



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 9, September 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.118



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# Comparative Study on Earthquake Analysis for Conventional and Flat Slab of RC High-Rise Structure Using Inverted V- Bracing at Different Zones

V S Tejananda<sup>1</sup>, Chetan Gonni S<sup>2</sup>

PG Student, Structural Engineering, Bapuji Institute of Engineering Technology, Davangere, Karnataka, India<sup>1</sup>

Assistant Professor, Dept. of Civil Engineering, Bapuji Institute of Engineering Technology, Davangere,

Karnataka, India<sup>2</sup>

**ABSTRACT:** The main objective of this project is to analyse & study the comparative seismic performance of conventional and flat slab structures with and without inverted v shaped bracing using ETABS. In earthquake zone the displacement and drift of the structures will be more so to have more stiffness to the structure inverted v-bracing is to be provided therefore this project is compared between conventional slab & flat slab (with drops) building with and without inverted v shaped bracing. All the structures were subjected to various kinds of loads such as dead load, live load, earthquake load. This study is mainly based on Response spectrum analysis which is linear analysis to know the seismic performance of the structures. Analysis was done as per IS:1893-2016. The results provide best information on storey drifts, displacements, and storey shears and show its performance on different conditions of the structure. For the obtained results we will check the best performic structure among all zones.

**KEYWORDS:** Inverted v-bracing, conventional slab, flat slab, ETABS, Response spectrum analysis, drift ratio, displacement, shear, seismic zone.

## I. INTRODUCTION

### 1.1 General

The earth crust from the movement of Tectonic plates due to sudden release of energy is known as earthquake. Thus, on large tectonic plates or lithospheric plates this entire earth rests, these lithospheric plates are slowly moves but when two edges of the plates are rubbed, the high energy is stored and there after slowly releases. Under this process, energy grows through the Earth intersection of formation of the seismic waves. Due to depending on earthquake magnitude, strength and frequency, the waves cause discontinuity of earth's surface and thus; total earth's crust have an effect.

### 1.2 Flat Slab

India is a second largest populous country in the world and as well as developing country. Due to scarcity of land, we have adopted high-rise buildings. In this high-rise the conventional structures, slab is supported by beam and column combination thus the work of construction is much more complication for formwork process and delay in time management. To overcome this conventional structures, the flat slab structures is used in this the concrete slab is directly supported by concrete columns without using of beams that reduces the total dead weight of structure.

**Simple Flat Slab:** In order to avoid using beams in warehouses, offices, and public spaces, this slab is also known as beam slab construction. Instead, slabs are supported directly by columns. In these constructions no



beams or column heads or drop panels are founded. The slabs are directly connected to column members.

**Flat Slab with Drop Panels:** The slab is thickened near the column by adding drops because the moments in the slab are higher there. **Fig -1:** Flat slab with Drop panel

**Flat Slab with Column Heads:** It increases shear strength, negative moment capacity and stiffening of slab. Column heads are occasionally expanded to lessen the perforation shear in the slab. Architecturally, the column heads can be placed at any angle, but for design purposes, only the concrete piece at  $45^\circ$  on either side of vertical is regarded as effective.

**Flat Slab with Column Head and Drop Panels:** this method is usually preferred when the deflection of slab loads cannot satisfy by the only column heads or drop panels. It increases the slab's capacity for negative moments, its shear strength, and its stiffness to reduce deflection.

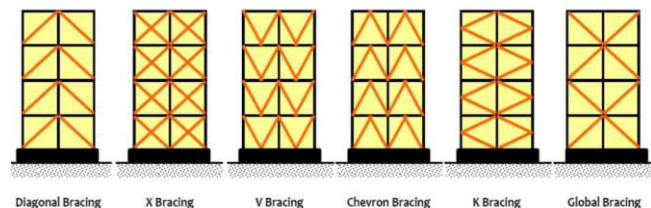
### 1.3 Bracings

All structures could sustain the loads acting on those during the service life by possessing moderate strength and also limit the deformation by possessing enough stiffness but this high-rise structure is affected by lateral forces due to earthquake. This bracing used in high rise concrete structure to reduce lateral deflections. Bracing systems will reduce the buckling capacity of the compression forces significantly and hence it is lower than the yielding tension capacity of the tensile stresses in high rise structures. Which means as the bracings reach their resistance capacity, the load should be resisted in the bending of the horizontal member.

#### 1.3.1 Types of bracing used in construction

The principal bracings are divided into the following six types based on the diverse requirements in construction systems.

1. Bracings in the front
2. Bracings for the back
3. V-shaped bracing
4. Inverted V-Type bracings
5. Bracings of the X-type
6. Bracings of the K-type



**Fig -2:** Different types of bracings

## II. OBJECTIVES OF STUDY

1. To study the behavior of Conventional slab with flat slab building with drop panels.
2. To use linear dynamic analysis is also known as (response spectra method) to examine the performance level of both conventional slab structure and flat slab structure with inverted V-shaped steel bracing.
3. From the above studies the best performance structure is considered for different seismic zone conditions.
4. Investigate the effects of lateral displacement, storey shear, storey drift, and slab stresses in a flat slab and conventional slab construction.
5. To determine which of the models taken into account for various seismic zones has the highest performance.

## III. METHODOLOGY

In this part, the comparison between conventional building structure and flat slab structure using with & without inverted v-bracings are modelled using the analysis software called ETABS 2018(1.1). The structures are developed and analysis is done by Response spectrum method of investigation with different load combinations as per the IS (Indian Standard) codal provisions. From above structures the best performance for lateral deflections structure is then analysed for different zones i.e., 2,3,4&5 then results are compared.

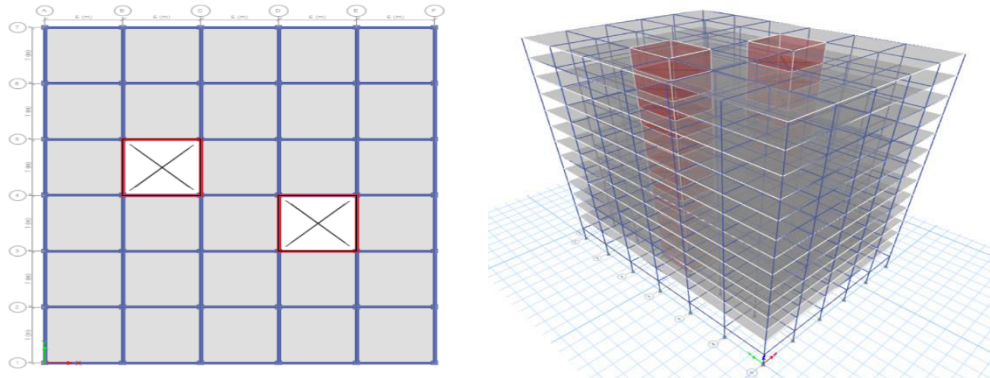
Table -1: Description of particulars

SL.NO.	PARTICULARS	SIZE/VALUE/DIMENSIONS
1.	No. of floor/levels	Base+G+12+TERRACE
2.	Type of structure	Commercial purpose
3.	Seismic zone	III
4.	Total height of building	46.6m
5.	Floor to floor height	3.3m
6.	Base to ground height	3.0m
7.	Ground to 1 <sup>st</sup> floor height	4.0m
8.	Plan dimensions	30x42m
9.	Grade of concrete	M30
10.	Grade of steel	Fe500
11.	Size of column	600x600mm & 450x600mm
12.	Shear wall thickness	300mm
13.	Conventional beam size	250x600mm
14.	Parapet beams of flat slab structure	350x600mm
15.	Slab thickness	150mm
16.	Flat slab thickness	200mm
17.	Drop thickness	350mm
18.	Drop panel sizes	2.0x2.34m & 1.5x1.75m(EDGES)
19.	Concrete Density	25KN/m <sup>3</sup>
20.	Solid Brick Density	20KN/m <sup>3</sup>
21.	Mortar Density	20.4KN/m <sup>3</sup>
22.	Earthquake Load	As per IS:1893-2016
23.	Soil type	II, Medium (as per IS:1893-2016)
24.	Damping ratio	5%
25.	Response reduction factor	5
26.	Zone factor	0.16
27.	Importance factor	1.5
28.	Live load on slab	5.0KN/m <sup>2</sup>
29.	Dead load on slab	1.5KN/m <sup>2</sup>
30.	Dead on flat slab for partition walls	1.5KN/m <sup>2</sup>
31.	Load on beams	12.42KN/m <sup>2</sup> (Outer wall-0.23m) 6.75KN/m <sup>2</sup> (Inner wall-0.125m)
32.	Outer Wall load on terrace (230mm thickness)	4.6KN/ m <sup>2</sup>

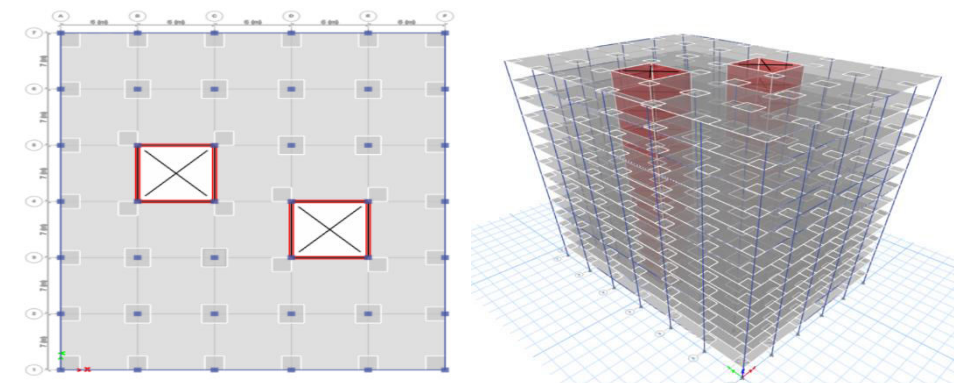
Table -2: Description of Configurations

BUILDING TYPE	CONFIGURATION
Conventional RC Framed Structure	CASE-1
Flat Slab Structure	CASE-2
Flat Slab Structure with inverted V-Bracing	CASE-3
Flat Slab structure with inverted V -Bracing for ZONE-2	CASE-3A
Flat Slab structure with inverted V-Bracing for ZONE-3	CASE-3B
Flat Slab structure with inverted V-Bracing for ZONE-4	CASE-3C
Flat Slab structure with inverted V-Bracing for ZONE-5	CASE-3D

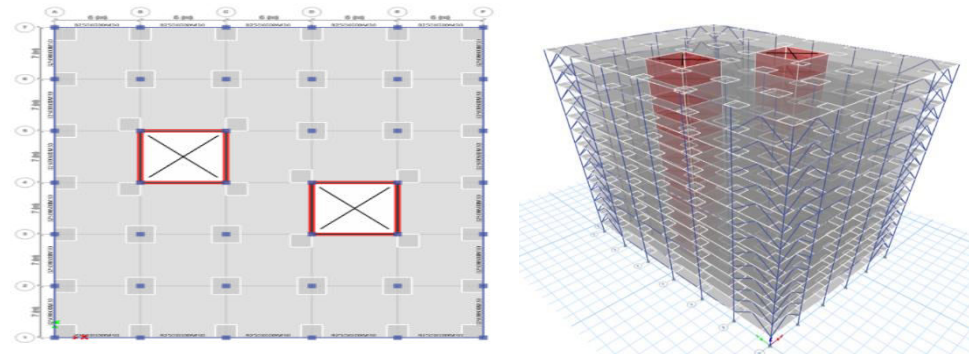




**Fig -3: Plan & 3D-View of Conventional Building (Case-1)**



**Fig -4: Plan & 3D-View of Flat Slab Building (Case-2)**



**Fig -5: Plan & 3D-View of Flat Slab with V'-Bracing (Case-3)**

## IV. RESULTS AND DISCUSSIONS

### 4.1 GENERAL

In this Chapter, the discussion is mainly on seismic analysis results like storey shear, storey drift and storey displacement by dynamic method of investigations for conventional frame and flat slab RC structure with and without inverted V bracings. Among this above 3 structures the best performed structure is viewed for all the different zones.

### 4.2 COMPARISON RESULTS OF CONVENTIONAL AND FLAT SLAB WITH AND WITHOUT BRACING STRUCTURES

#### 4.2.1 Storey Displacement

The maximum values of storey displacement in both X & Y -directions for 3 different cases are shown below. It is found that the CASE-3 has the minimum displacement values while compared with other 2 cases the values are 14.16 & 13.25mm in X & Y – Directions.

Table -3: Maximum Storey Displacement Values in RSA

MAXIMUM DISPLACEMENT VALUES (mm)		
Case/Direction	X-Direction	Y-Direction
CASE-1	16.933	16.103
CASE-2	14.872	13.857
CASE-3	14.164	13.25

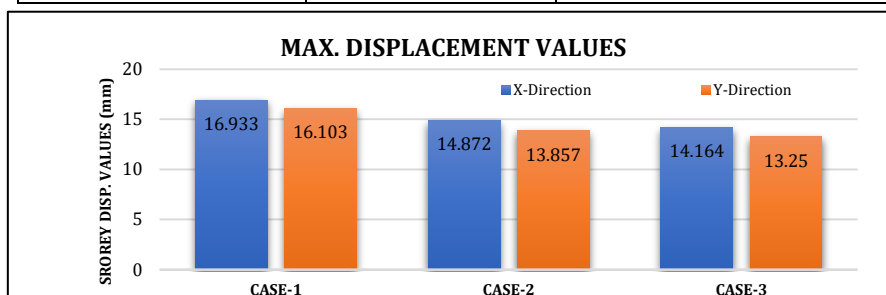


Fig -6: Graphical Representation of Storey Displacement by RSA for X &amp; Y – Direction

#### 4.2.2 Storey Drift

The maximum values of storey drift in both X & Y -directions for 3 different cases are shown below. It is found that the CASE-3 has the minimum drift values while compared with other 2 cases the values are 0.000376 & 0.000353 in X & Y – Directions.

Table -4: Maximum Storey Drift Values in RSA

MAXIMUM DRIFT RATIO VALUES		
Case/Direction	X-Direction	Y-Direction
CASE-1	0.000424	0.00042
CASE-2	0.00036	0.00034
CASE-3	0.00034	0.00032

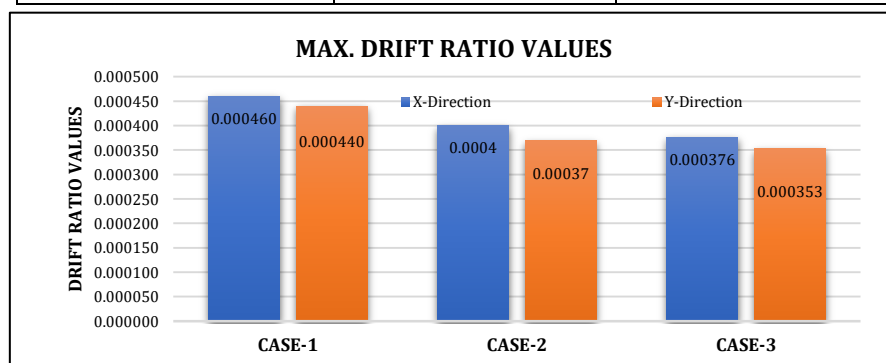


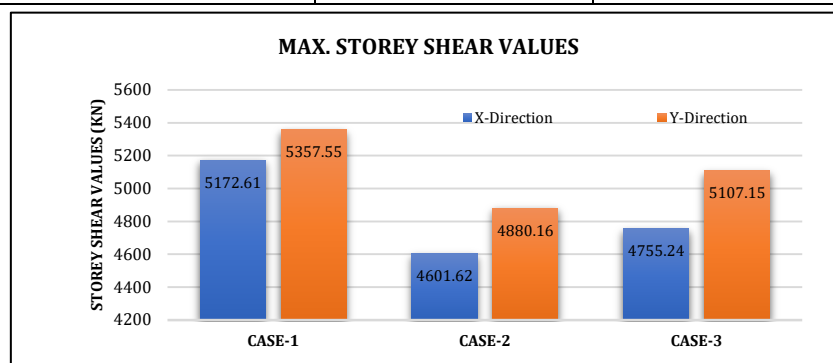
Fig -7: Graphical Representation of Storey Drift by RSA for X &amp; Y – Direction

#### 4.2.3 Storey Shear

The maximum values of storey shear in both X & Y -directions for 3 different cases are shown below. It is found that the CASE-3 has the maximum shear values while compared with other 2 cases the values are 4755.24 & 5107.15KN in X & Y – Directions.

**Table -5:** Maximum Storey Shear Values in RSA

MAXIMUM STOREY SHEAR VALUES (KN)		
Case/Direction	X-Direction	Y-Direction
CASE-1	5172.61	5357.55
CASE-2	4601.62	4880.16
CASE-3	4755.24	5107.15

**Fig -8:** Graphical Representation of Storey Shear by RSA for X & Y – Direction

#### 4.2.4 Overview of Results Obtained

From the above the 3 cases, it is found that displacement, drift ratio and shear values are minimum for CASE-3 (i.e., flat slab with inverted V bracings). So, for this best performed structure we are analysing it for different zones by RSA method as the same results are tabulated below.

### 4.3 COMPARISON RESULTS OF FLAT SLAB WITH BRACING STRUCTURES FOR DIFFERENT ZONES

#### 4.3.1 Storey Displacement

The maximum values of storey displacement in both X & Y -directions for 4 different cases are shown below. It is found that the CASE-3A & CASE-3D has the minimum and maximum displacement values respectively while compared with other cases the values are 8.9, 8.3mm & 31.7, 29.8mm in X & Y – Directions respectively.

**Table 6:** Maximum Storey Displacement Values in X & Y - direction by RSA

MAXIMUM DISPLACEMENT VALUES		
Case/Direction	X-Direction	Y-Direction
CASE-3A	8.9	8.3
CASE-3B	14.2	13.3
CASE-3C	21.2	19.9
CASE-3D	31.7	29.8

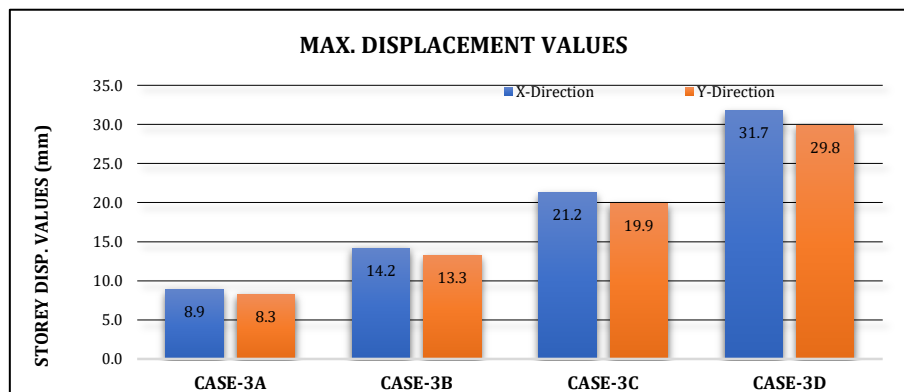


Fig -9: Graphical Representation of Storey Displacement Values in X &amp; Y - direction by RSA

#### 4.3.2 Storey Drift

The maximum values of storey drift in both X & Y -directions for 4 different cases are shown below. It is found that the CASE-3A & CASE-3D has the minimum and maximum displacement values respectively while compared with other cases the values are 0.00024, 0.00022 & 0.00084, 0.00079 in CASE-3A & CASE-3D respectively.

Table 7: Maximum Storey Drift Values in X &amp; Y - direction by RSA

MAXIMUM DRIFT RATIO VALUES		
Case/Direction	X-Direction	Y-Direction
CASE-3A	0.000240	0.000220
CASE-3B	0.000376	0.000353
CASE-3C	0.000560	0.000530
CASE-3D	0.000840	0.000790

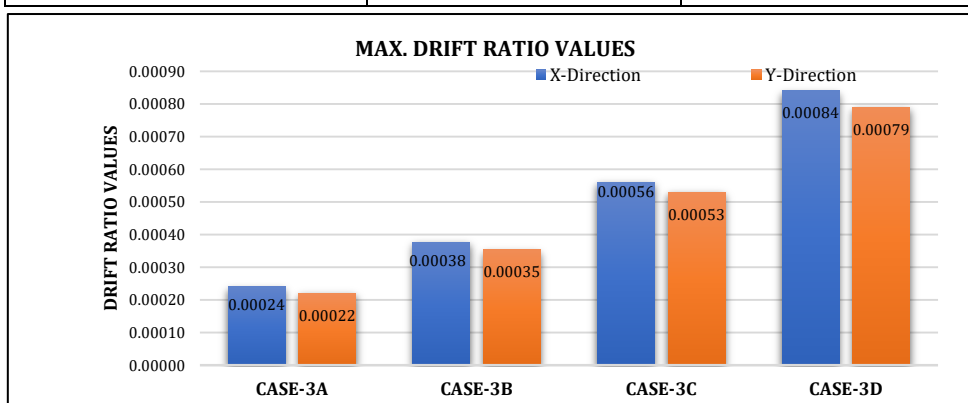
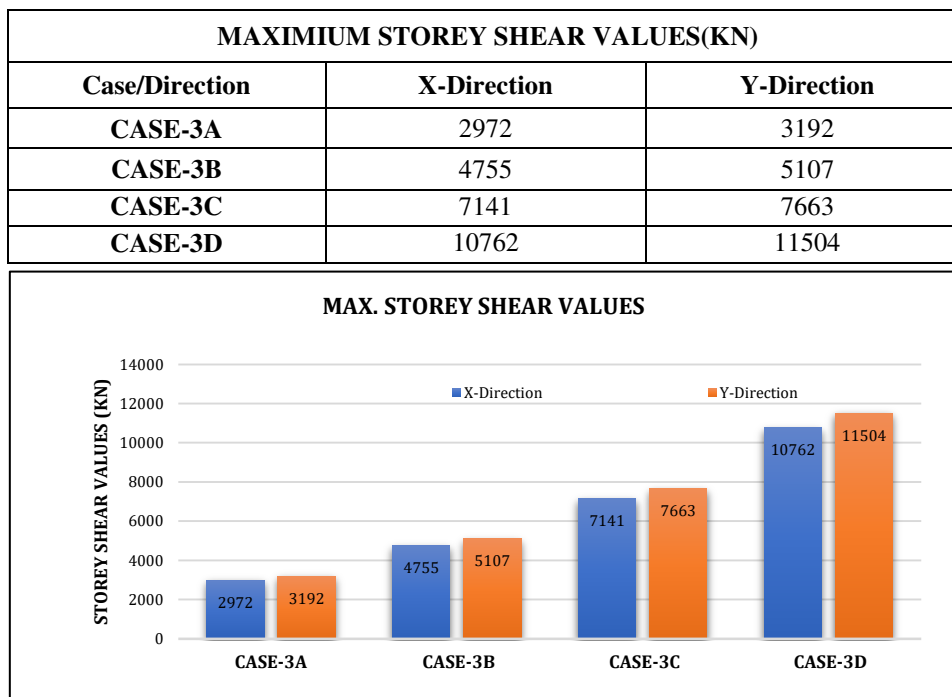


Fig -10: Graphical Representation of Storey Drift Values in X &amp; Y - direction by RSA

#### 4.3.3 Storey Shear

The maximum values of storey shear in both X & Y -directions for 4 different cases are shown below. It is found that the CASE-3A & CASE-3D has the maximum & minimum storey shear values respectively while compared with other cases the values are 2972, 3192KN & 7141, 7663KN CASE-3A & CASE-3D respectively.



**Table -8:** Maximum Storey Shear Values in X & Y - direction by RSA**Fig -11:** Graphical Representation of Storey Shear by RSA for X & Y – Direction

## V. CONCLUSION

In this current study, the impact of conventional structure, flat slab structure and flat slab with bracing structure for G+12 commercial building is analysed under RSA method and the results obtained are considered for zone-3. The best performed structures is considered for different zones the detained results of storey displacement, drift and shear is discussed further.

1. The results of the maximum storey displacement are found to be 19.6% and 21.50% lesser values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with conventional structure respectively.
2. The results of the maximum storey displacement are found to be 4.50% and 5.00% lesser values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with normal flat slab structure respectively.
3. The results of the maximum drift ratio are found to be 24.75% and 31.25% lesser values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with conventional structure respectively.
4. The results of the maximum drift ratio are found to be 5.85% and 6.25% lesser values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with normal flat slab structure respectively.
5. The results of the maximum shear values are found to be 8.75% and 5.00% lesser values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with conventional structure respectively.
6. The results of the maximum shear values are found to be 3.25% and 4.45% higher values in X & Y- Directions in flat slab with inverted V-bracings structure when compared with normal flat slab structure respectively.
7. By observing the above results the flat slab with inverted V-bracings structure has found to be minimum results when compared with other two structures. So that this flat slab with inverted v-bracings structure is used to checked in different seismic zones conditions and obtained results are detailed below.
8. For the obtained flat slab with inverted V-bracings structure for different zones has been conducted and found lesser values in zone-2 and higher values in zone-5 in all comparisons.
9. The values of storey displacement are found 2.56 times lower in X-direction and 2.60 times lower in Y-direction in zone-2 while compared to zone-5.
10. The values of storey drifts are found 2.50 times lower in X-direction and 2.60 times lower in Y-direction in zone-2 while compared to zone-5.

11. The values of storey shear are found 2.62 times lower in X-direction and 2.60 times lower in Y-direction in zone-2 while compared to zone-5.

#### VI. FUTURE WORK CONDUCTED

From the past study's and results we can recommend the future work can conducted on different parameters that are explained in detailed below.

1. The replacement of inverted V-bracing by other type of bracing for flat slab structure may be conducted at different positions.
2. The replacement of bracings by fluid viscos dampers can be placed at top stories of flat slab structure and deflection may controlled.
3. This study of comparison has been conducted at seismic zone-3 by changing it to higher effected zones-4 and 5 and the effect of the structures can be exposed in detailed.
4. The effect of bracings with different change in position of shear wall may control the lateral forces in flat slab structure.

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