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# Seismic Response of Irregular Structures

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***ABSTRACT***
*Auxiliary specialists frequently experience structures, which show some level of plan asymmetry. The exhibition of lopsided structures under seismic excitation is exceptionally poor and its conduct is profoundly perplexing when contrasted with that of ordinary structures. In this examination, seismic instigated torsion in hilter kilter RC structures has been read for different parameters. Identical Sidelong Power Technique (Mythical being) is embraced to consider the incited torsion according to IS 1893(Part 1): 2002 codal arrangements. FEM modelling is used to carry all the static and dynamic analysis of four 16 storied building models which were placed in different seismic zones of varying seismic intensities. The present investigation targets understanding the significance of codal arrangements, which are especially, accommodated the examination of torsionally lopsided structures. IS Code gives the data about number of parameters which impacts the inconsistency of the structure. In any case, in the present investigation the most noticeably terrible influenced abnormality affected by torsion are considered in detail. Consequently, the accompanying targets were recognized dependent on these parameters. The present examination centers around the discontinuities in a parallel power obstruction way, for example, out-of-plane balances of vertical components and so on.*

***Keywords:-****Irregular structures; Seismic design; Irregularity; Torsional behavior; Earthquake*

## INTRODUCTION

Genuine structures are quite often unpredictable, as immaculate normality is a romanticizing that infrequently happens. Auxiliary inconsistencies may fluctuate significantly in their tendency and on a basic level, are hard to characterize. As to, for functional purposes, major seismic codes recognize inconsistency in plan and in height, however it must be understood that frequently basic abnormality is the aftereffect of a mix of both. So as to distinguish the torsionally unpredictable structures, IS 1893 (Section 1): 2002 has given the unmistakable meanings of sporadic structures in Statement 7.1. An articulation for the plan capriciousness, which is especially required for the investigation of torsionally lopsided structures is given in Condition 7.9 of the IS 1893.In the codal provisions, it is also suggested that, the method of analysis to be used for a structure, depends on its irregularity, in addition to the total height of the structure and the seismic zone where it is situated (Clause 7.8.1). To comprehend the significance of codal arrangements, which are particularly implied for deviated structures, an endeavor is made in the present investigation thinking about different parameters, which are adding to torsional inconsistency.

In the present study, seismic analysis has been performed by Equivalent Lateral Force Method (ELF) i.e. the codal method. It is possible to evaluate seismic response of the structure only in the elastic range. However, it is mentioned in the literatures that, behavior of the asymmetric structure is highly complex in the inelastic range and this can be investigated by performing inelastic analysis. The effect of torsion is studied with various irregularities as specified in IS: 1893-2002 to evaluate the worst affected irregularity under the influence of torsional moments considering various irregularities.(Figure 1)

*(a) Highly Irregular Building* *(b) Collapse due to Seismic Torsion*

***Fig.1:-*** *Asymmetric Structures*

1. The present examination targets understanding the significance of codal arrangements, which are especially accommodated the investigation of torsionally unequal structures. IS Code gives the data about number of parameters which impacts the anomaly of the structure. Be that as it may, in the present examination the most exceedingly awful influenced abnormality affected by torsion are contemplated in detail. Consequently, the accompanying targets were distinguished dependent on these parameters. The present examination centers around the discontinuities in a parallel power opposition way, for example, out-of-plane counterbalances of vertical components and so on. To study the effect of irregular distribution of mass in plan on the seismic response of structures[1].
2. To study the influence of asymmetric distribution of stiffness on the structural responses[2].
3. To study the influence of plan configurations of a structure and its lateral force resisting system containing re-entrant corners[3].
4. To study the stiffness irregularity i.e. the lateral stiffness in less than 70% of above storey[4].
5. To study the effect of regular structure on the seismic response and comparing it with irregular distribution of mass, asymmetric distribution of stiffness and irregular plan configurations[5].

Since, the present study focuses mainly on the torsional moments in the structure, the structural modelling is done without infills. However to capture the realistic behavior of the structure, finite element modelling consisting of frame, wall and interface elements is recommended. For the analysis of structures having irregular geometric configurations, building codes of various countries recommended, an earthquake spectrum which shall be applied along the direction of principal axis, so that the responses will be maximum. In the present study, this issue is not considered in the analysis of structures. Fixed base condition is assumed for the columns in the present study, however it should be noted that torsional response may increase because of foundation movement. This aspect is not studied.(Figure 2)

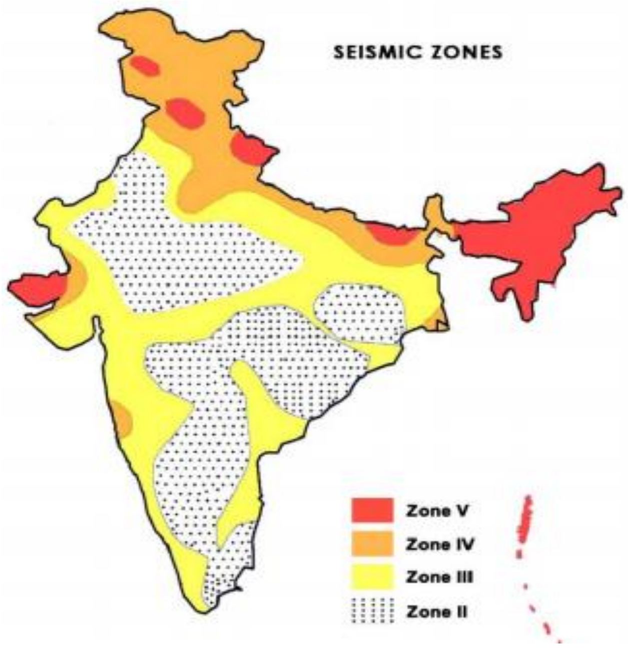


***Fig.2:-*** *Sketch of Seismic Zone Map of India as per IS: 1893 (Part 1) – 2007*

**MODELLING**

In all, four models were considered: Type-1: Regular model (Figure 3); Type-2: Heavy mass at 5th and 10th story (Figure 4); Type-3: Soft story at Base storey (Figure 5); and Type-4: Irregular geometry at plan as Re-entrant corners (Figure 6). Details of Buildings considered in this work are as follows (Table 1):

- Type of structure: Residential Building
- Height of typical floor: 3.2m
- Column size: 300 mmX500 mm
- Beam size: 300 mmX500 mm
- Slab thickness: 150 mm
- Masonry wall thickness: 230 mm
- Live load: 2 KN/m$^2$
- Floor finish: 1 KN/m$^2$
- Earthquake loads are calculated as per IS 1893(Part 1): 2002 for the seismic zone II, zone III, zone IV, zone V.
- Soil types considered as type II – Medium soil.
- All the columns are assumed to be fixed at their base.
- Characteristic compressive strength of concrete, $f_{ck}$: 20 N/mm$^2$
- Grade of steel: 500N/mm$^2$
- Density of Concrete: 25N/mm$^2$
- Modulus elasticity of concrete: 2000N/mm$^2$
- Poison's ratio of concrete, μ: 0.3
- Density of brick masonry, ρ: 19.2 KN/m$^3$
- Modulus of elasticity of brick masonry: 14000 N/mm$^2$
- Poison's ratio of brick masonry: 0.2
- Damping ratio: 5%

***Table 1:-*** *Seismic Calculations for All Zones*

| **Characteristics** | **Zone 2** | **Zone 3** | **Zone 4** | **Zone 5** |
|---|---|---|---|---|
| Number of stories | 16 | 16 | 16 | 16 |
| Typical storey height, m | 3.2 | 3.2 | 3.2 | 3.2 |
| Seismic zone, Z | 0.10 | 0.16 | 0.24 | 0.36 |
| Response reduction factor, R | 3 | 3 | 3 | 3 |
| Importance factor, I | 1 | 1 | 1 | 1 |
| Soil type | II | II | II | II |

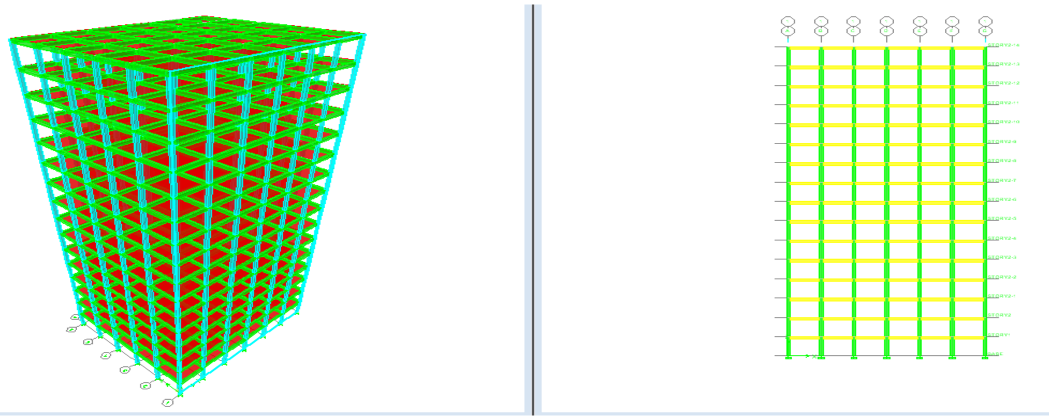

***Fig.3:-*** *ETABS Model of a regular 16 Storied Building (Type-1)*

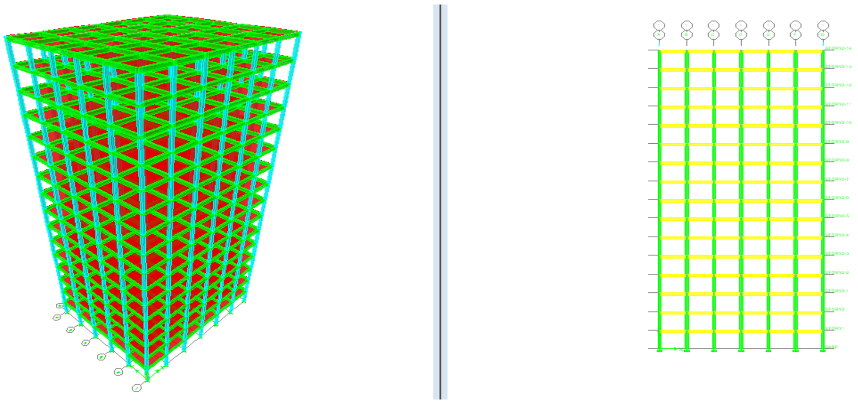

***Fig. 4:-*** *ETABS Model of an irregular 16 Storied Building (Type-2) in which an additional mass of 5 KN/m$^2$ is assigned at the fifth and tenth floors*

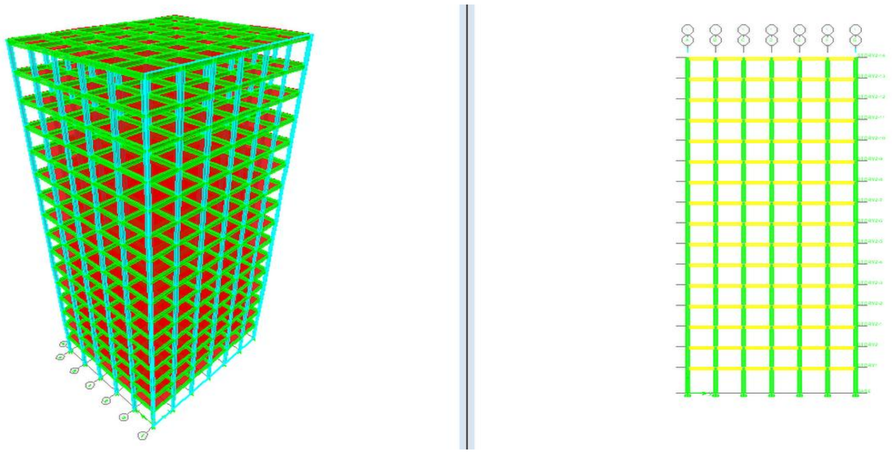

***Fig.5:-*** *ETABS Model of an irregular 16 Storied Building (Type-2) in which the base storey is modelled as soft storey*

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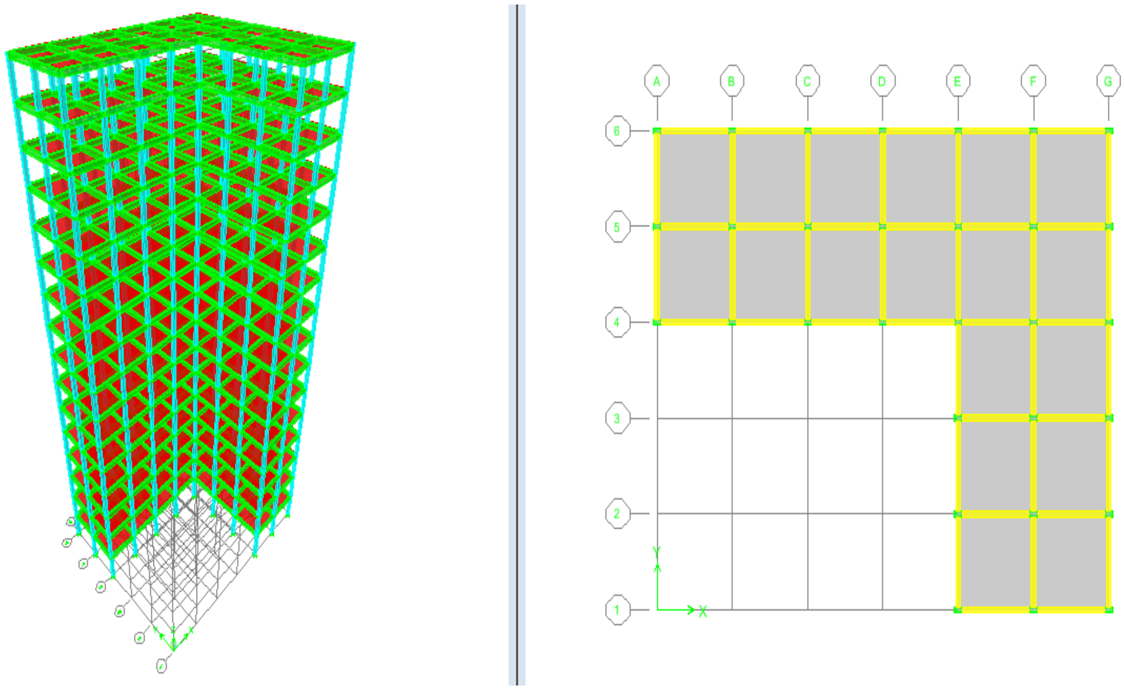



***Fig.6:-** ETABS Model of an irregular 16 Storied Building (Type-2) in which the plan is irregular and is made as re-entrant corners*

**RESULTS AND DISCUSSIONS**

The aftereffect of Base shear, Parallel uprooting, story float, Major timeframe at the principal, second and third mode are displayed for various inconsistencies and contrasted and customary model for various seismic zones of India.

Figure 7 demonstrates the diagram of Zone v/s Base shear all things considered, it demonstrates that as the zone builds Base shear additionally increments, so the most extreme Base shear is in Sort 4 for example Re-participant corner in zone 5 which is the most powerless seismic zone of India.

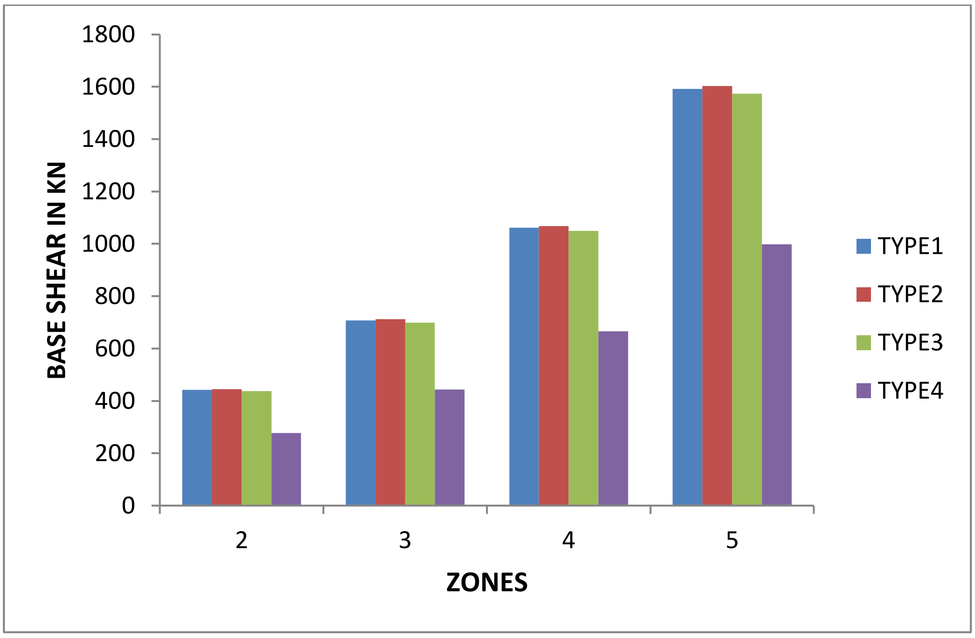



***Fig.7:-** Graph of Zone v/s Base shear for all type of models*

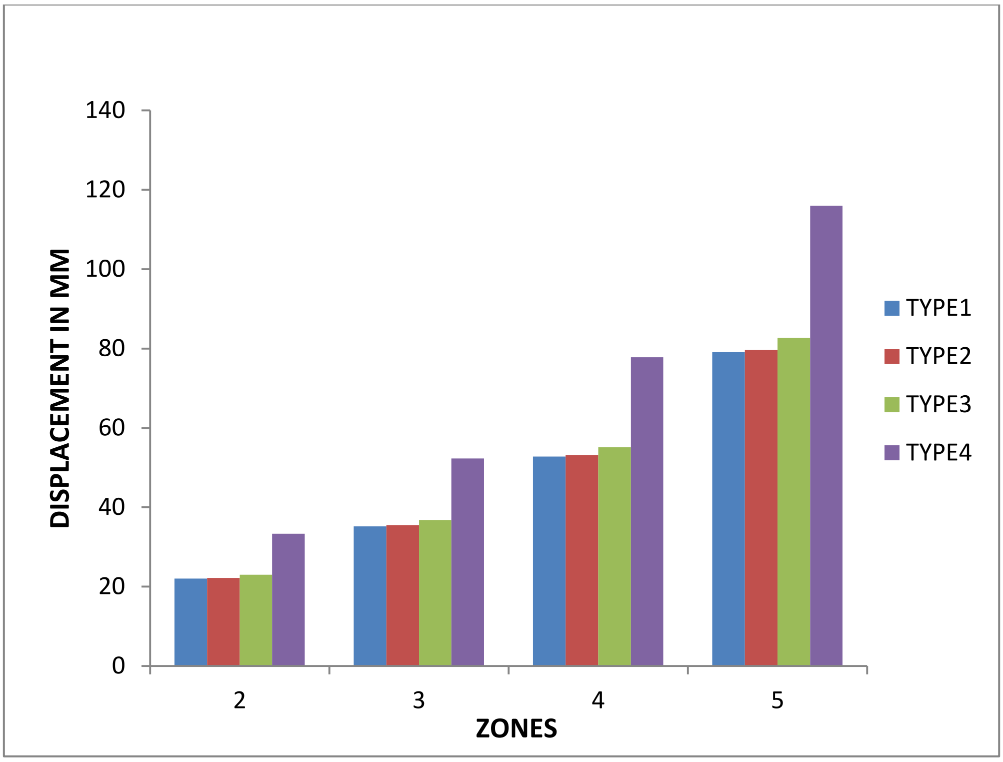
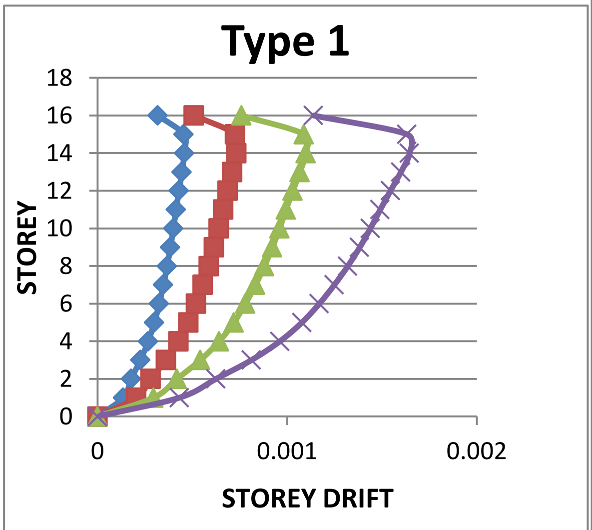


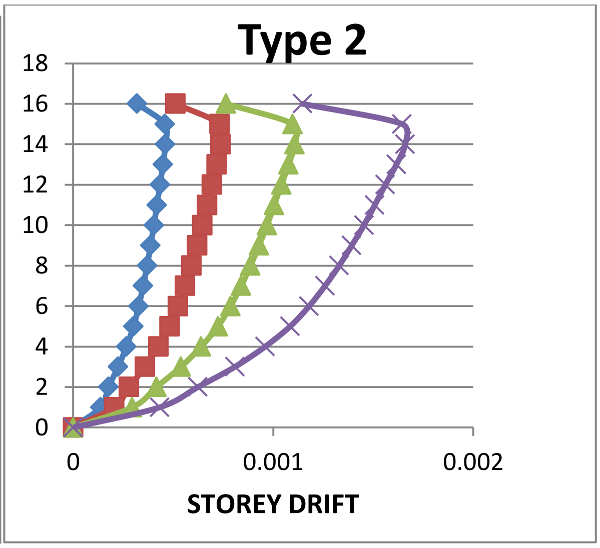

***Fig.8:-*** *Graph of Zone v/s Displacement for all type of models*

Figure 8 shows the graph of Zone v/s Displacement of all models; it shows that as the zone increases Displacement also increases, so the maximum Displacement is in Type 4 i.e. Re-entrant corner in zone 5 which is the most vulnerable seismic zone of India.

From Figure 9, it can be observed that from base storey to 14th storey the storey drift gradually increases but in 15th and 16th storey it decreases because usually storey drift is maximum in middle portion of the structure.

Figure 10 shows the graph of models v/s Time period of all models, it shows that in type 3 i.e. stiffness irregular (soft storey) model maximum time period is 3.13secs in mode 1.



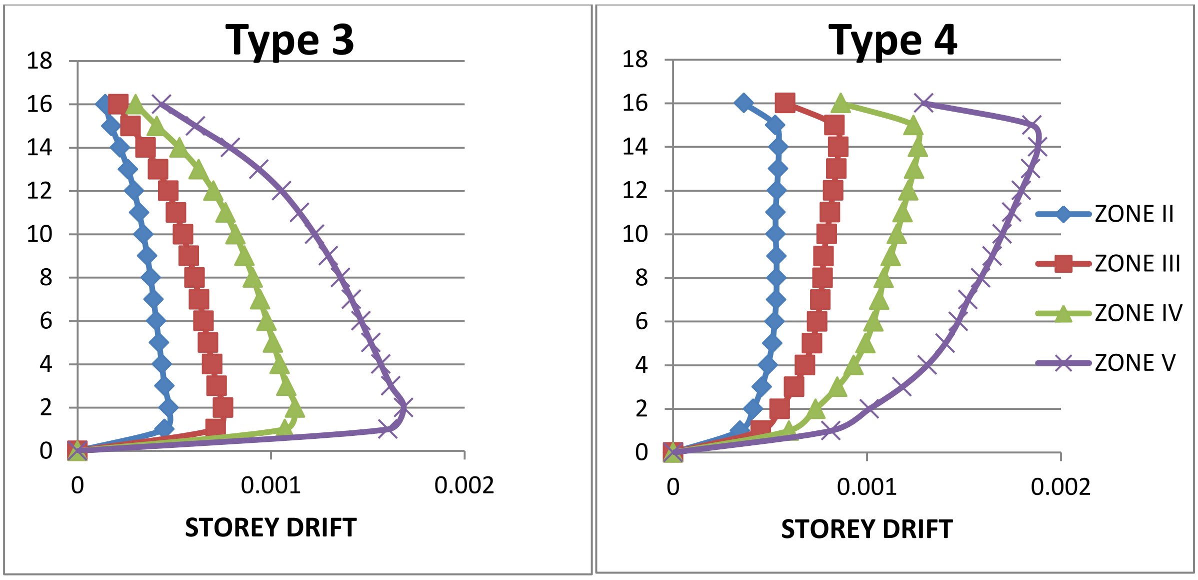



*Fig.9:-Graph of Storey drifts v/s Storey all the models*

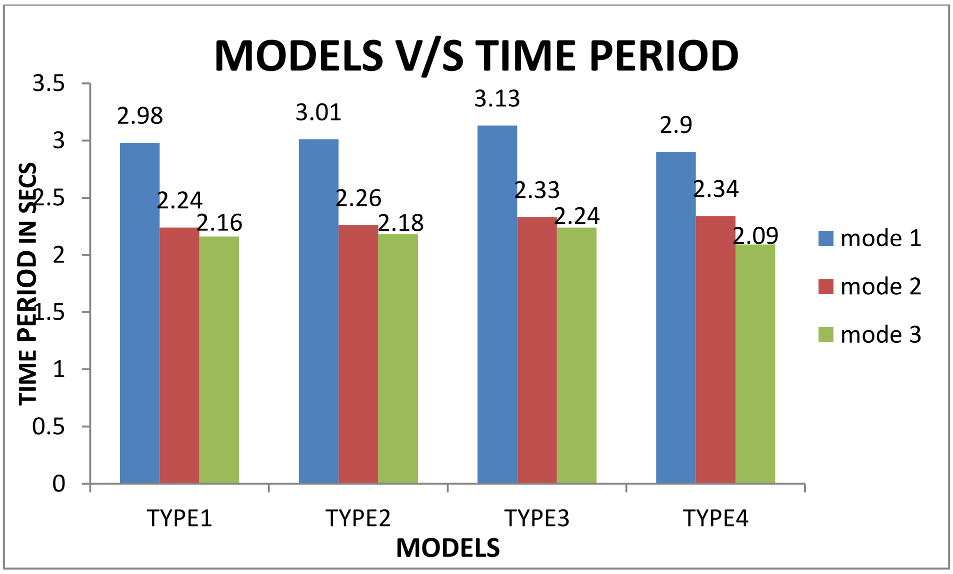



*Fig.10:-Graph of Time period v/s modes for all type of models*

## SUMMARY AND CONCLUSIONS

The present investigation tries to assess the impact of firmness on seismic reaction of a vertical sporadic structure on seismic zones II, III, IV, and V on medium soil. The investigation likewise stretches out to discover the impact of Base shear, horizontal uprooting of structures and major normal time of the customary and unpredictable models. The examination prompts the accompanying expansive ends. The following are the key observations of this study-

- The Base shear and sidelong removals are progressively expanded with increment in zone factors for all models.
- The horizontal uprooting is less in normal model contrast with vertical unpredictable models.
- The sidelong dislodging is most extreme in model kind 4 for example the Re-participant corner model.
- The sidelong dislodging is least in model sort 1 for example the customary model. The base shear is maximum in the model type-2 i.e.

mass irregularity, heavy mass in 5th and 10th floor.

- The base shear is minimum in model type-4 i.e. Re-entrant corner model.
- From the modal analysis, it shows that the natural time period is gradually increases with the type of irregularity.
- The timespan from the outset mode is high in model sort 3 for example solidness abnormality and low in the model sort 4 for example Re-contestant model. The base shear and lateral displacement are gradually increased with increase in zone factor for all types of models and maximum for severe zone-5.
- The vertical irregular models i.e. model-3 and model-4 shows the less base shear compare to other type of models.
- The base shear is almost same in regular model, model type-2 and model type-3.
- The regular model shows less displacement compare to irregular model, but the displacement is almost same in regular model and irregular model i.e. model type-2.
- At the point when sporadic structures are examined utilizing direct comparable static examination and Reaction range investigation thinking about various seismic zones as indicated by code arrangements, the outcomes got features the significance of mass, firmness and geometry of the structure. Following wide ends can be made in this regard:
- This study measures the impact of vertical abnormalities in mass and firmness on seismic requests.
- From the general examination and perception it tends to be infer that, Base shear and sidelong dislodging will increments as the seismic force increments from zone-2 to zone-5 which shows progressively seismic interest the structure should meet.
- Base shear for mass inconsistency is discovered more contrasted with every single other abnormality since base shear relies upon seismic load of the structure.[16]

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