International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Lateral Load Analysis of Multi-Storey Building with Vertical irregularities

Syed Yasir Md Jani [a], *Prof. Shaik Abdulla* [b]

[a] *Student, Department of Civil Engineering, Khaja Bandanawaz University, Kalaburagi, Karnataka.*

[b] *Assistant Professor, Department of Civil Engineering, Khaja Bandanawaz University, Kalaburagi, Karnataka.*

ABSTRACT

Points of weakness are where a structure first fails during an earthquake. This weakness results from a discontinuity in the structure's mass, stiffness, and shape. These structures are referred to as irregular structures since they have this discontinuity. Urban infrastructure is largely made up of irregular structures. Vertical irregularities are one of the major reasons of failures of structures during earthquakes. The object of the present work is to compare the seismic behaviour of regular building with vertically irregular building with step at different positions. For this purpose a total of six multi-storey buildings are considered i.e one is regular building and other five are vertical irregular building. To study the behaviour the response parameters selected are lateral displacement, time period, base shear and storey drift. All the buildings are assumed to be located in zone IV. For analysis Etabs software is used. For all six models equivalent static method and response spectrum method are applied to study the above parameters, and base on results conclusions are drawn.

Keywords: Lateral load, ETABS, Displacement, Base shear, Story drift.

1. Introduction

Dynamic Loads include both Earthquake and Wind loads, which may cause significant structural damage. Most contemporary buildings are built with architectural importance, and it is hard to design with regular forms in this era of architectural significance. Buildings that are subjected to dynamic stress often collapse because of structural abnormalities like this. As a result, much investigation is needed in order to get excellent performance even when the setup is subpar.

There should be no discontinuities with in geometry, mass, or components that resist load in an irregular structure, but if there is, then the structure is considered to be regular.

At the places of vulnerability, the structure begins to fall apart during an earthquake. Inconsistency in the structure's mass, rigidity, and shape contributes to this flaw. Irregular structures refer to constructions with this form of discontinuity. The urban infrastructure is heavily reliant on irregular constructions. One of the most common causes of building collapse during earthquakes is the presence of vertical abnormalities. Structures with spongy floors, for example, were the most often seen when disaster struck. As a result, it's critical to consider how vertical irregularities affect seismic assessment of structures. Buildings with varying levels of stiffness & mass have unique dynamic properties compared to a standard structure.

There is a considerable proportion of the city's infrastructure made up of non-standard structures. Structural, operational, & financial restrictions may be to blame for the appearance of irregularities. We want to learn more about the seismic behavior of buildings with vertical abnormalities as a result of our study. This is accomplished by calculating the seismic demand consequences of vertical mass, rigidity, or stiffness abnormalities.

1.1 Seismic Behavior Of Vertically Irregular Buildings:

The behavior of irregular structures has been the subject of several investigations in the past. Overall validity of inconsistency limitations, or the change in reaction owing to structures meeting these limitations, has not been quantified in such investigations, therefore the validity of these limits is unknown.

2. Literature Review

1. **Sumit Gurjar1, Lovish Pamecha:**

The object of the present work is to compare the seismic behaviour of regular building frame with vertically irregular building frame at different positions. For this purpose four frames of multi-storey buildings are considered. To study the behaviour the response parameters elected are lateral displacement and storey drift. All the frames are assumed to be located in zone II, zone III, zone IV and zone V. For analysis STAAD.Pro software is used.

Observation shows that for all the frames considered, drift values follow a similar path along storey height with maximum value lying somewhere near the thirteenth to fifteenth storey. From drift point of view, frame 1, 2 and 3 are within permissible limits in zone IV and zone V although at some storeys frame 2 and 3 exceeds marginally. But frame 4 in zone V exceeds permissible limits largely after tenth storey. In zone II and III all the frames are within permissible limit, hence there is no requirement of shear wall in these zones. And from displacement view point, only in zone II all the frames are within permissible limit. In zone III frame 1, 2 and 3 are in permissible limit but frame 4 requires shear wall to control the limit. In zone IV only frame 1 is within permissible limit, all other exceeds limits largely. And in zone V all the frames exceeds largely.

2. **Dr Prashant Hiwase1, Vipul V Taywade, Sharda P. Siddh:**

Two kinds of (G+15) structures were constructed, one regular and one Mass irregular. Checking maximum displacement for different models and settings in addition to see effects of lateral forces in both structures using seismic load.

When all is said and done, they've come to the conclusion that regular buildings perform better in earthquakes since their results values are lower compared to irregular structures.

3. **Jain Pritam Anil, Vaibhav. V. Shelar:**

This study, "Effect of Vertical Abnormality throughout Multi-Storied Buildings Under Impact Loading Utilizing Linear Static Static Analysis," examines how four types of 20-Storied 3-D frames respond to dynamic loads utilizing Linear Static analyse. There's really no Torsional impact as in regular frame due of symmetry, as examined in the study of four frames. Columns positioned in a plane perpendicular to the direction of force have a distinct reaction when applied to vertically uneven structures. This is because of the structure's Torsional rotation. Nodal deformations & drifting of frames obtained in this research are compared and evaluated. The initial shear force is the smallest, and it grows steadily until it reaches its maximum value at the top of the structure. Conclusion: G+25's storey drift is greater than G+15, G+20's. The base shear of G+25 is found to be greater than that of G+15 and G+20 Storey frames.

4. **Himanshu Bansal, Gagandeep:**

For this paper's research, we'll conduct RSA and THA on vertically uneven RC building frames, and then use IS 13920, the Equivalent static analysis & Time history analysis, to design for ductility. Stubbornness, bulk, and vertical geometry were all viewed as different sorts of irregularities. According to our findings, the first story has the highest shear force, and the lowest shear force is observed so at roof level. Larger base shear was detected in mass irregular structures compared to equivalent regular ones. Inter-storey drifts were greater in the irregular structure, which had a lower base shear. There was a significant difference between the displacements in a geometry irregular building and those in a regular structure for the first few floors in time history analysis, but as we descended to lower floors, the displacements both in buildings began to close the gap progressively. Higher upper-story displacements are caused by lower rigidity.

5. **Mohammed Ismail And Dr Abhijit Sinh Parmar:**

The primary objective of the study is to evaluate the loading machine's behaviour in a vertical anomalous multi-story building in the face of unusual pressures exerted on it during an earthquake. STAAD ProV8i SS6 software is used to conduct the assessment. The two types of G+12 story buildings having vertical geometric irregularity and mass irregularity Grow are compared. There are a total of 12 models that have been examined and their outcomes compared. By lowering the number of bays in X-path vertically downward, we can see how geometric irregularity affects the form of an aberrant structure (vertical geometric). It's done by comparing produced versions and determining cost of Bending Moment, node deformation, shear force, base shear, and other variables..

6. **Akhil R, Aswathy S Kumar:**

Structures with varying degrees of vertical irregularity are the focus of this study. RSA of a vertically uneven RC building is used to complete the project. An irregular 25X25m structure with a maximum height of 3.5m by every G+10 floor is modelled in this research. Rigidity, stiffness, & mass distribution in the building's vertical and horizontal planes affect the building's performance during study earthquake movements. The primary goal of this research is to compare the stiffness of three distinct regular structure models with three different plan irregular structure models with varying vertical irregular structures in order to find the stiffest model. Dynamic seismic loading is applied to all models in Zones V throughout the analysis process. After conducting response spectrum research, it has been discovered that the displacements in non-regularly shaped buildings are greater. Staad Pro V8i is used to model and analyze all building frames. It is possible to acquire a wide range of seismic responses, such as base shear, frequency, and node displacement. Regular construction is proven to perform better overall than irregular building. In STAAD Pro software, the Response Spectrum analysis is used to estimate the seismic behavior of multi - storied conventional buildings.

7. **Shridhar Chandrakant Dubule, Darshana Ainchwar:**

The goal of this project is to conduct RSA of irregularly shaped RC building frames, and to use IS 13920 related to RSA to the ductility-based design of structures. Analyses of irregular structures are put up against those of regular structures, and the findings are compared. A total of three abnormalities, namely mass, stiffness, and stiffness and mass irregularity, were examined. According to our findings, the first story has the highest shear force, and the lowest shear force is observed at the top of the structure. Larger base shear was detected in mass irregular structures compared to equivalent regular ones. The inter-storey drifts are bigger in the rigidity uneven construction because the base shear was less severe..

8. **Oman Sayyed, Suresh Singh Kushwah, ArunaRawat:**

The current research examines the seismic stability &behavior of G+10 RC structures, both regular and irregularly oriented vertically. Stiffness and setback vertical abnormalities are examined in this research. A total of eight structures, both regular and irregular, were modelled & seismic analysis was performed using the RSA technique. Story drift, storey displacement, overturn momentum, storey shear modulus, & storey stiffening are some of the several earthquake responses that may be derived. A comparison of regular and irregular structures has been done utilizing these answers. According to the findings, seismic stress causes instability in a structure due to its stiffness and setback irregularity. A proportional quantity of stiffness is useful in the development of RC models in order to manage the instability.

2.1 Following points observed from literature review:

- It is clear that regular structures have greater seismic performance than irregular ones since their results values are lower. When compared to other options.
- When compared to identical regular structures, the stiffness irregular construction receives less base shear.
- Structural rigidity uneven structure frames have a bigger base shear than identical regular building frames, according to the results of this study.
- There is a modest difference in displacements between upper and lower stories in mass irregular buildings, but as we go below, we see a greater difference in displacements than in regular structures.
- There is an abrupt shift in mass among 2 storeys of structure, and if the mass is substantial, the drift ratio will exceed the allowable limit at that level.
- Buildings with irregularities in mass and stiffness must be carefully evaluated and built.
- In order to get a clear picture of how multiple vibration modes interact, the response spectrum approach may be used effectively. It may also be used to make an educated guess about a building's seismic stability.
- A regular frame's seismic performance is superior than that of an equivalent irregular frame.
- RC building performance is significantly impacted by the structure's vertical irregularities, according to the study.

3. Objectives And Scope Of Study

3.1 Objectives:

1. Development of various 3D architectural models.
2. To carry out code-required lateral load analyses on various building models.
3. Similar static, response spectrum may be used to compute lateral loads for asymmetrical structures
4. To see how variability in height affects essential natural periods.
5. structure's seismic performance for a variety of various building types are examined in detail.
6. In static analysis, response spectrums and storey drifts are used to determine the storey displacements and drifts at each level.
7. Lastly comparing the result among both methods.

3.2 Scope of the Study:

1. The modelling and evaluation was done for RC framed regular and irregular building.
2. Mass of infill wall was considered.
3. Seismic zone factor is applied and comparing the result of displacement, drift, Time period, base shear.
4. By preparing different models with different vertical irregularities, study was carried out & out comes was associated.
5. Comparing outcomes of all six models and finding out the best suited model.

4. Methodology

G+25 Storied Buildings, with a floor height of 3.2m, are studied in this case. The building structure's features are also specified. Etabs software is used to produce the building model. The type of soil is moderate & seismic zone is zone IV. They've made six models of buildings. In accordance with Indian Seismic Zone IV, IS 1893-2002, the structure is modelled. As per IS 875 part I, part II & IS1893-2002, applied loads include active load, seismic load, and dead load for a specific building. The Equivalent Static Method & RSA are used in the analysis, which is done via the use of Etabs software. To calculate the maximal displacement & base shear, the study is conducted.

4.1 Model Description:

1. The effect of earth quake on building with vertical irregularities is examined.
2. Study of G+25 storey building is performed in Etabs.
3. Analysis is carried out in Zone-IV.
4. Soil considered for analysis of building is medium.
5. The results of the study are used to compare period of time, shear forces, drifting, & displacement.
6. The response spectrum approach & analogous static method are used to do analysis.

4.2 Different Models Considered for Study:

Model-01: A G+25 RC Framed rectangular building.

Model-02: A G+25 RC framed structure having vertical irregularity having one step.

Model-03: A G+25 RC framed structure having vertical irregularity two steps.

Model-04: A G+25 RC framed structure having vertical irregularity three steps.

Model-05: A G+25 RC framed structure having vertical irregularity four steps.

Model-06: A G+25 RC framed structure having vertical irregularity five steps.

Models develop in Etabs software:

Model-01:

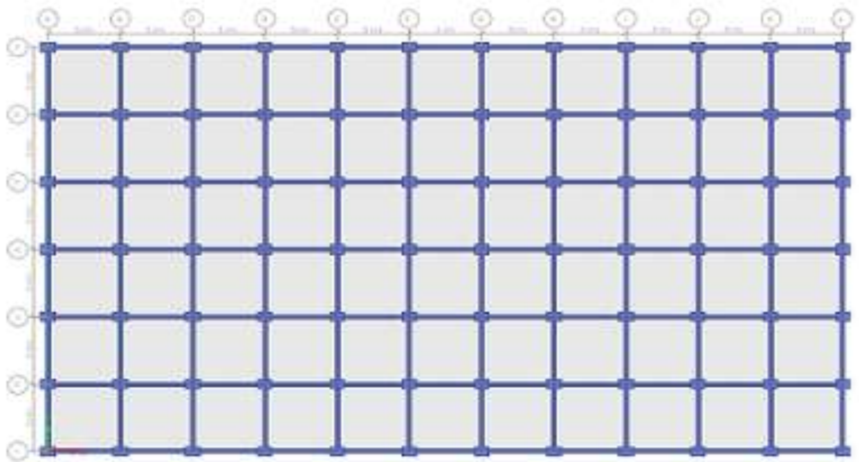
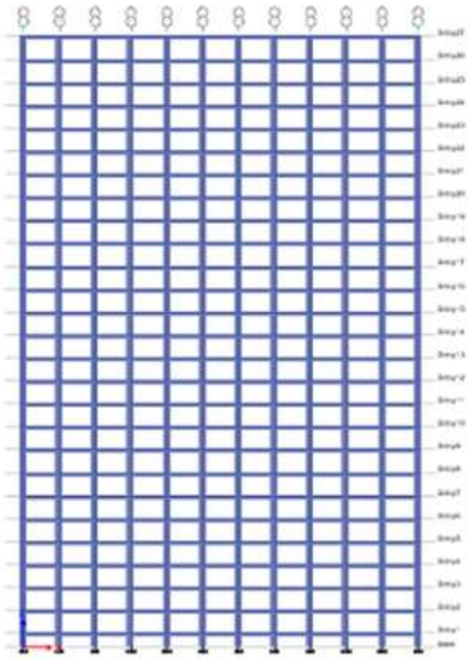


Fig-1 a Plan of rectangular building



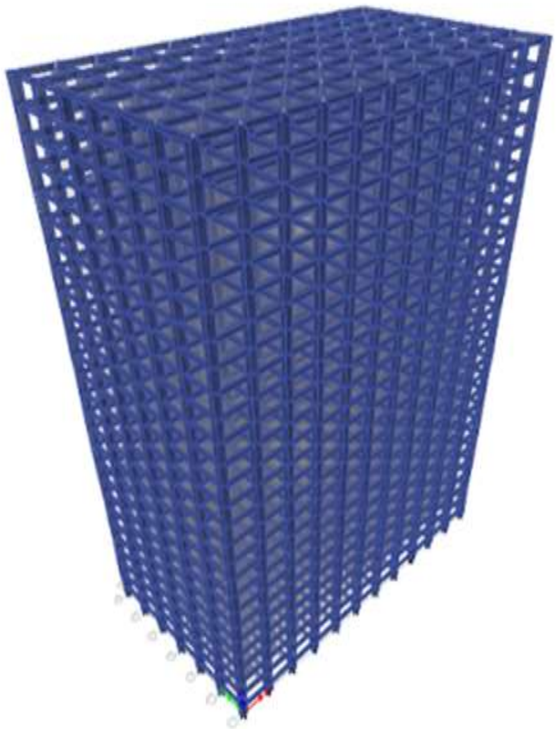


Fig-1 b: Elevation of Rectangular building **Fig-1 c: 3D View**

Model-02

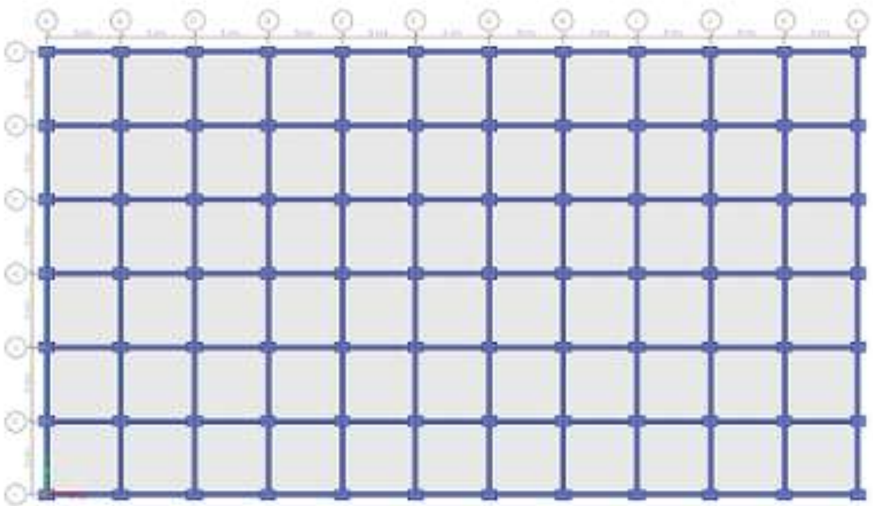


Fig-2a: Plan at Ground floor

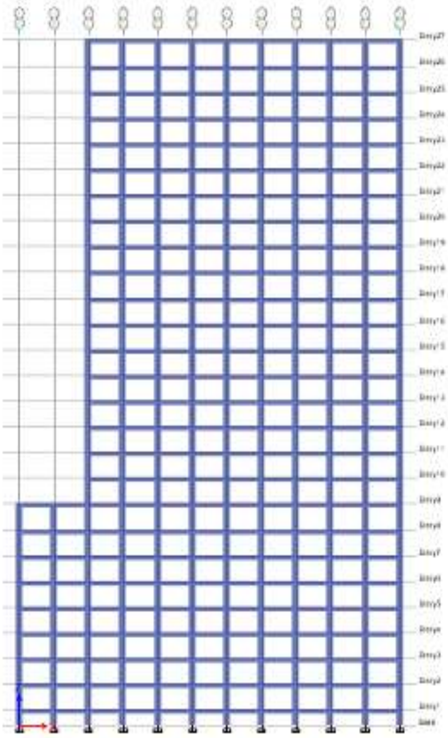


Fig-2b: Elevation

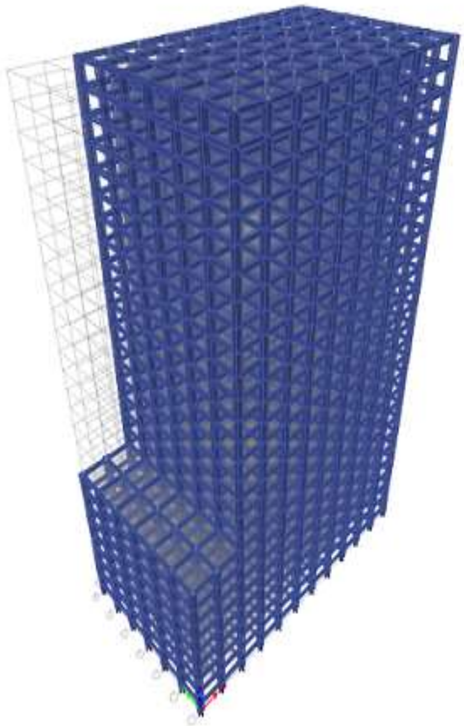


Fig-2c: 3D View

Model-03

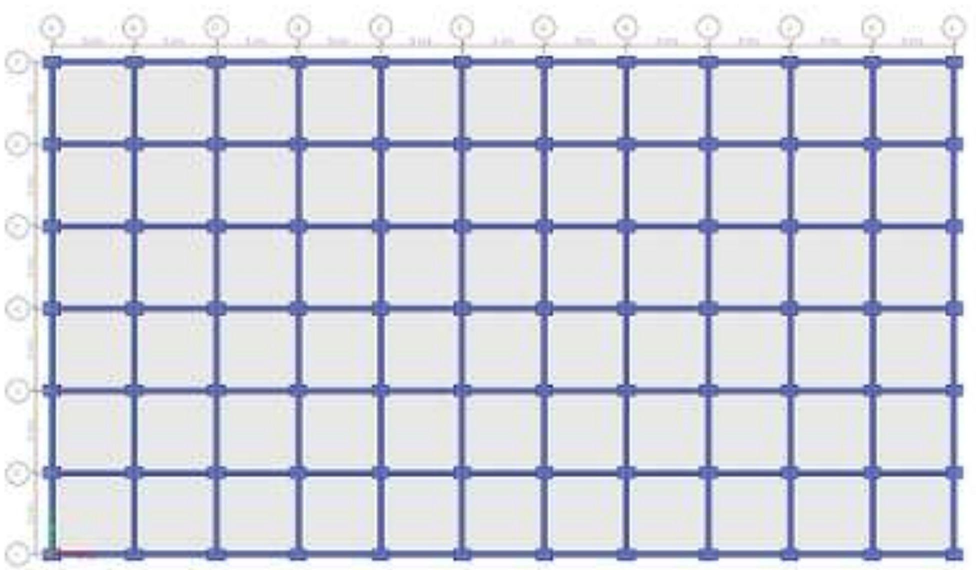


Fig-3a: Plan at Ground floor

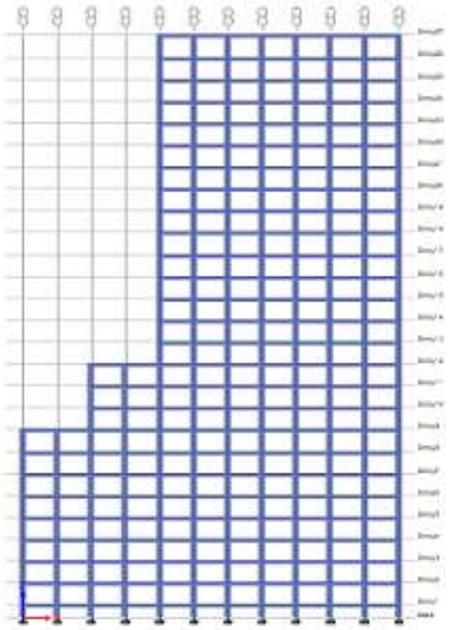


Fig-3b: Elevation

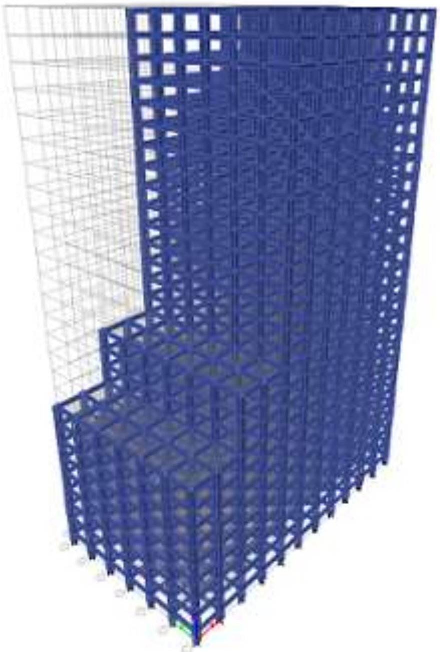


Fig-3c: 3D View

Model-04

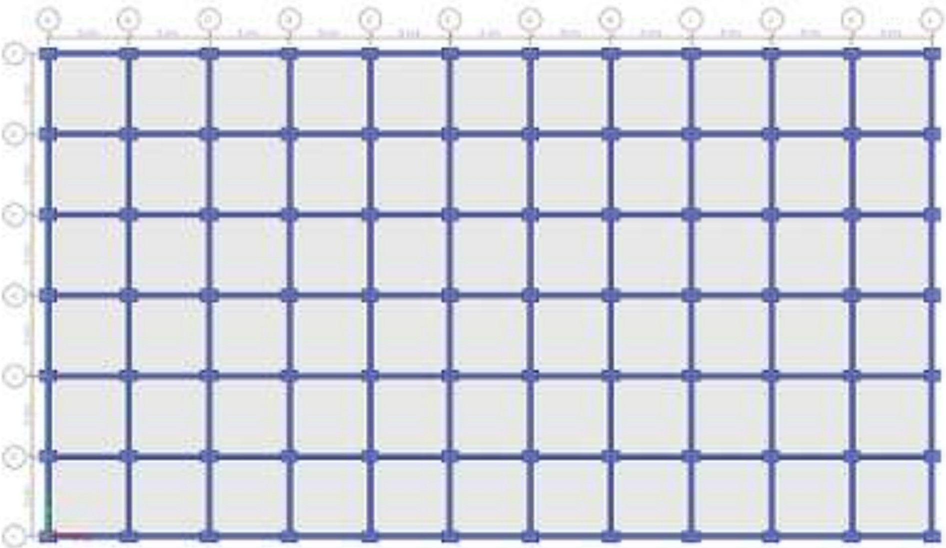


Fig-4a: Plan at Ground floor

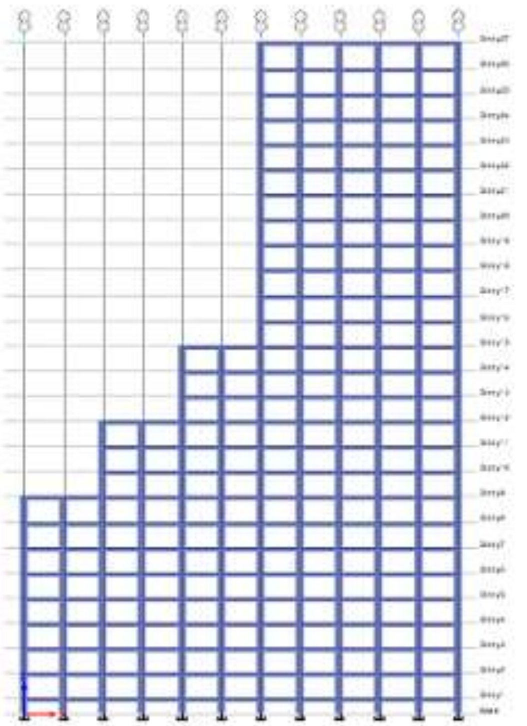


Fig-4b: Elevation

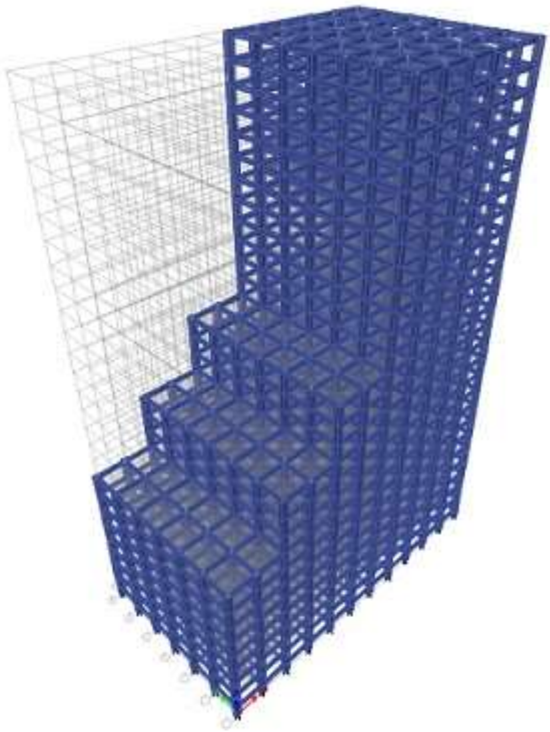


Fig-4c: 3D View

Model-05:

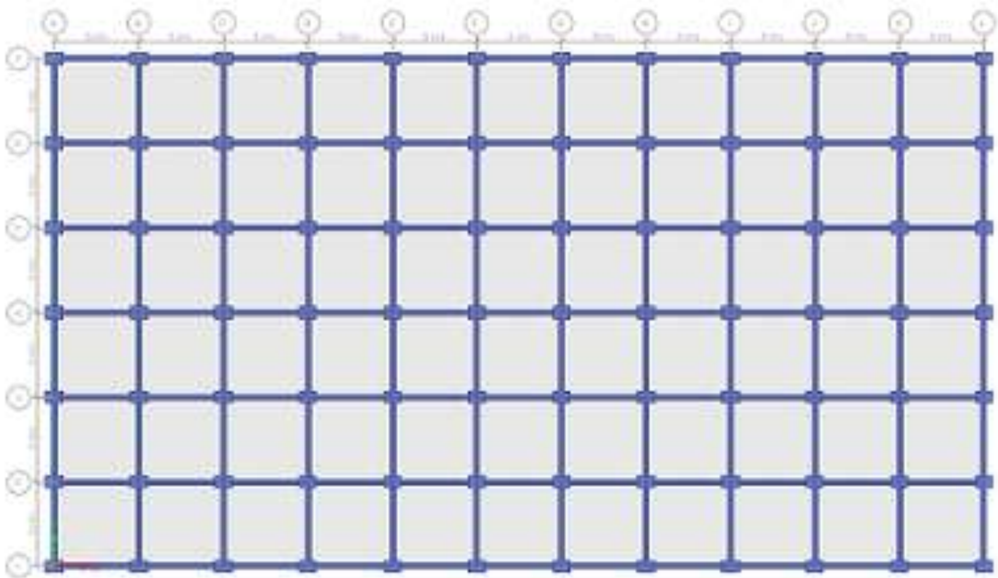


Fig-5a: Plan at Ground floor

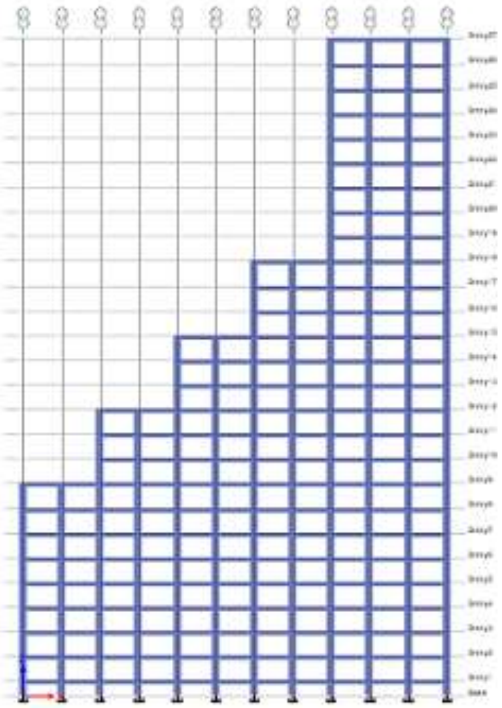


Fig-5b: Elevation

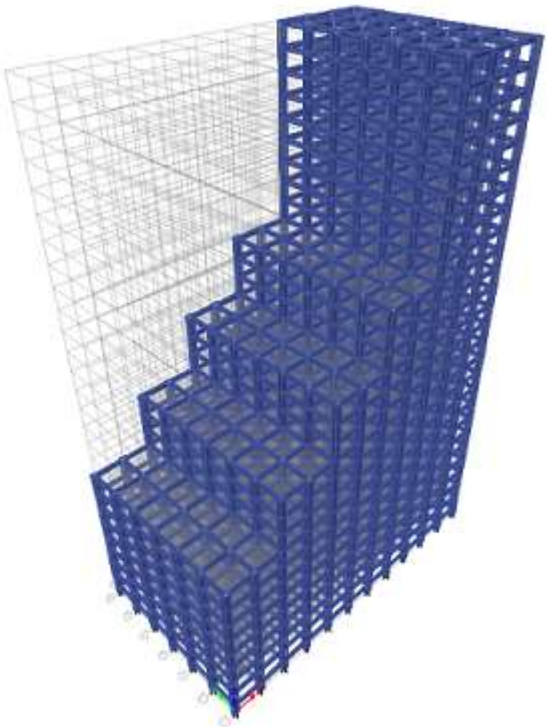


Fig-5c: 3D View

Model-06:

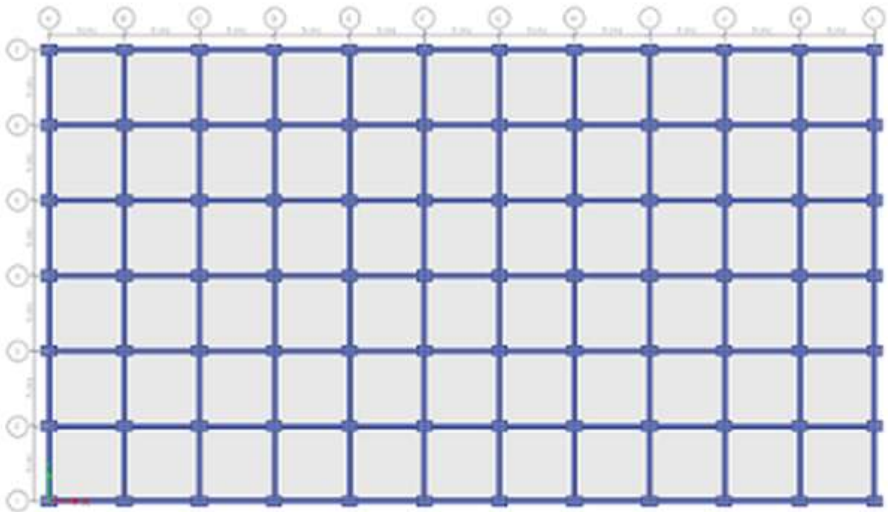


Fig-6a: Plan at Ground floor

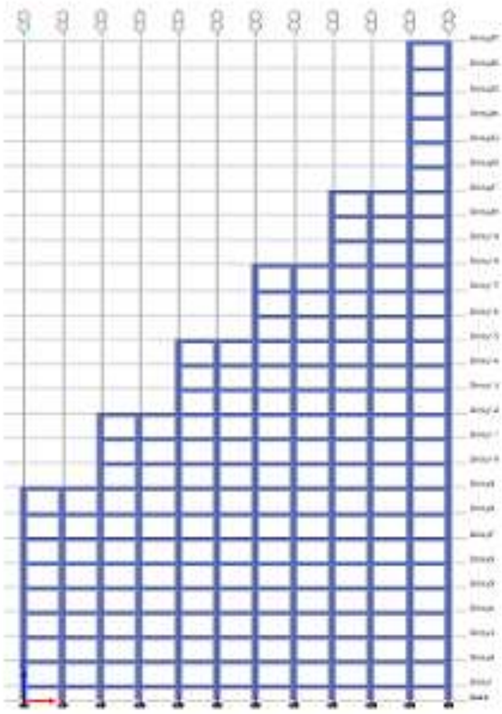


Fig-6b: Elevation

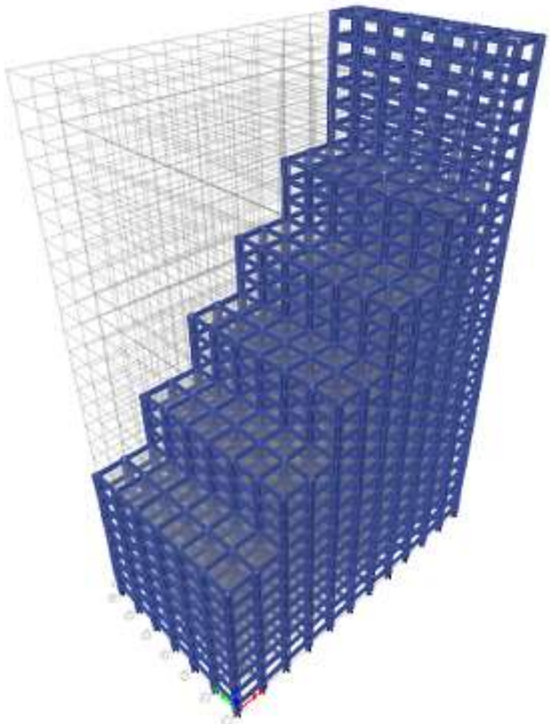


Fig-6c: 3D View

4.3 Details of structures:

Frame type	Reinforced concrete moment resisting frame
Building type	Commercial Building
Number of storey	26 (G+25)
Building length	55m
Building width	30m
Wall Thickness	230mm
Floor finishing	$1KN/m^2$
Live loading	$3KN/m^2$
Concrete grade	M30
Unit weight of masonry	$18KN//m^3$
Size of column	700mmx1000mm
Size of Beam	300mmx600mm
Slab thickness	150mm
Seismic Zone	IV
Soil kind	Moderate
Importance factor	1.0
Over all Height of building	85.2m

5. Results And Discussion

General:

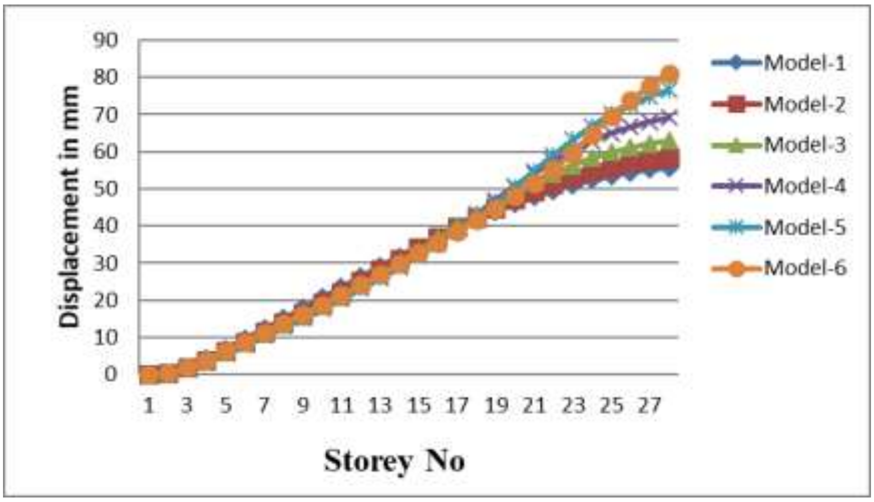
For the study purpose a total of seven models are prepared and lateral load is applied i.e seismic load. Here we have done analysis by applying Equivalent static technique& RSA& results are tabulated & comparisons are made.

Result due to Equivalent static method:

5.1 Lateral Displacement:

Table-1: Lateral displacement in mm along X-direction for model-1 to Model-6 due to Equivalent static method.

Storey No	Model1	Model2	Model3	Model4	Model5	Model6
Story27	55.7	58.4	62.9	69.1	76.5	81
Story26	55.1	57.8	62.1	68	74.8	77.6
Story25	54.4	57	61.1	66.6	72.6	73.8
Story24	53.5	56	59.8	64.9	70	69.4
Story23	52.4	54.7	58.2	62.7	66.8	64.6
Story22	51	53.1	56.3	60.2	63.2	59.6
Story21	49.5	51.3	54.1	57.3	59.1	55.2
Story20	47.8	49.4	51.7	54.1	54.7	51.6
Story19	45.8	47.2	49	50.7	50.2	48.1
Story18	43.8	44.8	46.2	47	46	44.8
Story17	41.6	42.3	43.1	43.1	42.3	41.7
Story16	39.3	39.7	40	39.2	38.7	38.6
Story15	36.9	36.9	36.7	35.5	35.2	35.5
Story14	34.3	34.1	33.3	32.2	32.1	32.6
Story13	31.7	31.2	29.9	29	29.1	29.7
Story12	29.1	28.2	26.7	26	26.1	26.9
Story11	26.4	25.1	23.8	23.2	23.4	24.2
Story10	23.6	22.2	20.9	20.4	20.7	21.5
Story9	20.8	19.3	18.2	17.8	18.1	18.8
Story8	18	16.6	15.7	15.4	15.6	16.3
Story7	15.2	14	13.3	13	13.2	13.8
Story6	12.4	11.4	10.8	10.6	10.8	11.3
Story5	9.6	8.8	8.4	8.2	8.4	8.8
Story4	6.9	6.3	6	5.9	6	6.3
Story3	4.3	3.9	3.7	3.7	3.7	3.9
Story2	2	1.8	1.8	1.7	1.8	1.8
Story1	0.4	0.3	0.3	0.3	0.3	0.3
Base	0	0	0	0	0	0

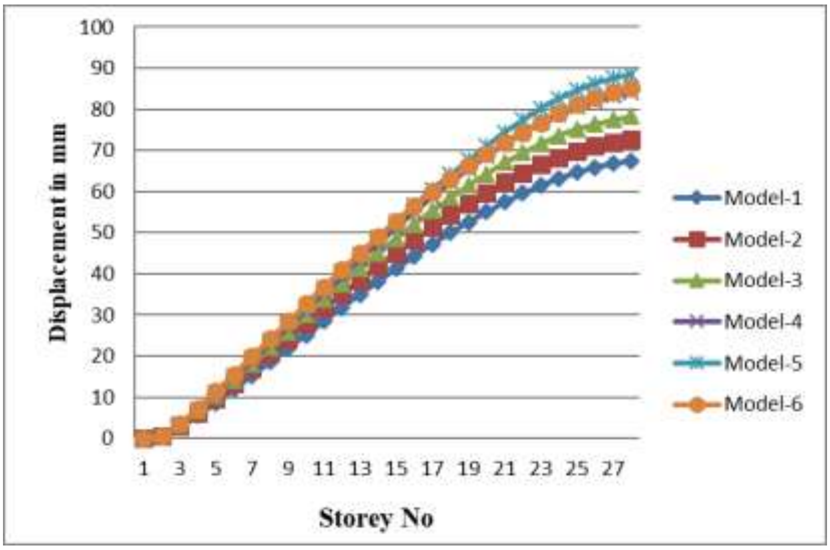


Graph-1: Displacing in mm of various models due to ESM along-X

By graph it's observed as regular building displacing is less. As we go with vertical irregularities in Model-02 the displacement increases by 4.62%, where as in model-03 the displacement increases by 11.44%, where as in model-04 the displacement is increases by 19.39% and where as in model-05 the displacement is increases by 27.18%, as we go with model-06 the displacement is increases by 31.32% compared to model-01along X-dir.

Table-2: Lateral displacement in mm along Y-direction for model-1 to Model-6 due to Equivalent static method

Storey No	**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**
Story27	67.5	72.7	78.2	84.1	88.4	85.1
Story26	66.8	72	77.4	83.3	87.5	84.2
Story25	65.9	71	76.4	82.1	86.3	82.9
Story24	64.7	69.8	75.1	80.7	84.6	81.3
Story23	63.2	68.3	73.5	78.9	82.6	79.2
Story22	61.5	66.5	71.6	76.8	80.2	76.8
Story21	59.6	64.4	69.4	74.4	77.4	74.3
Story20	57.5	62.2	67	71.7	74.4	71.9
Story19	55.1	59.7	64.3	68.7	71.1	69.2
Story18	52.6	57.1	61.5	65.6	67.6	66.3
Story17	50	54.3	58.5	62.2	64.1	63.2
Story16	47.2	51.4	55.3	58.7	60.5	60
Story15	44.3	48.3	52	55	56.7	56.5
Story14	41.3	45.1	48.6	51.3	52.8	52.8
Story13	38.2	41.9	45.1	47.4	48.8	49
Story12	35	38.5	41.4	43.5	44.8	45.1
Story11	31.8	35.1	37.7	39.4	40.6	41
Story10	28.5	31.6	33.9	35.4	36.4	36.9
Story9	25.2	28.1	30	31.3	32.2	32.7
Story8	21.9	24.4	26	27.2	28	28.5
Story7	18.6	20.7	22.1	23.1	23.8	24.2
Story6	15.3	17	18.2	18.9	19.6	19.9
Story5	12	13.3	14.2	14.9	15.3	15.6
Story4	8.7	9.7	10.4	10.8	11.2	11.4
Story3	5.6	6.2	6.6	6.9	7.1	7.3
Story2	2.7	3	3.2	3.3	3.4	3.5
Story1	0.5	0.6	0.6	0.6	0.7	0.7
Base	0	0	0	0	0	0



Graph-2: Displacement in mm of various models due to ESM along-Y

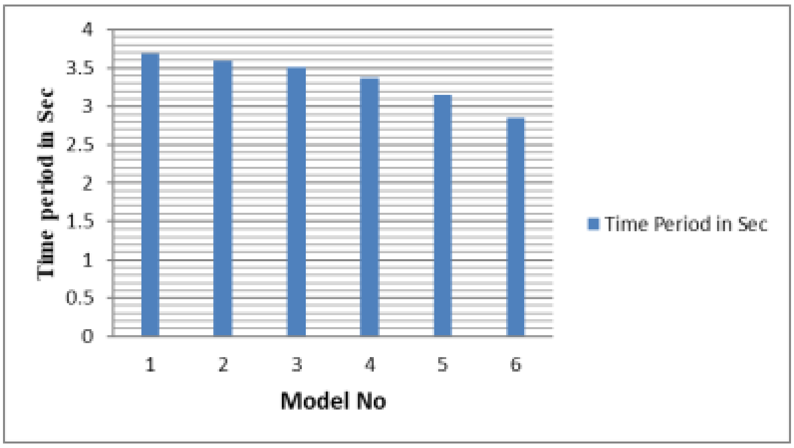
Into **Equivalent static analysis** it's observed as model with vertical irregularities i.e model2, model3, model4, model5, model6 has 7.15%, 13.68%, 19.73%, 23.64%, 20.68%, correspondingly more displacement when compared with model-1 in transverse direction.

5.2 Time Period:

Natural period is like the time required to shift back & forth between points A and B. Pushing a flag pole causes it to wobble according to its natural cycle. In earthquakes, the height of a structure may have a significant impact on its structural integrity. Damage to a higher structure is greater than that to a smaller one. Some buildings have been badly destroyed while others have not.

Table 3: Time period of all models

Model No	Time Period in Sec
1	3.691
2	3.595
3	3.509
4	3.372
5	3.151
6	2.847



Graph-3: Time period of all models

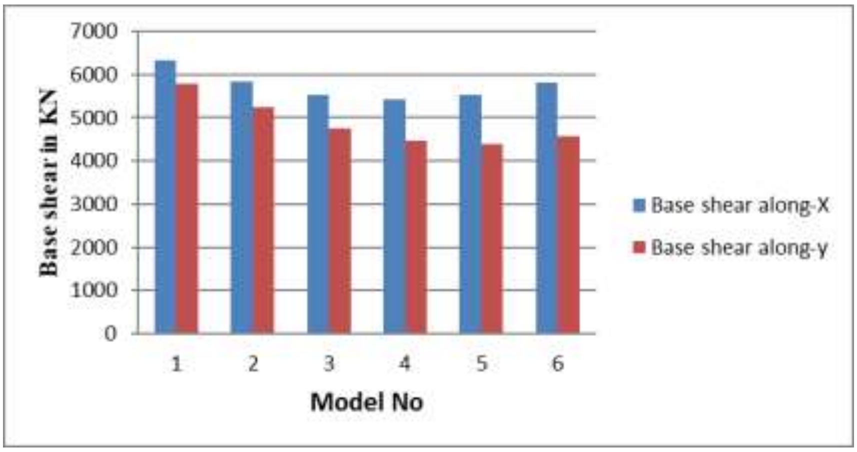
From the graph we can say that the time period is maximum for model-01, as we go with vertical irregularities the time period goes on decreases.

5.3 Base Shear Due To Seismic:

It's estimation of most anticipated lateral forces so as to arise because of seismic floor movement at the bottom of a structure.

Table 4: Base shear of all models due to ESM

Model	Base shear along-X	Base shear along-y
1	6321.03	5785.6
2	5835.7	5236.8
3	5526.58	4766.08
4	5417.3	4462.9
5	5527	4382.11
6	5821.2	4564.8



Graph-4: Base shear of all models due to ESM

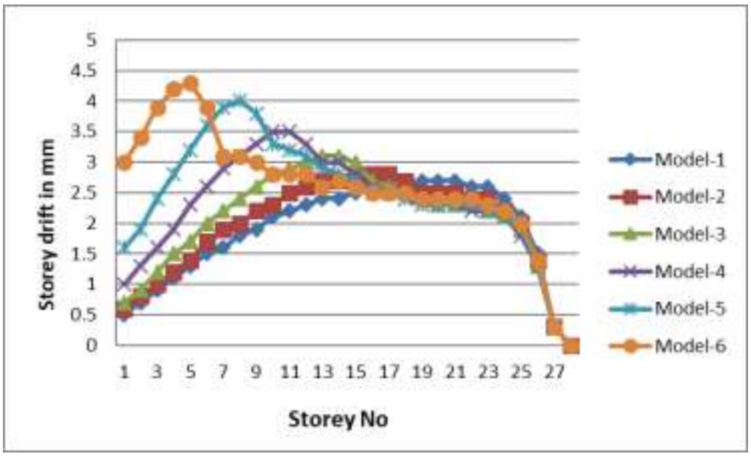
By graph its seen as base shear is maximum for model-01, as we go with vertical irregularities from model-02 to model-06 the base shear goes on decreases with respect to model-01.

5.4 Storey Drift Due To Seismic:

Table-5: Storey drifts in mm along X-direction for model-1 to Model-6 due to ESM

Storey No	Model1	Model2	Model3	Model4	Model5	Model6
Story27	0.5	0.6	0.7	1	1.6	3
Story26	0.7	0.8	0.9	1.3	1.9	3.4
Story25	0.9	1	1.2	1.6	2.4	3.9
Story24	1.1	1.2	1.5	1.9	2.8	4.2
Story23	1.3	1.4	1.7	2.3	3.2	4.3
Story22	1.5	1.7	2	2.6	3.6	3.9
Story21	1.6	1.9	2.2	2.9	3.9	3.1
Story20	1.8	2	2.4	3.1	4	3.1
Story19	1.9	2.2	2.6	3.3	3.8	3
Story18	2.1	2.3	2.8	3.5	3.3	2.8
Story17	2.2	2.5	2.9	3.5	3.2	2.8
Story16	2.3	2.6	3	3.3	3.1	2.8
Story15	2.4	2.7	3.1	3	2.9	2.6
Story14	2.4	2.7	3.1	3	2.8	2.7
Story13	2.5	2.8	3	2.8	2.7	2.6
Story12	2.6	2.8	2.7	2.6	2.5	2.5
Story11	2.6	2.8	2.6	2.5	2.5	2.5
Story10	2.6	2.7	2.5	2.4	2.4	2.5
Story9	2.7	2.5	2.4	2.3	2.3	2.4
Story8	2.7	2.5	2.3	2.3	2.3	2.4
Story7	2.7	2.5	2.3	2.3	2.3	2.4

Story6	2.6	2.4	2.3	2.2	2.3	2.4
Story5	2.6	2.4	2.2	2.2	2.2	2.3
Story4	2.4	2.2	2.1	2.1	2.1	2.2
Story3	2.1	2	1.9	1.8	1.9	2
Story2	1.5	1.4	1.3	1.3	1.3	1.4
Story1	0.3	0.3	0.3	0.3	0.3	0.3
Base	0	0	0	0	0	0



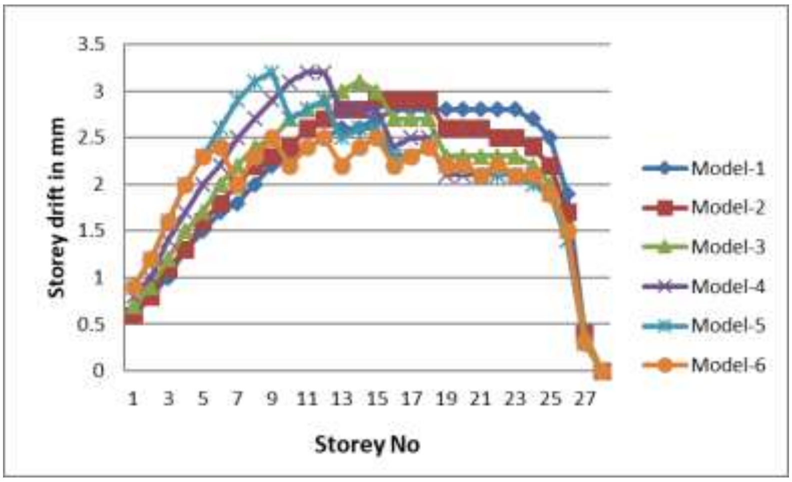
Graph-5: Storey drift in mm of all models due to ESM along-X

By graph its seen as storey drifting for model-01 to model-06 from ground to 15 storey the values are almost nearer but after that the drift values for model-04, model-05, model-06 are higher compared to model-01

Table-6: Storey drifts in mm along Y-direction for model-1 to Model-6 due to ESM

Storey No	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6
Story27	0.6	0.6	0.7	0.8	0.9	0.9
Story26	0.8	0.8	0.9	1	1.2	1.2
Story25	1	1.1	1.2	1.4	1.6	1.6
Story24	1.3	1.3	1.5	1.7	2	2
Story23	1.5	1.6	1.7	2	2.3	2.3
Story22	1.7	1.8	2	2.2	2.6	2.4
Story21	1.8	2	2.2	2.5	2.9	2
Story20	2	2.2	2.4	2.7	3.1	2.3
Story19	2.2	2.3	2.5	2.9	3.2	2.5
Story18	2.3	2.4	2.7	3.1	2.7	2.2
Story17	2.4	2.6	2.8	3.2	2.8	2.4
Story16	2.5	2.7	2.9	3.2	2.9	2.5
Story15	2.6	2.8	3	2.8	2.5	2.2
Story14	2.6	2.8	3.1	2.8	2.6	2.4
Story13	2.7	2.9	3	2.8	2.6	2.5
Story12	2.8	2.9	2.7	2.4	2.3	2.2
Story11	2.8	2.9	2.7	2.5	2.3	2.3
Story10	2.8	2.9	2.7	2.5	2.4	2.4
Story9	2.8	2.6	2.3	2.1	2.2	2.2
Story8	2.8	2.6	2.3	2.1	2.2	2.2
Story7	2.8	2.6	2.3	2.1	2.1	2.1

Story6	2.8	2.5	2.3	2.1	2.1	2.2
Story5	2.8	2.5	2.3	2.1	2.1	2.1
Story4	2.7	2.4	2.2	2.1	2	2.1
Story3	2.5	2.2	2	1.9	1.9	1.9
Story2	1.9	1.7	1.5	1.4	1.4	1.5
Story1	0.4	0.4	0.4	0.3	0.3	0.3
Base	0	0	0	0	0	0



Graph-6: Storey drifting in mm of all models due to ESM along-Y

By graph its seen as storey drifting values are almost same at roof level in model-01 to model-03 where as in model-05 and model-06 the storey drift increases by 33.33%.

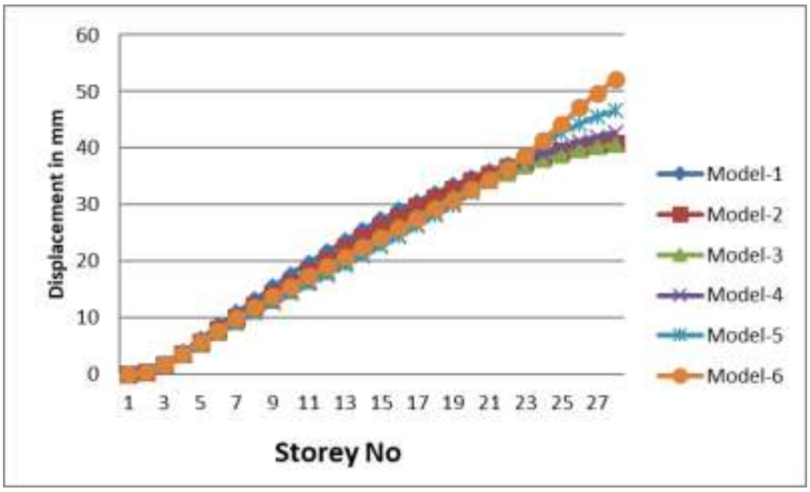
Result due to Response Spectrum method:

5.5 Lateral Displacement:

Table 7: Lateral displacement in mm along X-direction for model-1 to Model-6 due to Response Spectrum analysis

Storey	Model1	Model2	Model3	Model4	Model5	Model6
Story27	40.8	40.9	40.7	42.7	46.6	52.1
Story26	40.4	40.5	40.2	42	45.6	49.7
Story25	40	40	39.6	41.2	44.3	47.2
Story24	39.4	39.4	38.8	40.2	42.7	44.3
Story23	38.7	38.6	37.9	39	40.9	41.4
Story22	37.9	37.6	36.8	37.6	38.9	38.6
Story21	37	36.6	35.6	36	36.7	36.3
Story20	35.9	35.4	34.2	34.3	34.4	34.4
Story19	34.7	34.1	32.8	32.4	32.1	32.6
Story18	33.4	32.7	31.2	30.5	29.9	30.8
Story17	32	31.2	29.5	28.5	28.1	29.2
Story16	30.5	29.6	27.7	26.4	26.2	27.5
Story15	29	27.8	25.8	24.5	24.4	25.8
Story14	27.3	26	23.9	22.7	22.8	24.2
Story13	25.5	24.1	22	21	21.1	22.5
Story12	23.6	22.2	20.1	19.3	19.4	20.7
Story11	21.7	20.2	18.3	17.6	17.8	19

Story10	19.7	18.1	16.5	16	16.2	17.3
Story9	17.6	16.1	14.7	14.3	14.5	15.5
Story8	15.4	14.1	13	12.7	12.9	13.7
Story7	13.2	12.1	11.2	10.9	11.1	11.8
Story6	10.9	10	9.3	9.1	9.3	9.9
Story5	8.6	7.9	7.3	7.2	7.4	7.8
Story4	6.2	5.7	5.3	5.3	5.4	5.7
Story3	3.9	3.6	3.4	3.3	3.4	3.6
Story2	1.8	1.7	1.6	1.6	1.6	1.7
Story1	0.3	0.3	0.3	0.3	0.3	0.3
Base	0	0	0	0	0	0



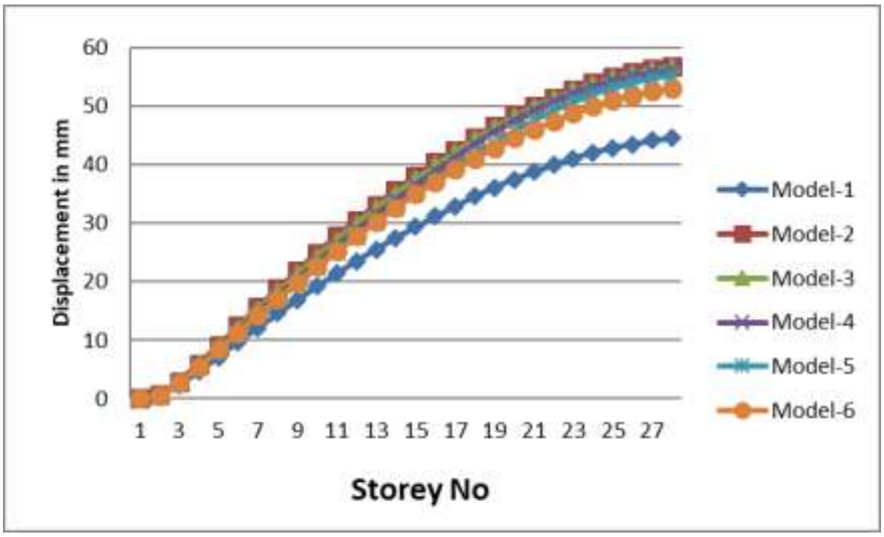
Graph-7: Displacement of every model due to RSM along-X

From the above graph it is noticed that the displacement is minimum for model-01 as we go with vertical irregularities from model-02 to model-03 the displacement is almost same, but from model-04 to model-06 the displacement goes on increases compared to model-01

Table-8: Lateral displacement in mm along Y-direction for model-1 to Model-6 due to Response Spectrum analysis

Storey	Model1	Model2	Model3	Model4	Model5	Model6
Story27	44.5	56.8	56.7	56.3	55.2	53
Story26	44.1	56.3	56.2	55.9	54.7	52.5
Story25	43.5	55.7	55.6	55.3	54	51.8
Story24	42.9	54.9	54.8	54.4	53.1	51
Story23	42.1	53.9	53.8	53.4	52	49.9
Story22	41.1	52.8	52.7	52.2	50.7	48.7
Story21	40	51.4	51.3	50.8	49.2	47.3
Story20	38.8	49.9	49.8	49.2	47.5	46
Story19	37.5	48.3	48.1	47.5	45.7	44.5
Story18	36.1	46.5	46.3	45.6	43.7	42.8
Story17	34.6	44.6	44.3	43.5	41.7	41.1
Story16	32.9	42.5	42.2	41.3	39.6	39.2
Story15	31.2	40.4	40	39	37.4	37.1
Story14	29.4	38.1	37.6	36.6	35.1	35
Story13	27.5	35.7	35.1	34.1	32.7	32.7
Story12	25.5	33.1	32.6	31.5	30.2	30.3

Story11	23.5	30.5	29.9	28.9	27.7	27.8
Story10	21.4	27.8	27.1	26.2	25.1	25.2
Story9	19.2	24.9	24.3	23.4	22.4	22.6
Story8	16.9	21.9	21.4	20.6	19.8	19.9
Story7	14.6	18.8	18.4	17.7	17	17.1
Story6	12.1	15.7	15.3	14.8	14.2	14.3
Story5	9.7	12.4	12.1	11.8	11.3	11.3
Story4	7.1	9.1	8.9	8.7	8.4	8.4
Story3	4.6	5.9	5.8	5.6	5.4	5.4
Story2	2.3	2.9	2.8	2.7	2.6	2.6
Story1	0.4	0.6	0.5	0.5	0.5	0.5
Base	0	0	0	0	0	0



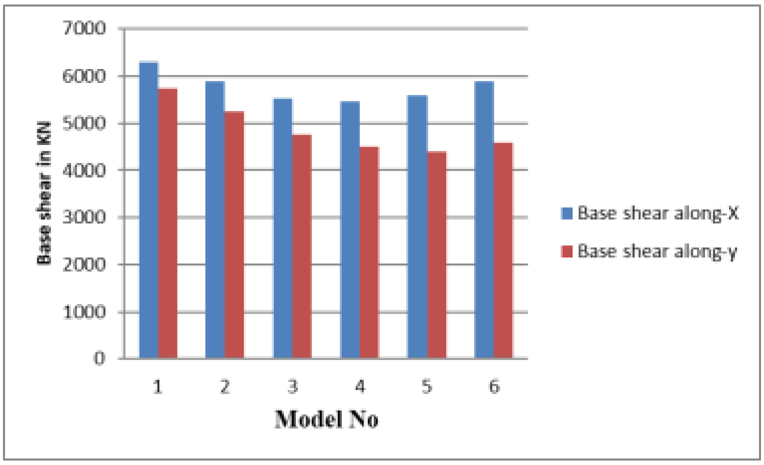
Graph-8: Displacement of all models due to RSM along-Y

By graph it has been seen as displacing is minimum for rectangular building i.e. for model-01, as we go with vertical irregularities from model-2 to model-06 the displacement goes on increases by 21.65%, 21.51%, 20.95%, 19.38, and 16.03%respectively with respect to model-01.

5.6 Base Shear Due To Rsa:

Table 9: Base shear of all models due to RSM

Model	Base shear along-X	Base shear along-y
1	6307.43	5748.70
2	5880.94	5252.31
3	5527.12	4746.39
4	5464.04	4488.97
5	5585.95	4392.6
6	5886.14	4586.06



Graph-9: Base shear of all models due to RSM

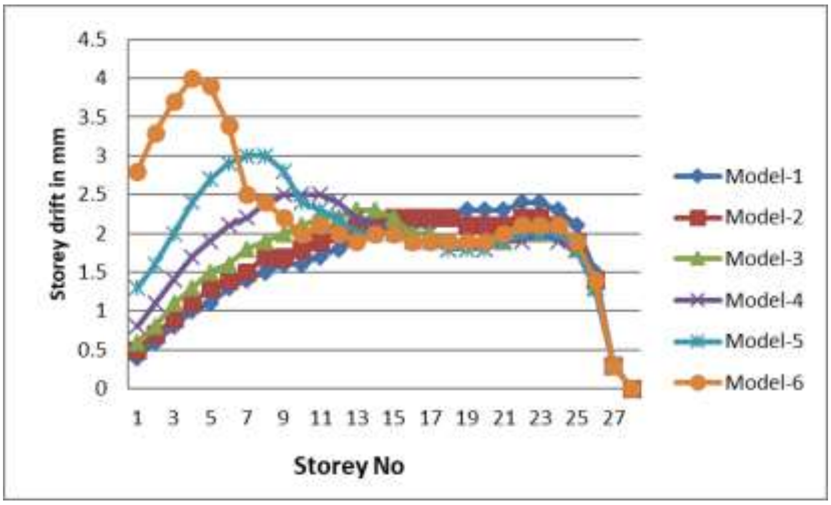
By graph its seen as base shear is maximum for model-01, as we go with vertical irregularities from model -02 to model-06 the base shear goes on decreases compared to model-01 along both in X & Y direction.

5.7 *Storey Drifting Due To RSA:*

Table-10: Storey drifts in mm along X-direction for model-1 to Model-6 due to RSM

Storey	Model1	Model2	Model3	Model4	Model5	Model6
Story27	0.4	0.5	0.6	0.8	1.3	2.8
Story26	0.6	0.7	0.8	1.1	1.6	3.3
Story25	0.8	0.9	1.1	1.4	2	3.7
Story24	1	1.1	1.3	1.7	2.4	4
Story23	1.1	1.3	1.5	1.9	2.7	3.9
Story22	1.3	1.4	1.6	2.1	2.9	3.4
Story21	1.4	1.5	1.8	2.2	3	2.5
Story20	1.5	1.7	1.9	2.4	3	2.4
Story19	1.6	1.7	2	2.5	2.8	2.2
Story18	1.6	1.8	2.1	2.5	2.4	2
Story17	1.7	1.9	2.2	2.5	2.3	2.1
Story16	1.8	2	2.2	2.4	2.2	2
Story15	1.9	2.1	2.3	2.2	2	1.9
Story14	2	2.1	2.3	2.1	2	2
Story13	2	2.2	2.2	2	2	2
Story12	2.1	2.2	2	1.9	1.9	1.9
Story11	2.1	2.2	2	1.9	1.9	1.9
Story10	2.2	2.2	1.9	1.8	1.8	1.9
Story9	2.3	2.1	1.9	1.8	1.8	1.9
Story8	2.3	2.1	1.9	1.8	1.8	1.9
Story7	2.3	2.1	1.9	1.9	1.9	2
Story6	2.4	2.2	2	1.9	2	2.1
Story5	2.4	2.2	2	2	2	2.1
Story4	2.3	2.1	2	1.9	2	2.1
Story3	2.1	1.9	1.8	1.8	1.8	1.9
Story2	1.5	1.4	1.3	1.3	1.3	1.4
Story1	0.3	0.3	0.3	0.3	0.3	0.3

Base	0	0	0	0	0	0



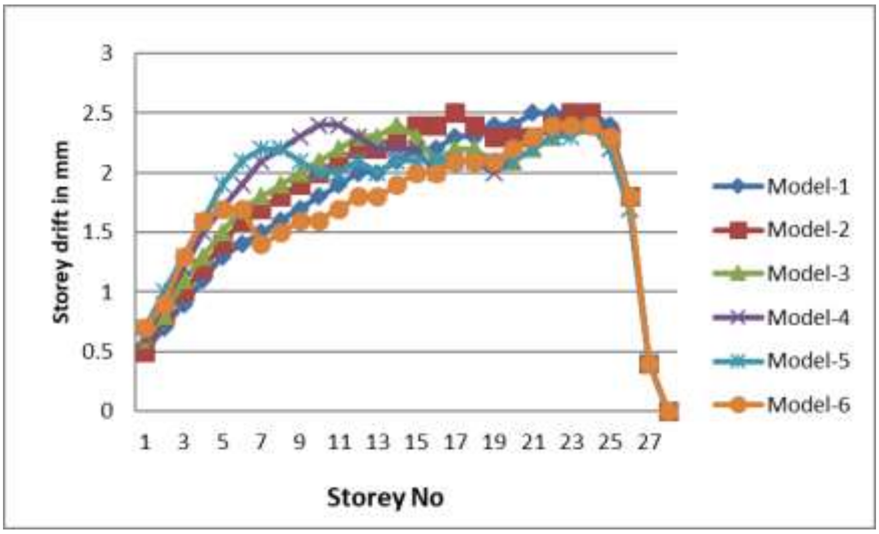
Graph-10: Storey drifting in mm of all models due to RSM along-X

From the above graph its noticed as storey drift is minimum for model-01 & it is maximum for model-06 with vertical irregularities. If we compare at storey 27 the storey drift for model-06 is 85.71% higher than the model-01

Table-11: Storey drifting in mm along Y-direction for model-1 to Model-6 due to RSM

Storey No	Model1	Model2	Model3	Model4	Model5	Model6
Story27	0.5	0.5	0.6	0.6	0.7	0.7
Story26	0.7	0.8	0.8	0.9	1	0.9
Story25	0.9	1	1.1	1.2	1.3	1.3
Story24	1.1	1.2	1.3	1.5	1.6	1.6
Story23	1.3	1.4	1.5	1.7	1.9	1.7
Story22	1.4	1.6	1.7	1.9	2.1	1.7
Story21	1.5	1.7	1.8	2.1	2.2	1.4
Story20	1.6	1.8	1.9	2.2	2.2	1.5
Story19	1.7	1.9	2	2.3	2.1	1.6
Story18	1.8	2	2.1	2.4	2	1.6
Story17	1.9	2.1	2.2	2.4	2	1.7
Story16	2	2.2	2.3	2.3	2.1	1.8
Story15	2	2.2	2.3	2.2	2	1.8
Story14	2.1	2.3	2.4	2.2	2.1	1.9
Story13	2.2	2.4	2.3	2.2	2.1	2
Story12	2.2	2.4	2.1	2	2.1	2
Story11	2.3	2.5	2.2	2.1	2.1	2.1
Story10	2.3	2.4	2.2	2.1	2.1	2.1
Story9	2.4	2.3	2.1	2	2.1	2.1
Story8	2.4	2.3	2.1	2.1	2.1	2.2
Story7	2.5	2.3	2.2	2.2	2.2	2.3
Story6	2.5	2.4	2.3	2.3	2.3	2.4
Story5	2.5	2.5	2.4	2.4	2.3	2.4
Story4	2.5	2.5	2.4	2.4	2.4	2.4
Story3	2.4	2.3	2.3	2.2	2.2	2.3

Story2	1.8	1.8	1.8	1.7	1.7	1.8
Story1	0.4	0.4	0.4	0.4	0.4	0.4
Base	0	0	0	0	0	0



Graph-11: Storey drift in mm of all models due to RSM along-X

From the above graph it is noticed that the storey drift at roof i.e at storey 27 is almost nearer. The storey drift in Y-direction is almost lesser compare to X-direction.

6. Comparison

6.1 Comparison of Equivalent static method & response spectrum technique:

Table-12: Comparison of maximum displacement in mm among all models

	Equivalent Static Method		**Response Spectrum Method**	
Model No	**Along-X**	**Along-Y**	**Along-X**	**Along-Y**
1	55.70	67.5	40.8	44.5
2	58.40	72.7	40.9	56.8
3	62.90	78.2	40.7	56.7
4	69.10	84.1	42.7	56.3
5	76.50	88.4	46.6	55.2
6	81	85.1	52.1	53

Table-13: Comparison of Base shear in KN among all models

	Equivalent Static Method		**Response Spectrum Method**	
Model No	**Along-X**	**Along-Y**	**Along-X**	**Along-Y**
1	6321.03	5785.6	6307.43	5748.70
2	5835.7	5236.8	5880.94	5252.31
3	5526.58	4766.08	5527.12	4746.39
4	5417.3	4462.9	5464.04	4488.97
5	5527	4382	5585.95	4392.6
6	5821.2	4564.8	5886.14	4586.06

Table-14: Comparison of Time period among all models

Model No	Time period	Percentage decrease compared to model-01
1	3.691	----
2	3.595	2.6%
3	3.509	4.93%
4	3.372	8.64%
5	3.151	14.63%
6	2.847	22.86%

7. Summary And Conclusion

7.1 Summary:

An effort has done to create model with regular and vertical irregularities in seismic zone-IV. A total of six models are developed and analysed by using equivalent static method &RSA. The displacing, base shear & time period are noted and following conclusions are seen as below.

7.2 Conclusions:

1. Vertical abnormalities reduce the basic natural time period.
2. The displacement for regular building is less compared to building with vertical irregularities.
3. A regular building has a higher base shear than a structure with vertical imperfections.
4. We may infer that a regular construction is the result of the comparisons we've made. Since an irregular structure shows smaller results values, this suggests that regular buildings fare better in an earthquake than other types.
5. The base shear of irregular structures is lower than that of regular ones.
6. For a regular building, storey drifting values are found to be lower than those for vertically uneven buildings.
7. The base shear of an irregular structure was smaller, and as a result, the inter-story drifts are bigger.

7.3 Scope for further study:

1. The present work is carried out for vertical irregular building with one step, the work may extend by taking at a time two to three steps as per requirement.
2. The work can be extended by considering soft soil in analysis.
3. The work may extend for higher storey more than 50 storeys.
4. The work is taken up for RCC structure hence it may extend with steel structure.
5. The work is taken up with seismic studies hence it may extend with wind study.
6. The present work is taken as linear analysis, hence it can be taken up with non linear analysis.

REFERENCES

Sumit Gurjar1, Lovish Pamecha: “seismic behaviour of buildings having vertical irregularities” International Journal of Engineering Science Invention Research & Development; Vol. III, Issue X, April 2017.

Dr Prashant Hiwase1, Vipul V Taywade, Sharda P. Siddh: Comparative analysis of vertical irregularities on high rise structure considering various parameters, International Conference on Advances in Civil Engineering (ICACE 2021).

JAIN PRITAM ANIL, VAIBHAV. V. SHELAR: Effect of Vertical Irregularity in Multi-storeyed Building under Seismic Loading International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET).

HIMANSHU BANSAL, GAGANDEEP: Seismic Analysis and Design of Vertically Irregular RC Building Frames International Journal of Science and Research (IJSR) Volume 3 Issue 8, August 2014.

MOHAMMED ISMAIL AND DR ABHIJIT SINH PARMAR: Dynamic Analysis of RC Building having Vertical Irregularity GRD Journal for Engineering | Volume 6 | Issue 7 | June 2021.

AKHIL R, ASWATHY S KUMAR: seismic analysis of regular and irregular buildings with vertical irregularity using staad.pro International Research Journal of Engineering and Technology (IRJET)

DILESHWAR RANA, PROF. JUNED RAHEEM: Seismic Analysis of Regular & Vertical Geometric Irregular RCC Framed Building, International Research Journal of Engineering and Technology (IRJET).

Shridhar Chandrakant Dubule, Darshana Ainchwar: Seismic analysis and design of vertically irregular R.C. building frames, International journals of Advance research in science and Engineering, Volume-07, issue-04, April-2018.

Oman Sayyed, Suresh Singh Kushwah, Aruna Rawat: Seismic Analysis of Vertical Irregular RC Building with Stiffness and Setback Irregularities, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 14, Issue 1 Ver. VI (Jan. - Feb. 2017)