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SEISMIC ANALYSIS ON BUILDING WITH HORIZONTAL AND VERTICAL IRREGULARITIES

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Abstract - *Earthquake is a very important aspect to be considered while designing structures. The performance of a irregular structure during sturdy earthquake motions based on the action of different loads acting along the horizontal and vertical planes of the building.*

The thesis mainly focuses on study of structural behaviour of building to understand irregularity which is due to horizontal & vertical plane hence structures with irregular shapes or plan have been considered. A set of ten different models are taken into account out of which the first model is with the regular structure, second-fifth with horizontal irregularities and the remaining sixth-tenth with both horizontal and vertical irregularities.

All the models are analysed by the ETABS software. The seismic analysis performed consists of the Equivalent static analysis, response spectrum analysis.

Keywords- *Structure Design, Plan Irregularity, Seismic Response Parameters etc.*

1. INTRODUCTION

1.1 GENERAL

Structural analysis is to determine the affecting form and the certain measurable extent of precise building to bring into existence the purpose and will exist un-changed safely

Throughout the useful life of the structure. ETABS yield static forces and also the forces producing motion is been analysed for lateral and downward loads. Dynamic study is comprises of earthquake response spectrum or accelerogram time period.

If all the building elements are arranged with uniformity and the earthquake striking in the familiar direction is optimal. Due to lack of availability of land in big cities, architects usually go for the irregular building structures to make the effective use of available area and to impart provision of proper light and ventilation in the structures. However, the structural irregularity is a combined state of two types that is horizontal and vertical. The horizontal irregularity may be classified on the bases of Asymmetrical plan shapes, Re-Entrant corners, Diaphragm discontinuity and irregular distribution of mass, strength, stiffness along plan etc., and the vertical irregularity may be classified on the bases of Mass, Strength, Stiffness and Setback. Adequate to most of such asymmetries, the structure's lateral resistance of earthquake is generally torsionally uneven & thus creating great amount displacement, drift and high force concentrations within the resisting elements which can cause severe damages and may lead to collapse of the structure

The thesis mainly emphasizes to gain the knowledge of different shapes of structures such as rectangular, T, E, F & S types for both horizontal & vertical irregularities by using ETABS. A 32m x 40m 15- storeys structure having 4m x 4m bays is modelled using ETABS. Loads which are considered have been taken in a manner conforming to the code IS-1893(2002).

We observe that the existing structures are frequently irregular as perfect regularity is an idealization that rarely occurs in the practice. Regarding buildings, for practical purposes, major seismic codes across the globe differentiate between irregularity in plan and in elevation, but it must be realized that irregularity in the structure is the consequence of a combination of both types. It is seen that irregular structural alignments in elevation or in plan were frequently recognized one of the major action of collapse through precedent seismic motions.

1.2.1 OBJECTIVES

- The aim of this research is to show the performance & behaviour of rcc framed regular & vertical geometric irregular structures under seismic motion.
- To accomplish a comparative knowledge on the various seismic parameters for the different forms of reinforced concrete moment resisting frames(MRF) with varying number of stories, configuration and types of irregularity.
- To study the change in different seismic response parameters along the increasing height and increasing bays.
- To obtain the storey drifts & displacements at each one of the storey's using equivalent static analysis & response spectrum analysis.
- Comparing the results from different methodologies.

1.2.2 SCOPE OF THE STUDY

The purpose of this hypothetical study is to evaluate the seismic properties and characteristics for regular & vertical geometry structures. The main aspect of this analysis is to obtain the sustainability of the building regarding the performance of the buildings by using the aid of capacity and the demand of the structure for a designed strong motion earthquake characteristics using the different method of analysis.

II. METHODS OF SEISMIC ANALYSIS

2.1 GENERAL

The purpose of the carrying out the process of seismic analysis is to find actually the several parameters which purely includes the force, the deformation, capacity of each of the components in the building structure. These analysis methodologies are listed in a hierarchical order as follows:

- Linear static analysis. (ESA)
- Linear dynamic analysis. (RSA)
- Non linear dynamic analysis. (time history)

2.1.1 LINEAR STATIC ANALYSIS
(Equivalent Static Method)

This is one of the simple most analysis procedures which makes ease for the structural designer to perform and carry out the design process. This analytical method is also prescribed in almost all the codal formats used for seismological analysis and is used mostly for the building which has some regular parameters of components for the purpose of design. This method is also popular by the name lateral forces method as the effects in this method of seismic motion are purely assumed to be the similar one as that which becomes as a result from the static transverse loads.

The different codal provisions gives their own methods to obtain and to distribute the static forces so that to obtain the effects of seismic ground motion on the structural frames. Generally the expression is initially defined to set a prescribed value of the minimal lateral seismic force, which is also named as the base shear force. The single basic general requirement for the building structure with respect to the application of this methodology is purely that the natural vibration period of the building structure must be limited to a maximal values, which certainly results to a minimal values of frequency or the stiffness. This is because of the fact that often reacts is primarily determine by it's first modes of vibrations. Resulting therefore in minimal values of frequency the contribution of the higher modes can be generally neglected.

2.1.2 LINEAR DYNAMIC ANALYSIS
(Response Spectrum Analysis)

The linear dynamic method of analysis has been proved to be the efficient ever design methods and almost mostly used and suggested by the structural designers for the purpose of analysis and design of the RC framed structure and their respective components.

When we carry out the dynamic analysis, the inelastic response is empirically purely reviewed, As the non linear behavioural properties of the buildings which purely govern the designing under the strong ground motion. Due to these reasons the designers suggests and they too prefer the simplex methodology to carry out the analysis with the help of the elastic dynamic analysis methods.

The consideration of the modal contributions of each modes is the very important parameter in case of the multi-storeyed buildings. A unique deformation possess at each single modes. The several important factors of the building structures are purely depends on the contributions from these vibration modes. The modal contributions resulting from the higher modes is smaller for the seismic response of a short to medium rised buildings because of the influencing property of the
fundamental mode is very larger that is in the range of about 70-90% .
Here in this method it is mostly important to consider the vibrations at the initial stages so that we get the results in a almost nearer exactly conditions.

III. ANALYTICAL MODELLING

3.1 DESCRIPTION OF MODELS

Model 1: The model-1 is a rectangular symmetry model.

Model 2: The model-2 is a T-shape model with irregularity in horizontal direction.

Model 3: The model-3 is a E-shape model with irregularity in horizontal direction.

Model 4: The model-4 is a F-shape model with irregularity in horizontal direction.

Model 5: The model-5 is a S-shape model with irregularity in horizontal direction.

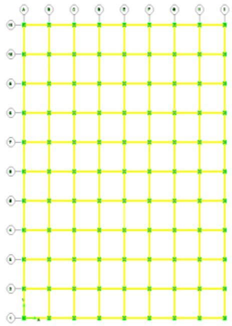
Model 6: The model-6 is symmetry model with irregularity in vertical direction from tenth-fifteenth storey.

Model 7: The model-7 is T-shape model with a combination of horizontal & vertical irregularity from tenth-fifteenth storey.

Model 8: The model-8 is E-shape model with a combination of horizontal & vertical irregularity from tenth-fifteenth storey.

Model 9: The model-9 is F-shape model with a combination of horizontal & vertical irregularity from tenth-fifteenth storey.

Model 10: The model-10 is S-shape model with a combination of horizontal & vertical irregularity from tenth-fifteenth storey.



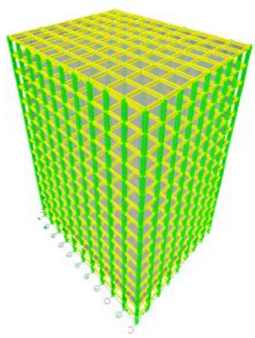


Fig:1 model-1 Fig:2 model-1 3D view

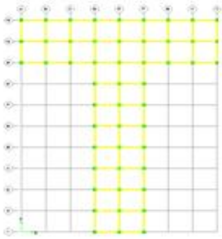


Fig:3 model-2

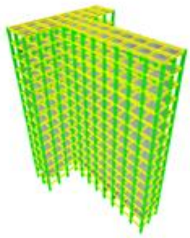


Fig:4 model-2 3D view

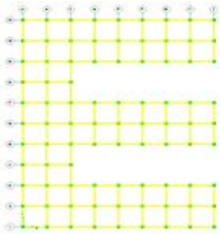


Fig:5 model-3

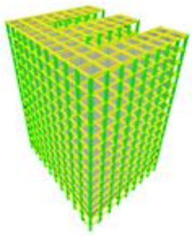


Fig:6 model-3 3D view

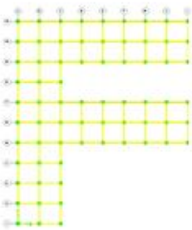


Fig:7 model- 4

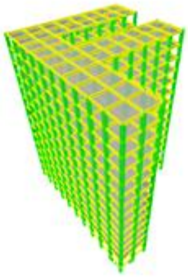


Fig:8 model-4 3D view

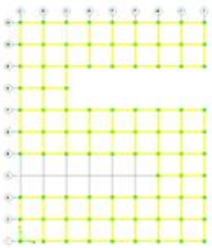


Fig:9 model-5

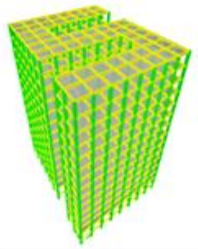


Fig:10 model-5 3D view

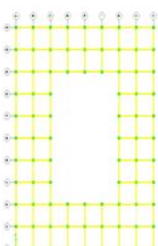


Fig:11 model-6

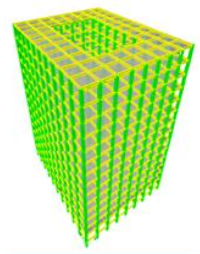


Fig:12 model-6 3D view

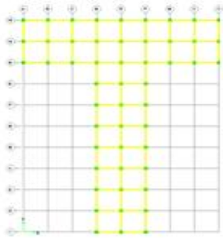


Fig:13 model-7

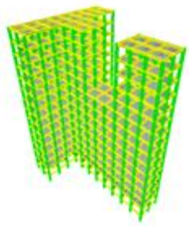


Fig:14 model-7 3D view

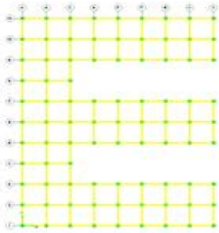


Fig:15 model-8

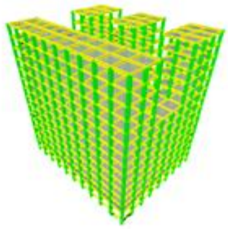


Fig:16 model-8 3D view

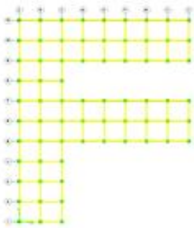


Fig:17 model- 9

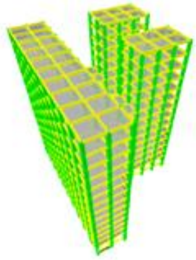


Fig:18 model-9 3D view

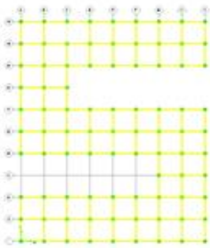


Fig:19 model-10

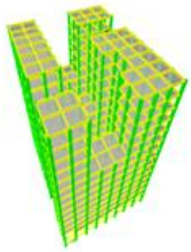


Fig:20 model-10 3D view

3.2 Design Data

3.2.1 General

Height of each storey=4m

Depth of foundation=2.0m

3.2.2 Loads

Live load= 3.0 KN/m^2

Floor finishes= 1.0 KN/m^2

Wall load= 11.385 KN/m

Fig:11 model-6 Fig:12 model-6 3D view

3.2.3 Seismic Data: Zone factor (table 2 of IS: 1893-2002)= = 0.36 (Zone V)

Importance factor (table 6 IS : 1893-2002)

= 1.0

Response reduction factor (table 7 IS: 1893-2002)= 5 (SMRF)

Soil type (figure 2 of IS 1893-2002)=Type II (Medium soil)

3.2.4 Member Properties:

Thickness of RC slab= 0.150 m

Column size= (0.6X0.6) m

Beam size= (0.23X0.45) m

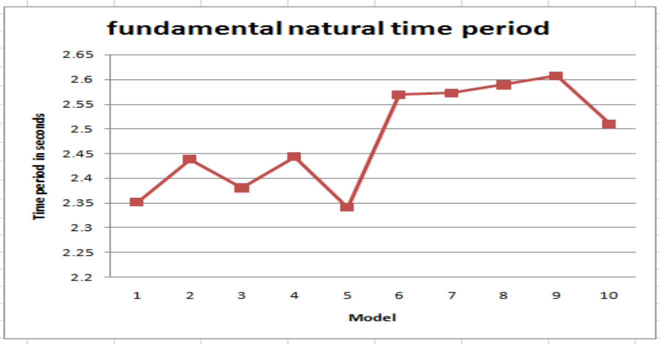
Thicknesses of brick masonry wall= 0.230 m

IV. ANALYTICAL RESULTS AND DISCUSSIONS

The results obtained are of various parameters such as fundamental natural time period, storey drifts, storey displacements, and the design seismic base shear etc. The seismic performance and behavior of any building frames can easily be predicted based on studying these parameters.

4.1 Fundamental Natural Time Period

Chart no-1



\ Table-1 Fundamental natural time period for different building models

Model No	T in sec
1	2.5103
2	2.6074
3	2.5899
4	2.5734
5	2.5692
6	2.3415
7	2.4431
8	2.3802
9	2.4383
10	2.3518

While comparing all the models the model no 01 has a smallest value as compared to all other models, where as model no 09 has the highest value. And also model no 2,3,4,& 5 has the small values and model no 6,7,8,10 has higher values.

Therefore we can easily come to conclusion that by increasing height & bays their is also increase in the fundamental natural period of the building.

4.2 Design Seismic Base Shear:

Table-2 Design seismic base shear for all models in both directions

	Equivalent static analysis		Response static analysis	
Model No	Design seismic base shear in KN (Longitudinal direction)	Design seismic base shear in KN (Transverse direction)	Design seismic base shear in KN (Transverse direction)	Design seismic base shear in KN (Transverse direction)
1	5370.07	5436.41	4642.98	4701.51
2	2312.25	2477.39	1527.44	2147.22
3	4399.57	4034.48	3823.49	3317.53
4	3371.26	3201.51	2288.09	2133.35
5	4399.57	4066.98	3813.10	3529.33
6	5317.44	5389.92	4559.08	4627.71
7	2451.23	2451.58	1483.86	2103.30
8	4328.86	3996.75	3674.38	3005.89
9	3487.64	3290.17	1819.03	1886.97
10	4329.22	4045.02	3674.63	3396.27

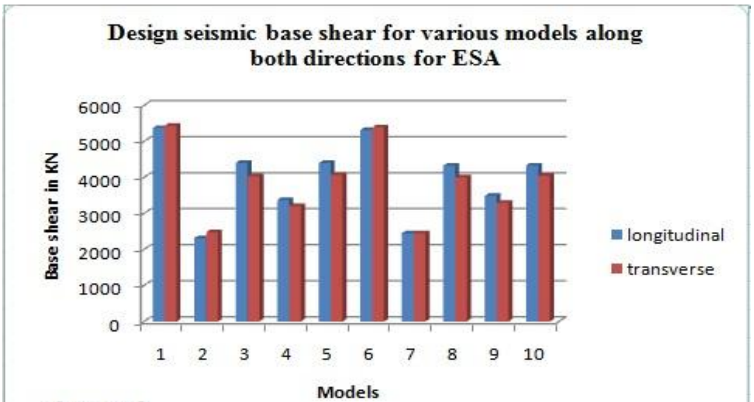


chart no-2

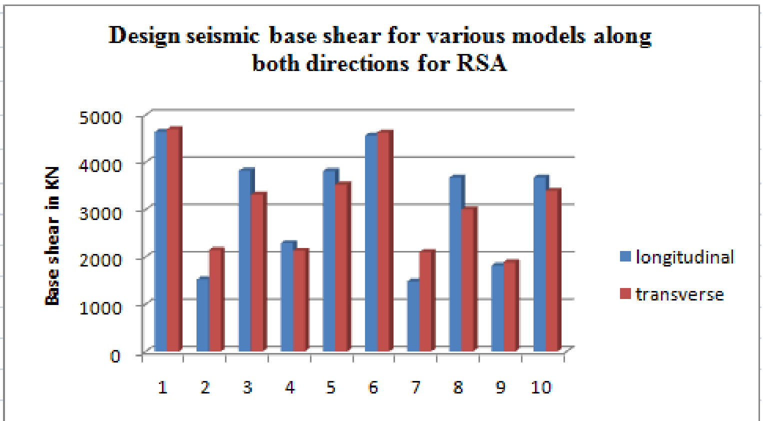


chart no-3

From above chart no-2 &chart no-3 we see that the base shear values in both the longitudinal as well as transverse direction are at its peak (highest) in the model no-01 and model no-06 for both ESA & RSA method.

4.3 Story Drifts

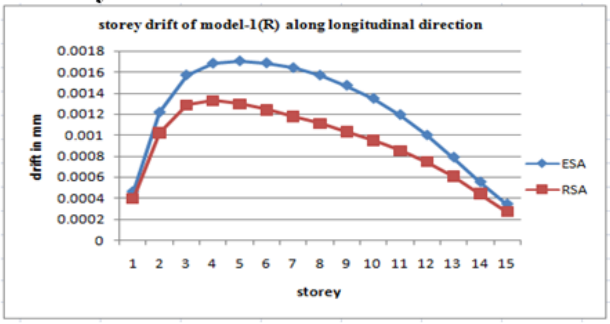


Chart -4

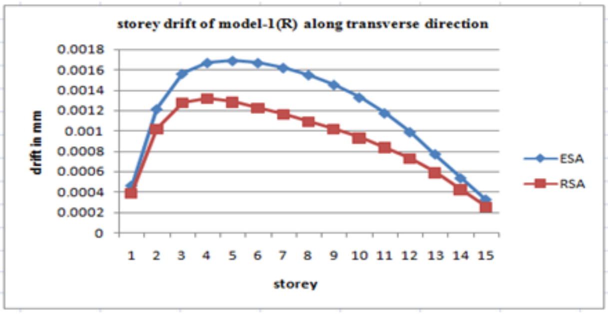
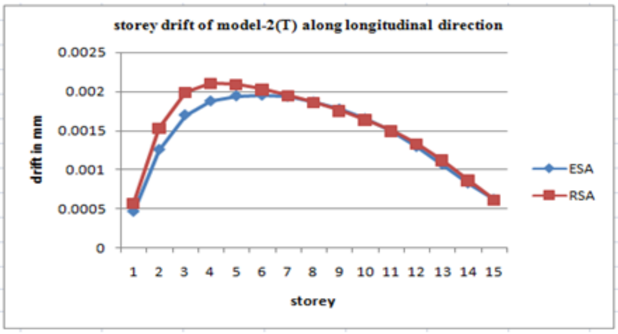


Chart -5



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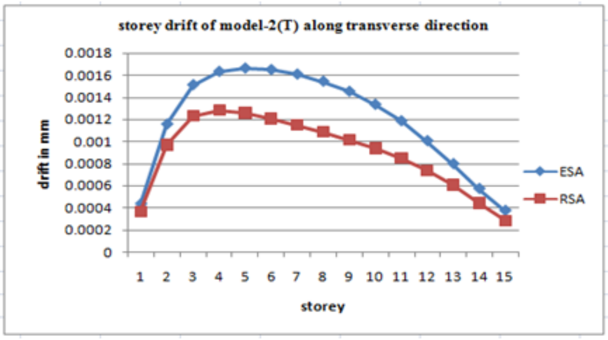

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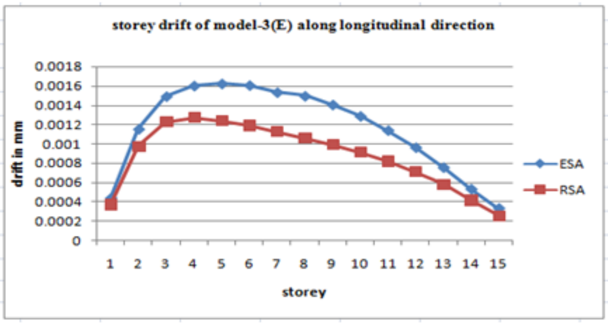

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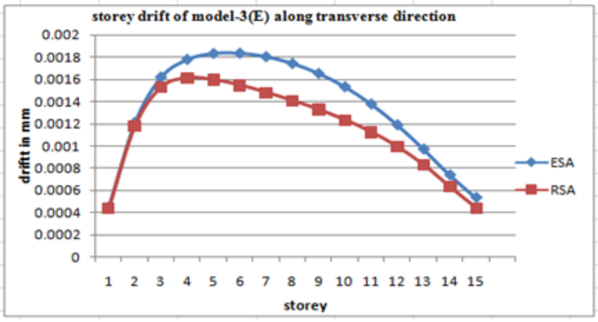

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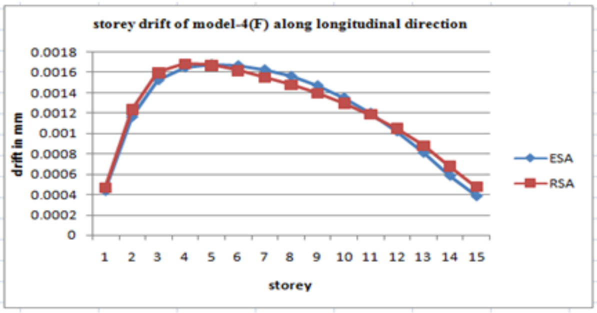

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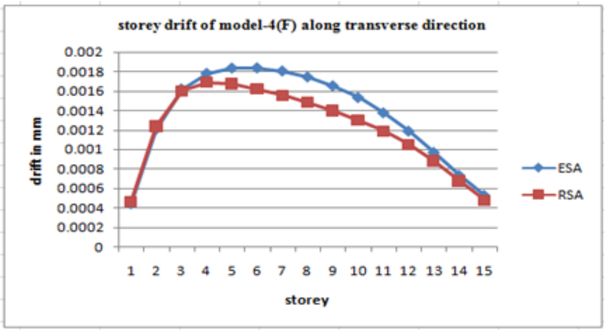

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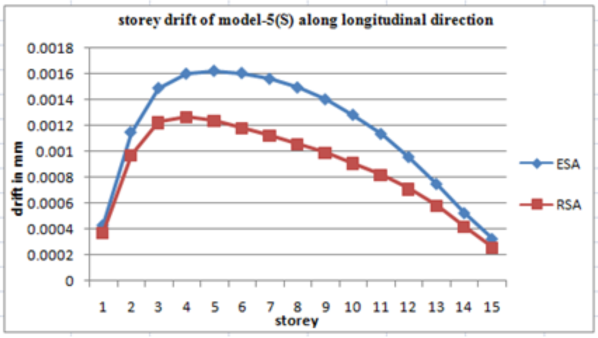

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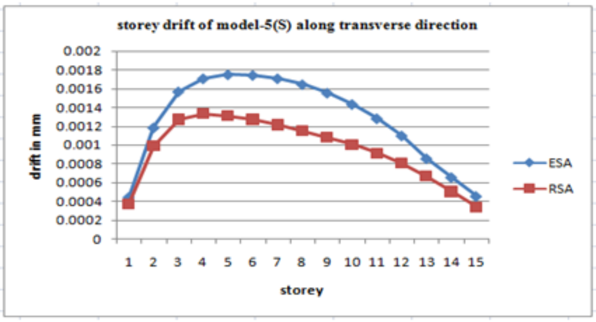

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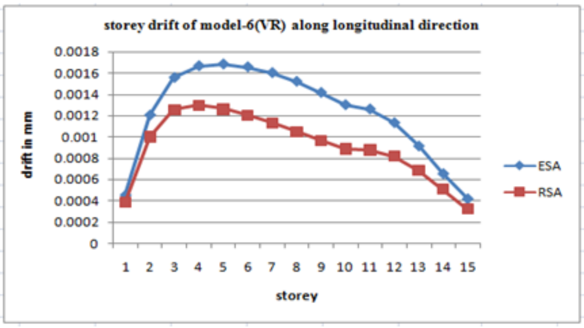

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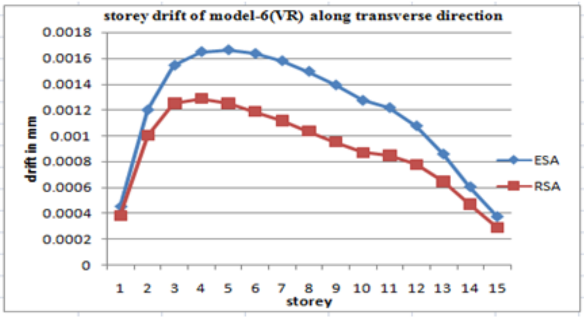

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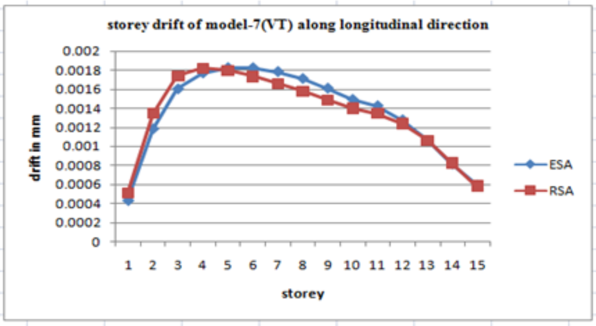

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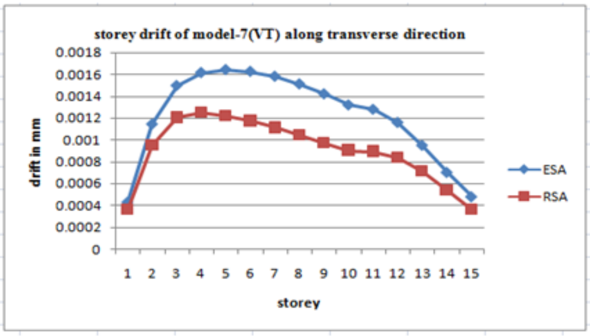

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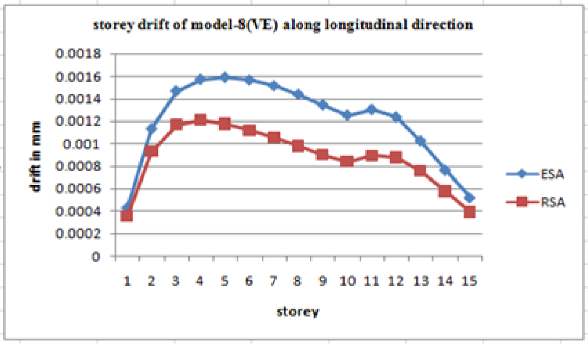

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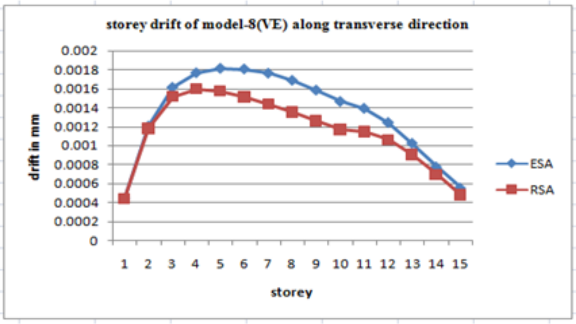

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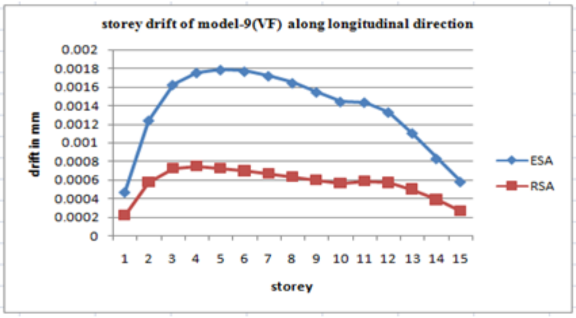

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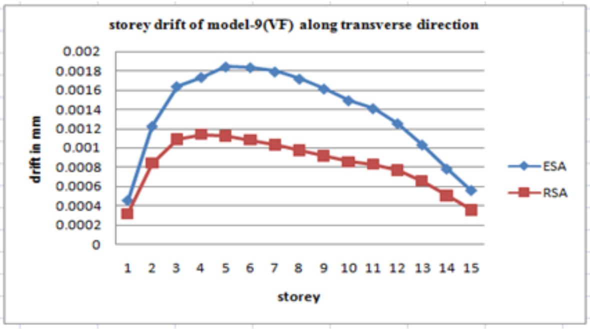

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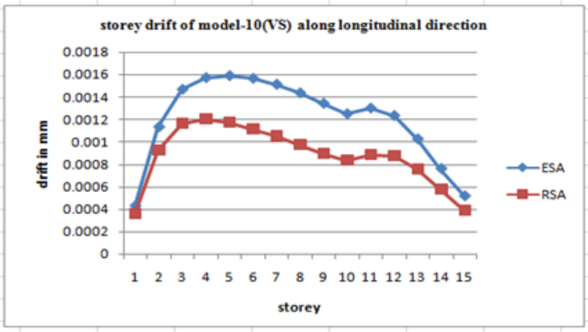

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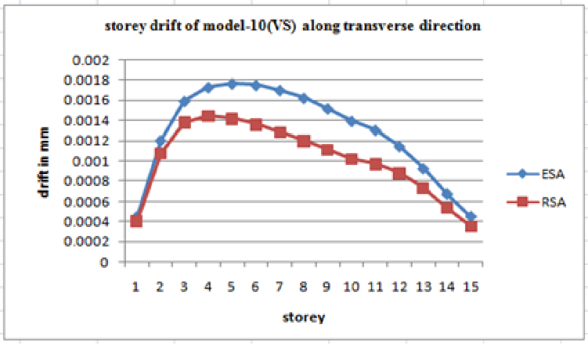
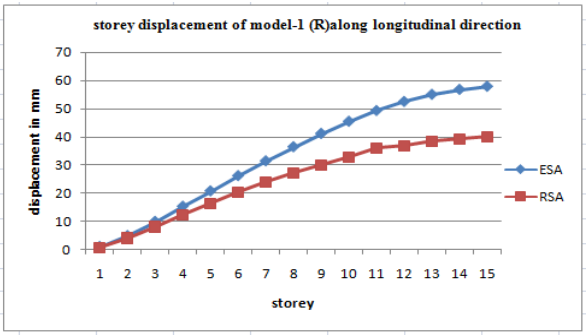


Chart -23

From the table 6.1, it can be seen that the T shape frame model (model 2) yields higher drift values as compared to other models .The drift values gradually increases from storey level 2 to storey level 11 then starts decreasing from storey 12 in the longitudinal directions for RSA & transverse direction for ESA as shown in the chart 6.4&6.5. Also the storey drift in both the directions satisfy the permissible limit i.e. 0.004*h =0.004*3.5 =0.014m =14mm.

4.5 Displacements



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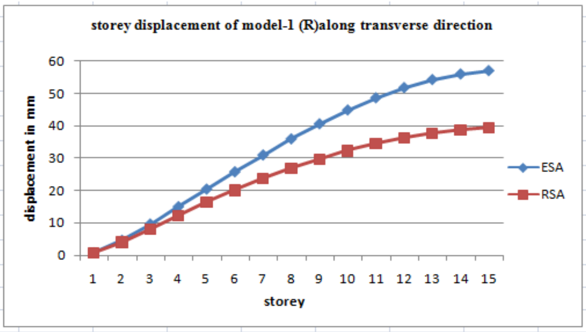

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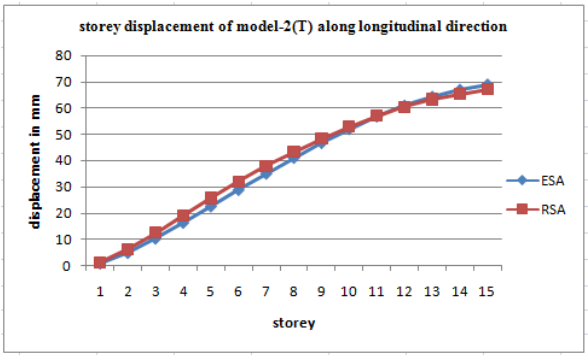
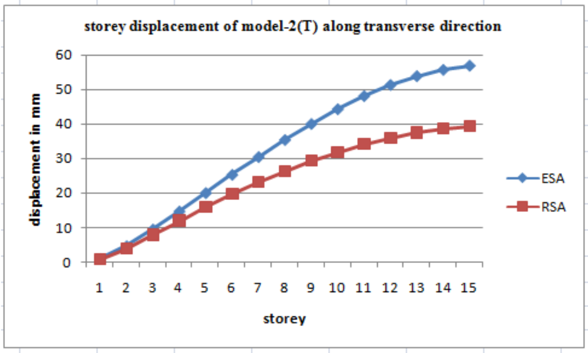


Chart-26



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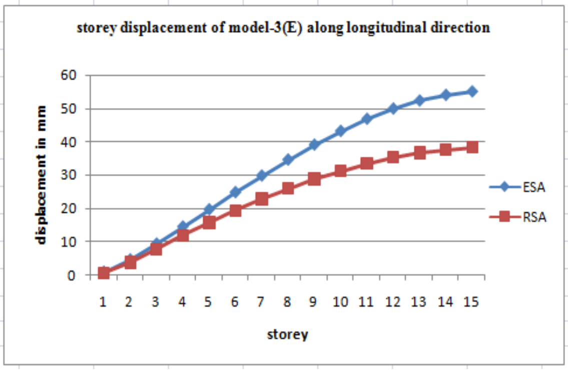

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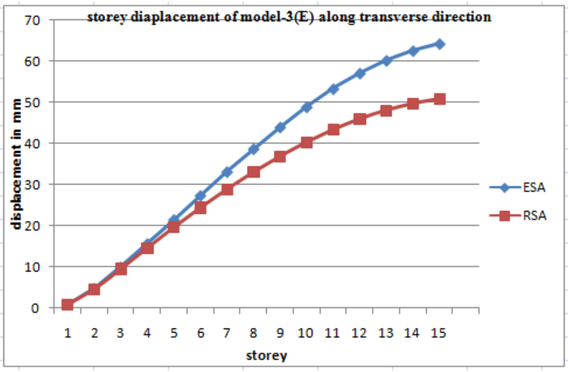

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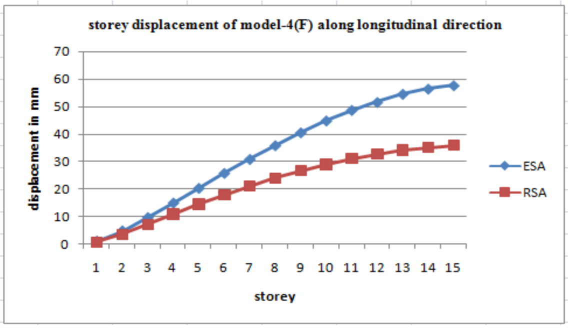

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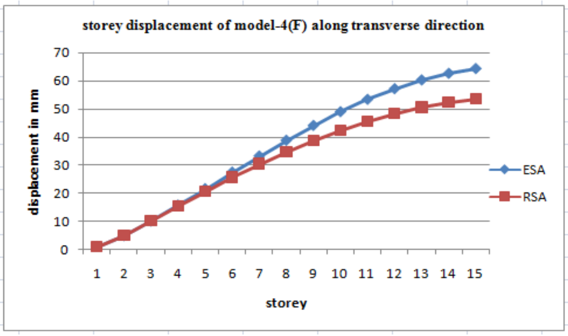

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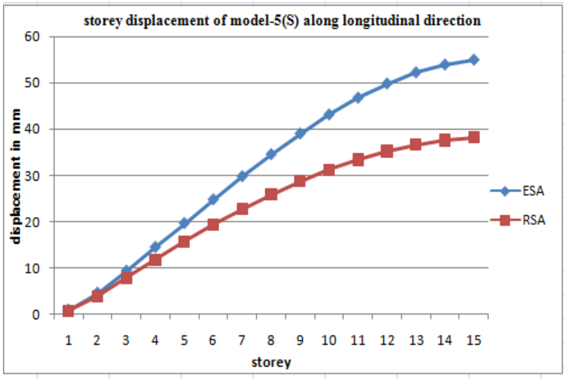

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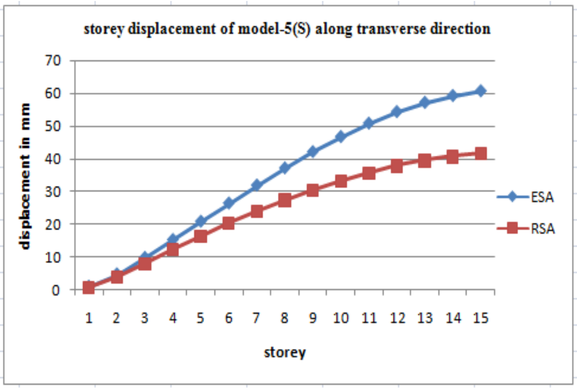

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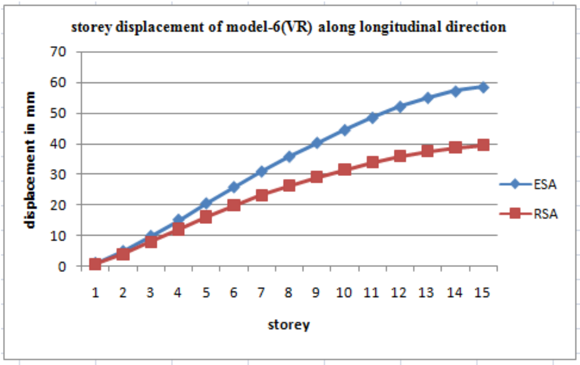

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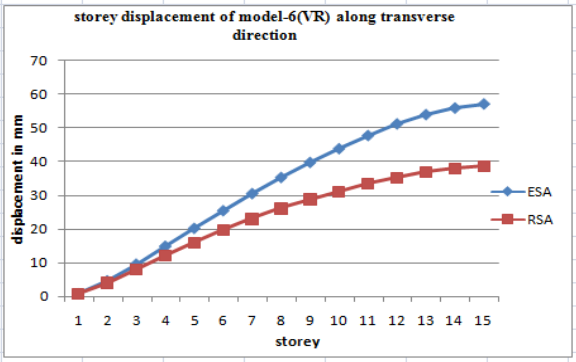

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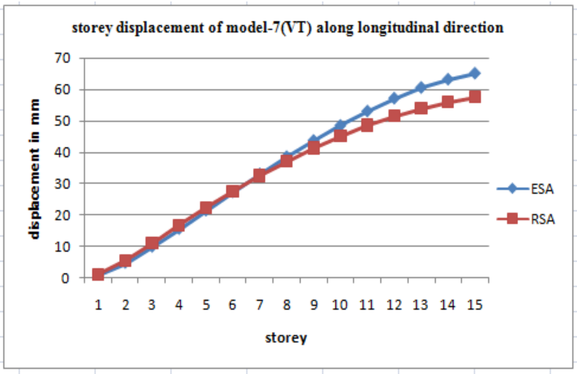

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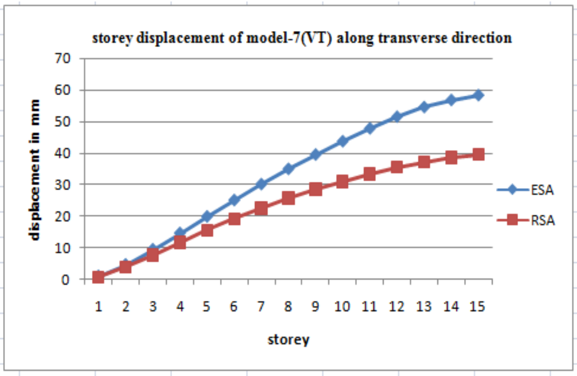

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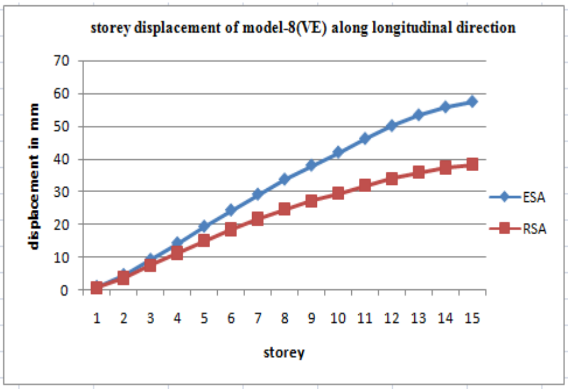

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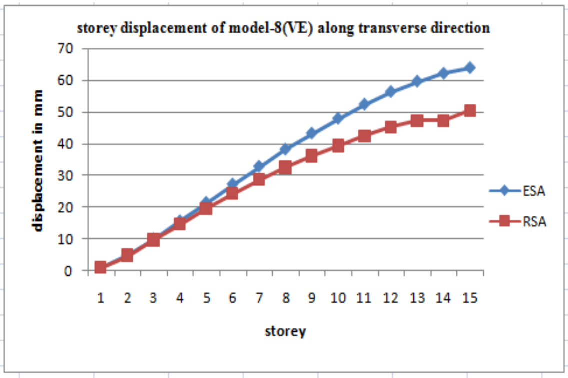

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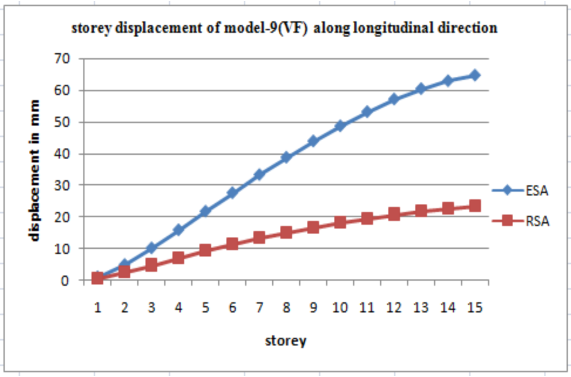

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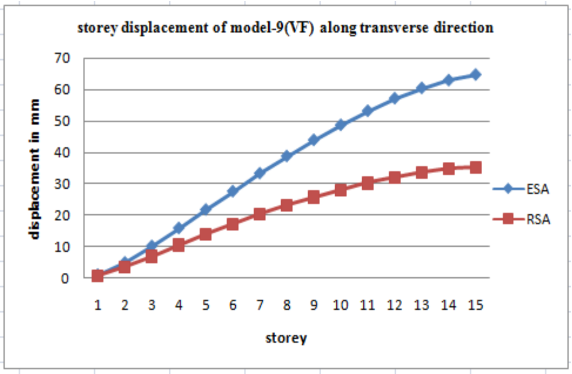

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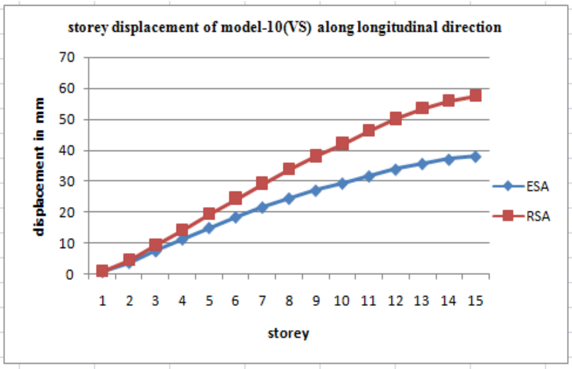

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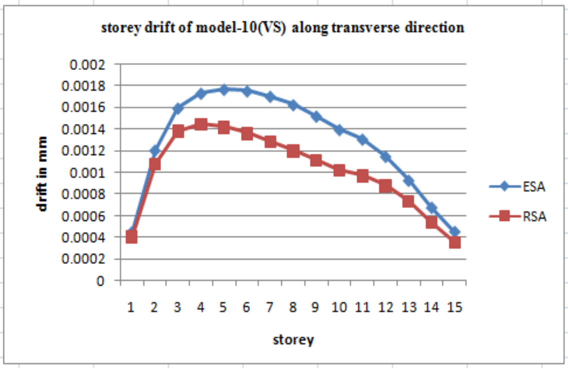

Chart -43

The T-shape frame (model 2) yields the higher values of displacement due to irregular geometry shape for ESA compared to other method in which the ESA curve lies above the curves obtained of RSA. From the tables 6.11 to 6.20, for model 1 to model 10, it is observed that, the displacement values for models are smaller in comparison to model 2. Also the displacement in the transverse direction is more that the corresponding displacement in the longitudinal direction for the model 3 & model 4.. From the above observations we at this position can say that buildings with irregular geometry shape yield large displacement & more effective against seismic forces as in case compared to regular geometry shape.

V. CONCLUSIONS

1. The fundamental natural time period is observed to be the less for the model which is symmetry in shape as compared to asymmetry in shape.
2. It has also been noticed that the time period increases for the models which are asymmetry in shape when subjected to irregularities in both horizontal & vertical direction.
3. It is found that base shear yields low value in Response spectrum analysis when compared with the Equivalent static analysis.
4. It is concluded that as the amount of setback increases, the critical storey shear force also increases. The regular building frames possess very low shear force compared to setback irregular frames.
5. It is observed from the analysis that there is large displacement and drift in model-(2) i.e. T-shape when it is compared with the other model in Response spectrum analysis & Equivalent static analysis.
6. After carrying out the analysis and the results we came to the conclusion that the seismic performance of regular frame is found to be better than corresponding irregular frames in nearly all the cases. Therefore it is suggested to construct a regular frame to minimize the seismic effects.

5.1 SCOPE FOR FUTURE STUDY

In these modern days majority of structures are involved to an architectural significance & it is not possible to plan the regular form of structure. The case study in this thesis is specified on response spectrum analysis & equivalent static analysis as it will be insufficient to gain the knowledge of linear behaviour of the building & as a result to large amounts of research in non-linear static analysis i.e. push over analysis & non-linear dynamic analysis is focused.

The study can be extendable by taking into consideration the effect of bracing system in horizontal & vertical irregularities will be more effective.

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