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Comparative Analysis of Multi-Storey Building by Response Spectrum Method and Time History Analysis in Different Seismic Zones

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Abstract
In recent years, India has seen a tremendous increase in the construction of RC frame structures. Numerous towns and cities located in the country's moderate to severe seismic zones have numerous structures that are similarly designed and built. An earthquake is an abrupt, swift shaking of the ground brought on by the shifting and shattering of rock beneath its surface. Earthquakes are among the most powerful natural occurrences, and they can have frightening effects. It is clear from previous earthquakes that many structures suffer whole or partial damage as a result of EQ, hence it is important to ascertain how these structures will respond to an earthquake. Different methods of seismic structure analysis exist. In this project work, a multi-story structure's seismic analysis is performed utilizing the Response Spectrum Analysis method and the Time History Method employing acceleration data from the Bhuj Earthquake in accordance with IS-1893-2002-Part-1. This project focuses on comparing the parameters acquired using the two approaches.
Keywords:*Response Spectrum Method, Time History Method, Seismic Zones, Bhuj Earthquake.*

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I. INTRODUCTION

The building industry is currently concentrating more on the growth of structures vertically than horizontally due to a scarcity of available land space as well as the rapid urbanization and population increase. People moving to urban areas is the cause of the growth in land value. As a result, it has become expensive to construct a standalone home in an urban area. The problem of parking spaces, multi-family dwellings, etc. in urban areas also becomes apparent. Apartment culture has consequently influenced the building business, resulting in the need for multi-story complexes that serve multiple functions, such as housing for shopping, food catering, parking, and entertainment. Tall buildings should be carefully designed because of their vulnerability to the multiple lateral stresses they encounter.

The structural designer focuses on the structure's economy for its intended purpose over the course of its lifetime. Utilizing a program named ETABS, analysis and design are performed. Extended 3D Analysis of Building System is known by the acronym ETABS.

ETABS models can be created directly from CAD drawings or from templates onto which ETABS items can be superimposed. Directly from the software, a report is provided with all the information of the reinforcement.

Different materials, such as steel, RCC, composite, or any other user-defined material, can be allocated to the structural elements within the same model.

1.1.1 About Earthquake in India

In 1935, the Geological Survey of India (GSI) created the country's first national seismic zoning map. In the beginning, in 1956, there were three zones: severe, light, and minor. The seismic zones were further classified into seven zones by the Bureau of Indian Standards in 1962 based on the epicenters and the seismic map, namely zones 0, I, II, III, IV, V, and VI. The zonal map was later altered in 1966, and in 1970, due to the magnitude 6.5 earthquake that occurred in the Deccan Plateau, which was in zone 0 at the time, the zonal map was once again significantly revised. Finally, the 1984 revision of the zonal map brightened the zones into four zones, II, III, IV, and V.

1.1.2 Case Study: Bhuj

Gujarat, a western Indian state, experienced a significant earthquake on January 26, 2001, at 8:46 AM. The 2001 Gujarat earthquake also goes by the name Bhuj earthquake. According to estimates, the earthquake's

Richter scale magnitude was 6.9. (Moment magnitude, Mw 7.6). The epicenter was near Bhachau, in the Kutch area, 20 kilometers from Bhuj. A 7.7 on the Richter scale was recorded for the epicenter. Two minutes of the earthquake were followed by a disaster. About 70% of the country's regions experienced vibrations as a result of the earthquake, and Pakistan and Nepal also experienced foreshocks. Data collected after the earthquake showed that regions up to 300 km from the epicenter were seriously damaged, which caused large losses in 22 of Gujarat's 25 districts, primarily in the Kutch district.

1.2 METHODOLOGY

Knowing the fundamental information about a building, such as its size, type, and location in relation to seismic and wind hazards, is crucial before any kind of building is constructed. This study uses ETABS software to analyse a residential building under consideration.

1.2.1 Building Configuration Details

Figure 1 represents the building column beam layout

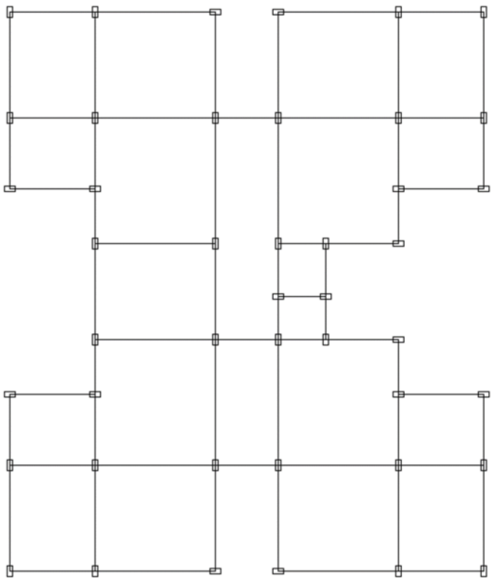

Figure1:Building Column beam layout

Table 1 represents the building configuration details

Table 1: Building Configuration Details

Building Type	RCC Framed
Nature of the Building	Residential
Dimension of the Building	20m x 24m
Height of the Building	15m
Foundation Depth	2.1m
Bottom Story Height	3m
Similar Stories Height	3m
Concrete Grade	M30
Steel Grade	HYSD 500
Size of Plinth	230mm x 600mm
Size of Columns	230mm x 450mm
Size of Beams	230mm x 380mm
Thickness of Slab	150mm
Thickness of Wall	230mm
Live Load on Slabs	3 kN/m^2
Floor Finish on Slab	1.0 kN/m^2
Wall Load	11.73 kN/m^2
Density of Brick	20 kN/m^2
Density of Concrete	25 kN/m^2
Methods of Analysis	Response Spectrum Method and Time History Analysis Method
Seismic Zones	Zone II, Zone III, Zone IV, Zone V

1.2.2 Response Spectrum Method

This method involved employing waves and vibrations of mode forms to determine how the structure would react to earthquake forces. The reaction spectrum concept was incorporated into building regulations for many nations' design needs in the middle of the 20th century. The response spectrum method used in seismic analysis was thought to have an advantage in terms of more precise displacement and member force predictions in structural systems. The response spectrum is a representation of the highest possible responses to an idealized single-degree freedom system with various natural periods and the same damping. The same earthquake's influence caused ground motion at their bases.

Table 2Seismic Details for Response Spectrum

Seismic Zones	Zone II	Zone III	Zone IV	Zone V
Zone Factor ‘Z’	0.10	0.16	0.24	0.36
Gravity ‘G’	9086.65 mm/s^2			
Importance Factor ‘I’	1			
Response Reduction ‘R’	5			
Soil Type	II (Medium Soil)			
Time Period ‘Ta’	Program Calculated			
Scale Factor ‘S’	IG/2R		908.665	
Modified Scale Factor	0.85S x(EQ/RS)		(varies)	

1.2.3 Time History Method

The earthquake response history of the structure is chosen in accordance with the application of a time-dependent force (seismic accelerogram). In other words, the moment and force diagrams can be found at each of a number of predetermined points during the applied motion. Real structures are analyzed using nonlinear finite element analysis software since manually calculating the time history for structures with more degrees of freedom quickly becomes impossible. The behaviour of linear elastic and nonlinear inelastic materials has been computed using step-by-step integration techniques.

Table 3 Seismic Details for Time History Method

Seismic Zones	Zone II	Zone III	Zone IV	Zone V
Zone Factor ‘Z’	0.10	0.16	0.24	0.36
Importance Factor ‘I’	1			
Response Reduction ‘R’	5			
Soil Type	II (Medium Soil)			
Time Period ‘Ta’	Program Calculated			
Scale Factor ‘S’	1			
Modified Scale Factor	EQ/((THmax+THmin))/2		(varies)	

II. RESULT AND DISCUSSION

The results obtained after comparison are as discussed below

1.3.1 Base Reactions

(i) Base reactions of RS and TH compared in X direction

From the figure 2 it is observed that the base reaction results vary for all four seismic zones and the maximum base reaction result is 1149.142 kN for RSX and 1416.589 for THX in X direction subjected under seismic zone V and minimum of 319.206 for RSX and 393.4970 for THX kN in X direction subjected under seismic zone II.

Table 4:Base reactions of RS and TH in X direction.

Seismic zones	Zone factor	Base Reaction kN	
		RSX	THX
Zone II	0.10	319.206	393.497
Zone III	0.15	510.73	629.595
Zone IV	0.24	766.094	944.3927
Zone V	0.36	1149.142	1416.589

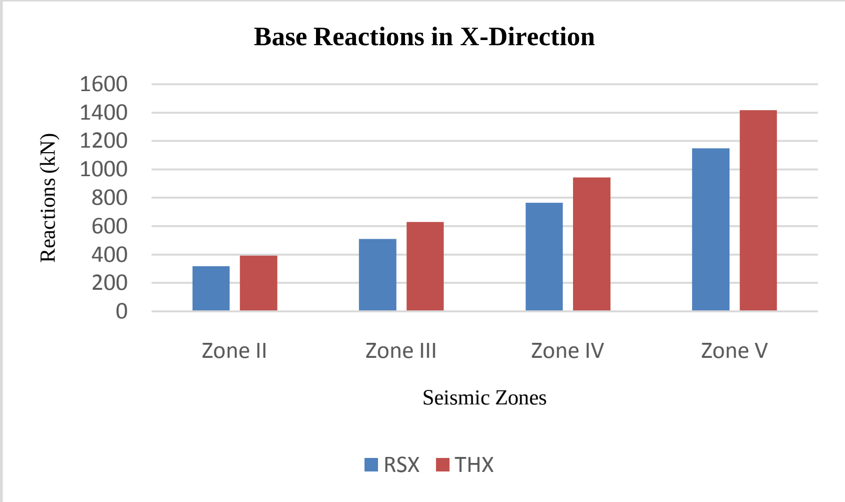

Figure 2: Base reactions of RS and TH in X direction

(ii) Base reactions of RS and TH compared in Y direction

From the figure 3 it is observed that the base reaction results vary for all four seismic zones and the maximum base reaction result is 1149.142 kN for RSX and 1416.589 for THX in X direction subjected under seismic zone V and minimum of 319.206 for RSX and 393.4970 for THX kN in X direction subjected under seismic zone II.

Table 5: Base reactions of RS and TH in Y direction

Seismic zones	Zone factor	Base Reaction kN	
		RSY	THY
Zone II	0.10	380.421	448.6137
Zone III	0.15	608.676	717.7819
Zone IV	0.24	913.014	1076.6729
Zone V	0.36	1369.522	1615.0097

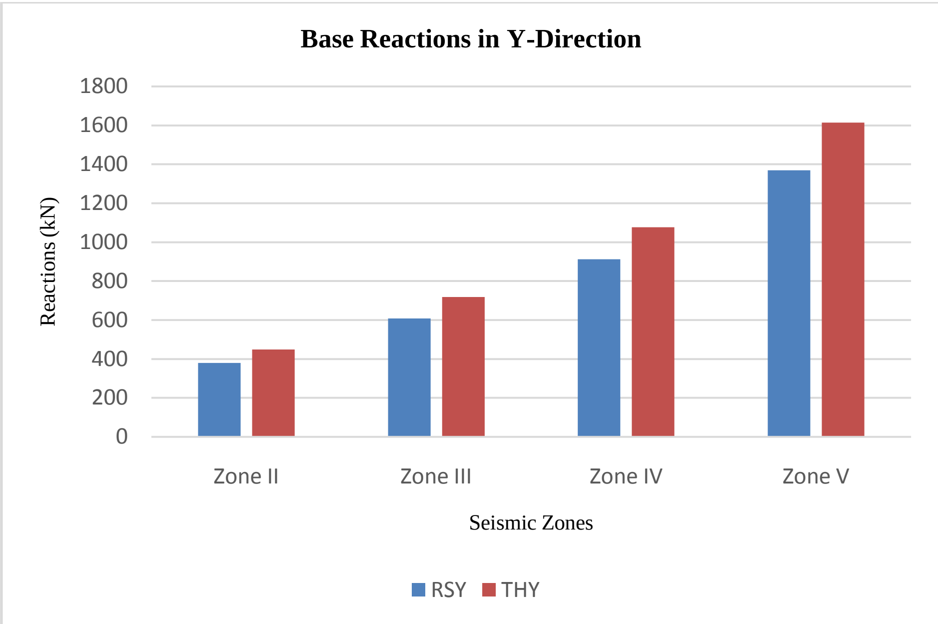

Figure 3: Base reactions of RS and TH in Y direction

1.3.2 Max Storey Shear

(i) Max storey shear of RS and TH compared in X direction

From the figure 4 it is observed that the storey shear results for the structure in X direction for RSX and THX is maximum at Zone V having 1149.1418 and 1413.9269 respectively.

Table 6:Max storey shear of RS and TH in X direction

Seismic zones	Max Storey Shear kN	
	RSX	THX
Zone II	319.2061	392.7575
Zone III	510.7294	628.412
Zone IV	766.0942	942.6179
Zone V	1149.1418	1413.9269

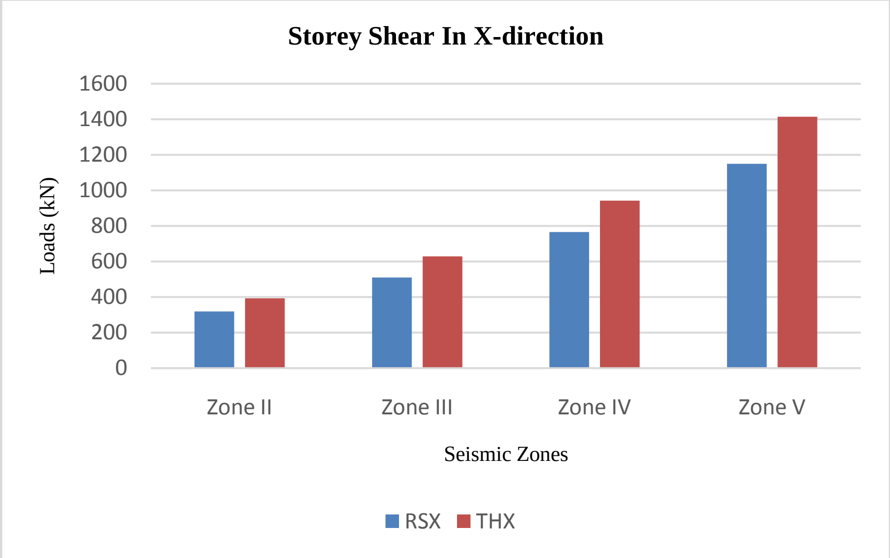

Figure 4: Max storey shear of RS and TH in X direction

(ii) Max storey shear of RS and TH compared in Y direction

From the figure 5 it is observed that the storey shear results for the structure in Y direction for RSY and THY is maximum at Zone V having 11369.522 and 1614.0565 respectively.

Table 7:Max storey shear of RS and TH in Y direction

Seismic zones	Max Storey Shear kN	
	RSY	THY
Zone II	380.421	448.349
Zone III	608.676	717.7819
Zone IV	913.014	1076.6729
Zone V	1369.522	1614.0565

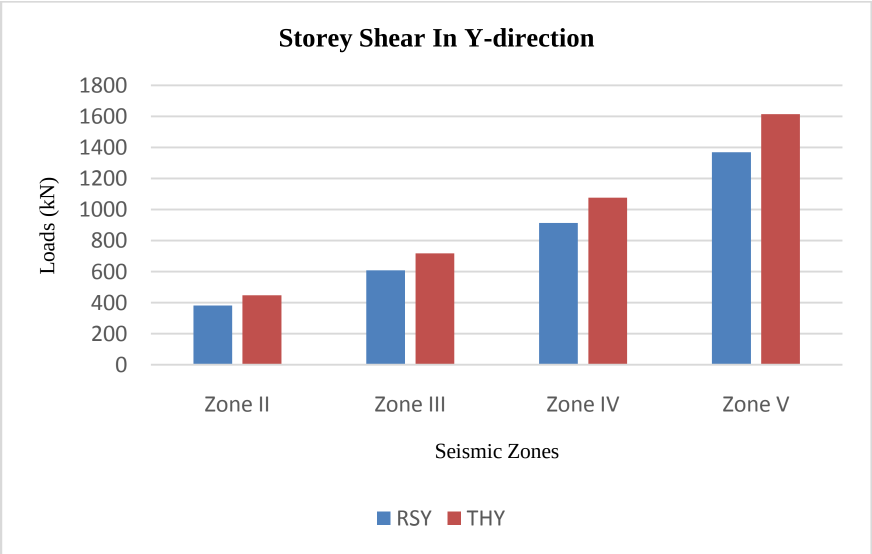

Figure 5: Max storey shear of RS and TH in Y direction

1.3.3 Max Storey Drift

(i) Max storey Drift of RS and TH compared in X direction

From the figure 6 it is observed that the storey Drift results for the structure in X direction for RSX and THX is maximum at Zone V having 0.001564 and 0.001831 respectively.

Table 8:Max storey Drift of RS and TH compared in X direction

Seismic zones	Max Storey Drift	
	RSX	THX
Zone II	0.000434	0.000506
Zone III	0.000695	0.000811
Zone IV	0.001043	0.001221
Zone V	0.001564	0.001831

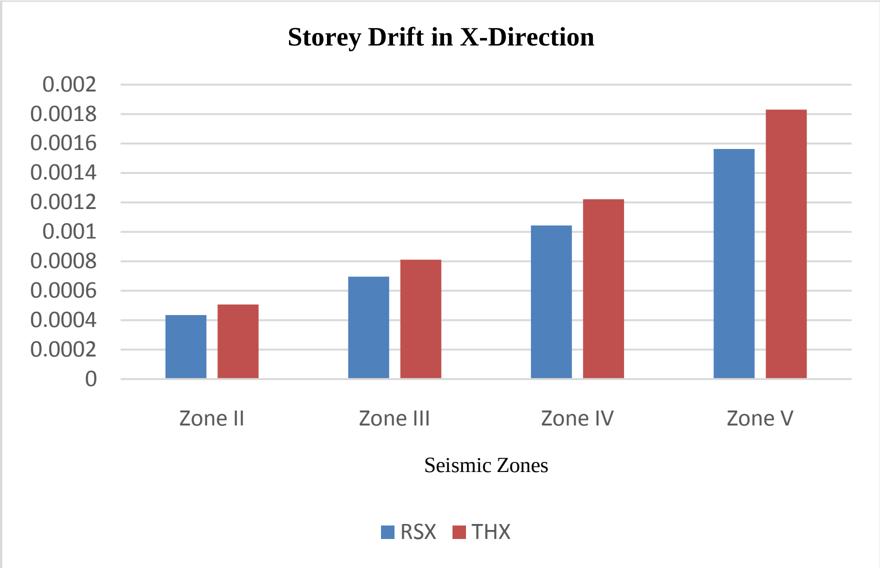

Figure 6: Max storey Drift of RS and TH compared in X direction

(ii) Max storey Drift of RS and TH compared in Y direction

From the figure 7 it is observed that the storey Drift results for the structure in Y direction for RSY and THY is maximum at Zone V having 0.001335 and 0.001596 respectively.

Table 9:Max storey Drift of RS and TH compared in Y direction

Seismic zones	Max Storey Drift	
	RSY	THY
Zone II	0.000371	0.000442
Zone III	0.000593	0.000707
Zone IV	0.00089	0.001064
Zone V	0.001335	0.001596

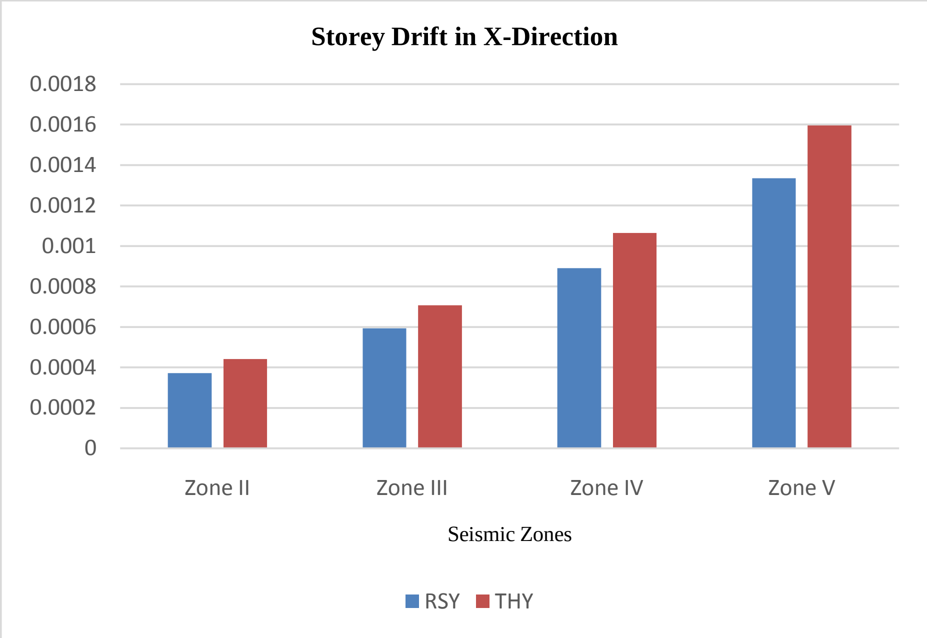

Figure 7: Max storey Drift of RS and TH compared in Y direction

1.3.4 Max Storey Displacement

(i) Max Storey Displacement in X direction

From the figure 8 it is observed that the storey Displacement results for the structure in X direction for RSX and THX is maximum at Zone V having 17.87 and 20.89 respectively.

Table 10:Max Storey Displacement in X direction

Seismic zones	Max Storey Displacement 'mm'	
	RSX	THX
Zone II	4.964	5.803
Zone III	7.942	9.285
Zone IV	11.913	13.927
Zone V	17.87	20.89

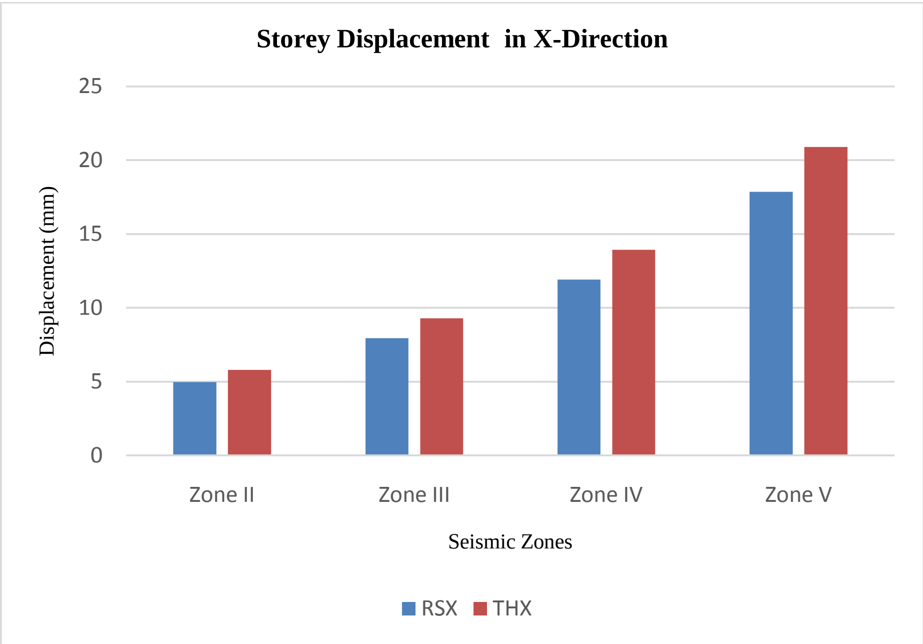

Figure 8: Max Storey Displacement in X direction

(ii) Max Storey Displacement in Y direction

From the figure 9 it is observed that the storey Displacement results for the structure in Y direction for RSY and THY is maximum at Zone V having 15.123 and 17.046 respectively.

Table 11:Max Storey Displacement in Y direction

Seismic zones	Max Storey Displacement 'mm'	
	RSY	THY
Zone II	4.201	4.735
Zone III	6.721	7.576
Zone IV	10.082	11.364
Zone V	15.123	17.046

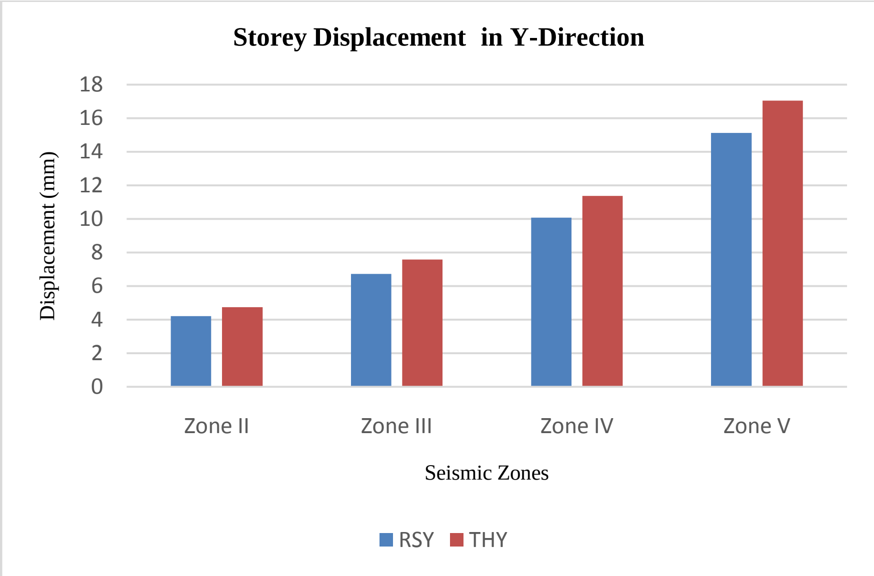

Figure 9: Max Storey Displacement in Y direction

1.3.5 Max Storey Acceleration

(i) Max Storey Acceleration in X direction

From the figure 10 it is observed that the storey Acceleration results for the structure in X direction for RSX and THX is maximum at Zone V having 808.24 and 1393.38 respectively.

Table 12:Max Storey Acceleration in X direction

Seismic zones	Max Storey Acceleration 'mm/sec^2'	
	RSX	THX
Zone II	224.51	387.05
Zone III	359.22	619.28
Zone IV	538.83	928.92
Zone V	808.24	1393.38

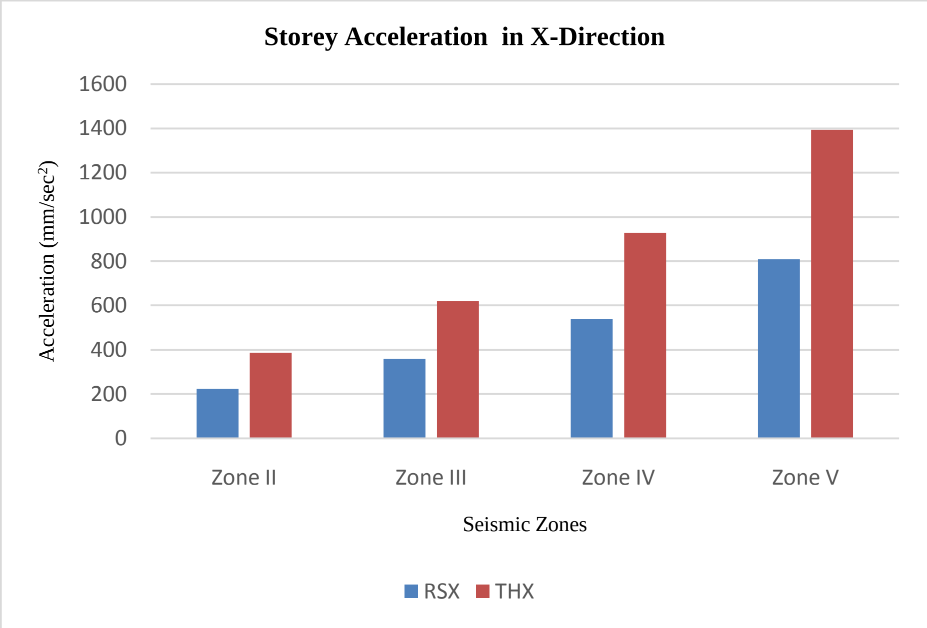

Figure 10: Max Storey Acceleration in X direction

(ii) Max Storey Acceleration in Y direction

From the figure 11 it is observed that the storey Acceleration results for the structure in Y direction for RSY and THY is maximum at Zone V having 876.36 and 1639.69 respectively.

Table 13:Max Storey Acceleration in Y direction

Seismic zones	Max Storey Acceleration 'mm/sec^2'	
	RSY	THY
Zone II	243.99	455.47
Zone III	390.38	728.75
Zone IV	585.57	1093.12
Zone V	878.36	1639.69

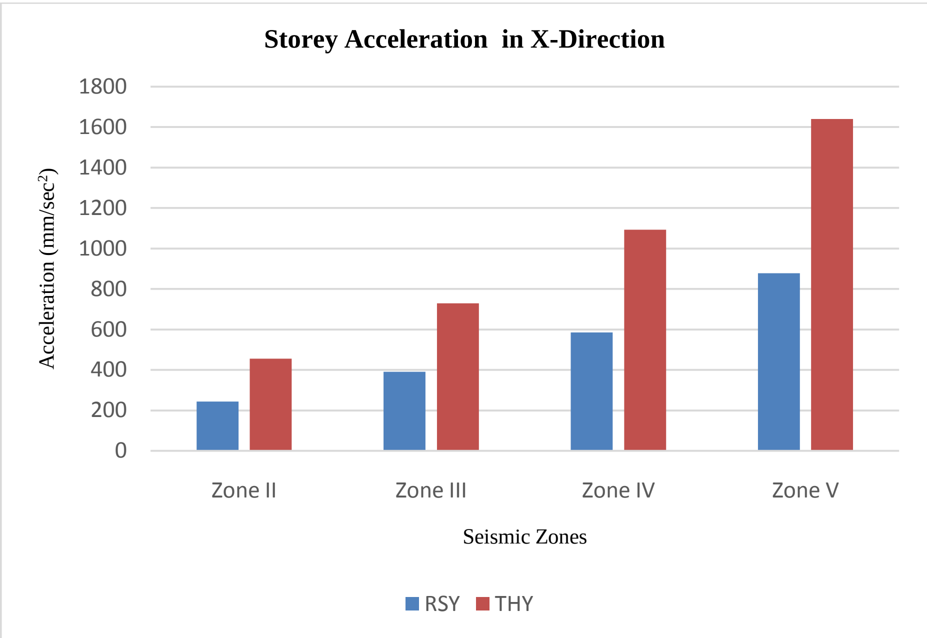

Figure 11: Max Storey Acceleration in Y direction

III. CONCLUSION

1. With respect to Response spectrum method, the Base Reactions in X direction has increased 23 % and 18% in Y direction for Time History Method.
2. The Storey Shear in Time History Method has increased up to 17.5 % in X direction and 17.7 % in Y direction when compared to Response Spectrum Method.
3. The Storey Drift in Time History Method has increased up to 16.67 % in X direction and 12.6 % in Y direction when compared to Response Spectrum Method.
4. With respect to Response spectrum method, the Storey Displacement in X direction has increased 12.95 % and 8.47 % in Y direction for Time History Method.
5. The Storey Acceleration in Time History Method has increased up to 48.32 % in X direction and 63.66% in Y direction when compared to Response Spectrum Method.
6. When compared, Response Spectrum Method has lower values for all the parameters than Time History Method

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