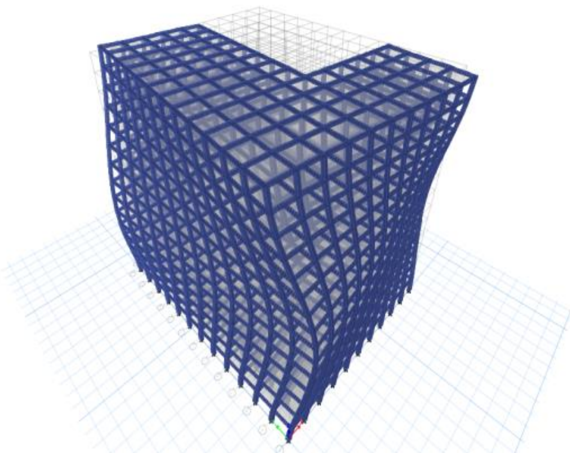
(a) Fig. 2



(b) Fig. 3



(c) Fig. 4



(d) Fig. 5

6. CONCLUSION

1. Storey shear inversely varies with respect to number of storeys.
2. Storey stiffness increases with increase in storey height. But this case is satisfied only till 6th storey level. The value of shear stiffness is maximum for all the shape. But after 6th storey, the stiffness goes on decreasing.
3. Joint displacement is directly proportional to the storey levels or no of storey. The values are maximum for L-shaped structure suggesting maximum deformation in that particular shape. It is lowest in rectangular shaped structure due to similarity of the structure.
4. Centre of mass displacement is directly proportional to number of storeys. It is observed that maximum value of Centre of mass displacement is in T-shaped structure followed by I-shaped structure. L-shaped structure has the lowest value amongst the 4 shapes.
5. It is observed that asymmetrical plans undergo more deformation than symmetrical plans and therefore while constructing a new structure in high seismic zone, it is most likely to construct a structure which is symmetric in shape so as to provide better stability.

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