IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Comparative study on seismic behaviour of rc structure with framed tube structure and Shear wall for multistoried structure

Krushnmurti S. Desai, Dr. Sachin P. Patil
[1]P.G. Student of Civil Engineering Department of Sanjay Ghodawat university, Kolhapur, India
[2] HOD of Civil Engineering Department Sanjay Ghodawat university, Kolhapur, India

Abstract: Due to rising land prices in most nations because of population growth. The trend of constructing tall buildings has been on the rise, and currently, these structures typically have between 150 and 200 stories. This tendency is expected to persist as high-rise towers continue to be developed These high-rise structures are subject to extremely high lateral load because of wind and seismic pressures. By resulting in large deformations and strains, these loads have the potential to significantly change the structure's stability and functionality. Vertical loads and lateral forces both need to be resisted to avoid serious damage. Because earthquakes induce ground shaking and ground displacement, it is imperative to stop their detrimental effects.

Keywords–Displacement, Earthquake, Structure stability and functionality

1.0 INTRODUCTION

High-rise buildings need to be built with strong structural systems that can support these loads and provide adequate safety and serviceability. The main objective of seismic design is to withstand lateral forces experienced during an earthquake. This helps decrease the likelihood of harm to individuals within the earthquake-affected area. Structural engineers frequently recommend employing a tube system for lateral resistance in high-rise structures. It gives considerable resistance to lateral stresses and seismic waves. Tubular structures have been widely employed as a reliable structural method to sustain lateral loads in tall buildings. High-rise buildings are envisioned as hollow, cantilever tubes that are oriented perpendicular to the earth. Modern lateral stability technologies have made it possible to build a taller, more powerful structure. Famous structural engineer Fazlur Rahman Khan created the framed tube construction in 1960. The framed tube concept is one of the most widely used structural solutions for tall buildings. In the external frames of the structure, deep spandrel beams are securely joined to closely spaced columns. In this kind of arrangement, it had a significantly stiffer outside tube. Figure 1.1 illustrates that the column spacing within the structure can vary from 1.5m to 4.5m. Spandrel beams can range in depth from 0.5 to 1.2 meter. The entire structure functions as a hollow tube. This serves as a perpendicular cantilever against the earth. Most lateral loads are resisted by a hollow tube, and gravity loads are resisted by an interior column. The framed tube system's adaptability allows it to accommodate several floor plan geometries, such as rectangular, square, circular, and irregular ones. This design offers an advantage by transferring bending moments and shear forces from the columns to the spandrel beams. These beams operate akin to the flanges of a vertical cantilever beam, thereby diminishing the load-bearing demands on the columns.

2.0 FUTURE SCOPE

Advanced Seismic Analysis Techniques: Explore and develop advanced seismic analysis techniques specifically tailored for Framed Tube Structures. These techniques could include considering higher modes of vibration, soil-structure interaction effects, and non-linear behavior to obtain more accurate seismic response predictions. Comparison of Framed Tube Structure Seismic Behavior with and Without Shear Wall. Seismic Performance of Mega-Framed Tube Structures: Study the seismic performance of mega-tall buildings designed using the Framed Tube concept. Analyse the behavior of such structures under extreme lateral loads and assess their safety and stability. Innovative Framed Tube Configurations: Investigate and optimize innovative Framed Tube configurations to further enhance their lateral stiffness, strength, and energy dissipation capabilities. This could involve exploring novel arrangements of core columns, perimeter frames, and bracing systems.

3.0 METHODOLOGY

3.1 General

This chapter contains the methodology adopted for the detailed description of the research work. The methods of analysis and the specifics of the model are detailed in this section. This study is being done to find out how the different seismic zones would affect RC and framed tube structures.

The two types of seismic analysis techniques now being utilized to determine the structure's demand are as follows:

- Linear Static method

- Linear dynamic method

3.1.1 Linear Static Method

In a design process known as linear static analysis, the structure is subjected to analogous static forces brought on by wind or earthquakes. The computation of story forces is prescriptive, and IS-1893 Part I 2016 computation formulas are given. Regular structures, low seismicity regions, and environments where the fundamental mode of vibration dominates dynamic Behavior without substantial higher modes or torsion effects are the typical application domains for linear static analysis.

3.1.2 Linear Dynamic Method

According to IS-1893 Part-I 2016, when the time Ta is greater than 0.4 and Dynamic Analysis is performed, the Linear Dynamic Method is utilized to evaluate the demand of the structure for buildings whose reaction is dominated by more than one mode.

Response Spectrum Method- For conducting seismic analysis and design of a structure at a specific location, it is essential to utilize the actual time history records of seismic ground motions. The existence of such records everywhere is not feasible, though. Additionally, the seismic analysis of a structure must consider more than just the maximum ground acceleration. The behavior of the structure is influenced by its inherent dynamic properties and the frequency content of the ground motion. To address these challenges, the response spectrum is commonly used in seismic studies of structures. The response spectrum can be thought of as the point where an SDOF system will respond maximally given a particular damping ratio. To determine the lateral forces created in a structure because of an earthquake, response spectra can be utilized to obtain the peak structural responses within the linear range. This aids in the construction of structures that are earthquake-resistant.

3.2 Problem statement

In this present dissertation work, it is proposed to carry out a comparative study of RC structure framed tube structure and shear wall structure for increasing numbers of stories (40, 50, and 60) under seismic loads. The seismic analysis of structures using ETAB software. Structures are situated in different seismic zones (II, III, IV, and V), and seismic parameters are taken from IS-1875 Part I.

3.3 Input Data of Building

3.3.1 Framed-Tube Structure:

The building's slab and beam parts are all the same at every height.

- Size of beam- 450x900mm
- Slab Thickness – 200mm
- Floor height- 3.6m

Table 3.1, Table 3.2, and Table 3.3 Shows section properties for different stories and zones of a building. These properties include column sizes, middle column sizes, beam sizes, and slab thickness. It is divided into five zones (II, III, IV, V), and for each zone, it provides information about the size of outer columns, corner middle columns, and main middle columns. Information about the size of the beams (both outer spandrel beams and inner beams) is given in meters. The thickness of the slab is provided.

Table 3.1 Section properties for 40-story.

Zone	II	III	IV	V
Size of Outer column (m) Corner Middle main	0.90X0.90 0.90X0.45 0.75X0.75	0.90X0.90 1.05X0.60 0.90X0.90	1.20X1.20 1.50X0.60 1.05X1.05	1.20X1.20 1.65X0.60 1.20X1.20
Size of Middle column (m)	0.90X0.90	1.05X1.05	1.05X1.05	1.20X1.20
Size of the beam (m) Outer Spandrel Beam Inner Beam	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90
The Thickness of Slab (mm)	0.20	0.20	0.20	0.20

Table 3.2 Section properties for 50-story.

Zone	II	III	IV	V
Size of Outer column (m) Corner Middle main	1.35X1.35 1.05X0.60 0.90X0.90	1.35X1.35 1.05X0.60 1.05X1.05	1.50X1.50 1.50X0.60 1.05X1.05	1.50X1.50 1.80X0.60 1.35X1.35
Size of Middle column (m)	1.20X1.20	1.20X1.20	1.20X1.20	1.35X1.35
Size of the beam (m) Outer Spandrel Beam Inner Beam	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90
Thickness of Slab(m)	0.20	0.20	0.20	0.20

3.4 Shear Wall Structure:

The building's slab and beam parts are all the same at every height.

- Size of beam- 450x900mm
- Slab Thickness – 200mm
- Shear Wall – 400mm
- Floor height- 3.6m

Table 3.3 Section properties for Shear Wall Structure

Size of Column				
Zone	II	III	IV	V
40-Story	1.05X1.05	1.05X1.05	1.20X1.20	1.35X1.35
50-Story	1.20X1.20	1.20X1.20	1.35X1.35	1.50X1.50
60-Story	1.35X1.35	1.50X1.50	1.50X1.50	1.50X1.50

3.5 The basic material properties used are as follows:

- Grade of concrete for beam and slab = M40
- Grade of concrete for column = M60
- Grade of steel = Fe500

Table 3.4 Section properties for 60-story.

Zone	II	III	IV	V
Size of Outer column (m) Corner Middle main	1.35X1.35 1.05X0.60 0.90X0.90	1.35X1.35 1.20X0.60 1.05X1.05	1.50X1.50 1.65X0.60 1.05X1.05	2.00X2.00 1.80X0.60 1.35X1.35
Size of Middle column (m)	1.35X1.35	1.35X1.35	1.35X1.35	1.35X1.35
Size of the beam (m) Outer Spandrel Beam Inner Beam	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90	0.30X0.75 0.45X0.90
Thickness of Slab(m)	0.20	0.20	0.20	0.20

4.0 Experiments

4.1 General

The software work completed for the dissertation is contained in this chapter. This study is being done to investigate how high-rise RCC buildings respond to seismic stresses and how the Framed Tube structural system affects that. The modeling is done using ETABS software. The finite element method of analysis is the foundation of the software.

4.2 Model details:

To investigate the seismic response of a 40, 50, and 60-story high-rise RCC Shear Wall Structure and Framed Tube Structure.

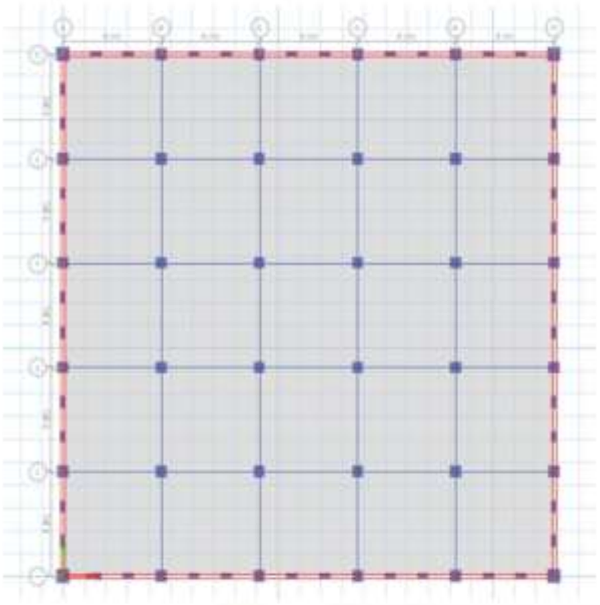

Figure 4.1: Plan of given Framed Tube Structure

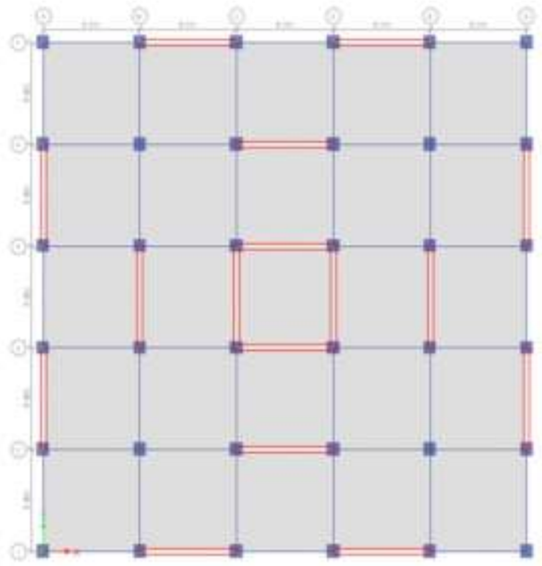

Figure 4.2: Plan of given Shear wall Structure

4.3 Given data for structures:

Table 4.1 provides important details about a Framed Tube Structure and Shear Wall Structure. These details are essential for understanding and analyzing the structural characteristics and performance of the building in various conditions.

Table 4.1: Details of Framed Tube Structure

Type of frame	Framed Tube Structure and Shear Wall Structure
plan	40 x 40 m
Bays in X- and Y-direction	5 bays of 8m each
Type of soil	Hard Rock
Importance factor	1.5
Response Reduction Factor	5
Height of floor	3.6 m
Slab thickness	200 mm
Wind Speed	44 m/sec
Terrain Category	4
Important Factor	1
Risk Coefficient	1
Topography	1

4.4 Modeling of Structure:

ETABS software is used for building modeling and analysis. It is done to analyse buildings with 40, 50, and 60 stories in various seismic zones.

4.4.1 Software modeling of 40-story Framed Tube Structure:

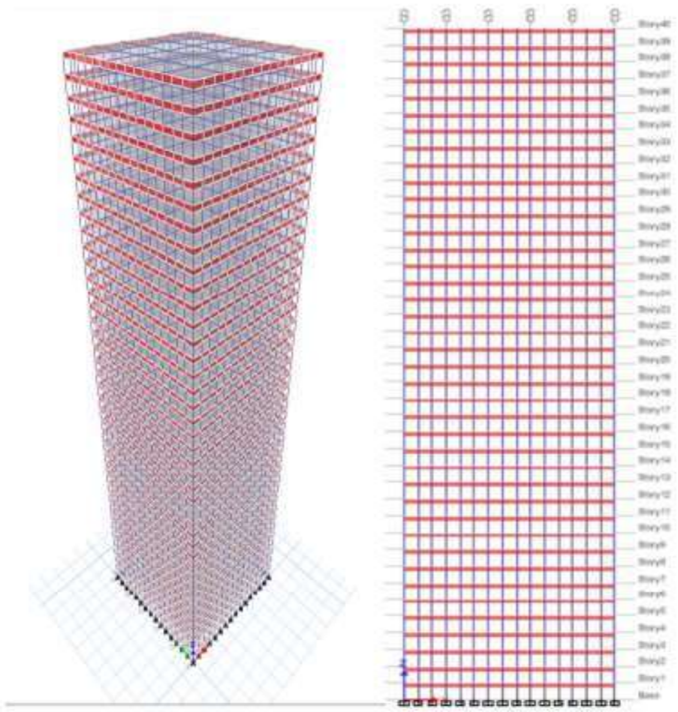

Figure 4.3: Model of 40-story Framed Tube Structure

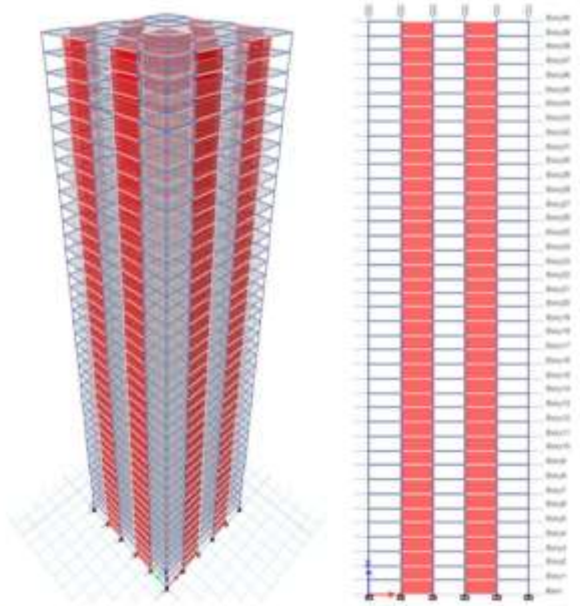

Figure 4.4: Model of 40-story Shear Wall Structure

5.0 RESULTS AND DISCUSSION

5.1 General

In the analysis process, both wind and seismic loads are imposed on each model, followed by evaluating each model utilizing the ETAB 2016 software. The research results for each building model, including metrics such as storey drifts, base shear, and displacements, are compared among themselves.

5.2 Displacement

According to Indian standards, the maximum displacement allowed in a multi-story building for seismic events is □ □□□ (where H represents the height of the building), and for wind events, it is H/500. Therefore, the maximum displacement for different stories can be calculated accordingly using these values shown in table5.1.

Table 5.1 Maximum Displacement as per Indian Regulations

No. of Story	Height (m)	Seismic Displacement $\left(\frac{H}{250}\right)$ mm.	Wind load Displacement $\left(\frac{H}{500}\right)$ mm.
40-Story	140m	560mm	280mm
50-Story	175m	700mm	350mm
60-Story	210m	840mm	420mm

Table 5.2: Maximum Displacement for Framed Tube Structure

No. of Story	Zone	II	III	IV	V
40-Story	Displ. Eq. X	20.34mm	32.37mm	43.56mm	64.84mm
	Displ. Resp. X	111.59mm	172.32mm	231.18mm	359.6mm
	Displ. WL. X	41.42 mm	39.226mm	31.35mm	29.77mm
50-Story	Displ. Eq. X	25.66mm	40.84mm	57.16mm	88.01mm
	Displ. Resp. X	138.166mm	218.24mm	311.83mm	483.03mm
	Displ. WL. X	65.88 mm	64.49mm	55.32mm	54.91mm
60-Story	Displ. Eq. X	43.33mm	61.50mm	88.06mm	136.61mm
	Displ. Resp. X	228.18mm	318.2mm	467.1mm	729.61mm
	Displ. WL. X	118.78mm	98.36mm	96.0mm	94.64mm

Table 5.3: Maximum Displacement for the Shear Wall Structure

No. of Story	Zone	II	III	IV	V
40-Story	Displ. Eq. X	46.16mm	74.10mm	104.48mm	122.2mm
	Displ. Resp. X	173.9mm	282.29mm	393.65mm	550.49mm
	Displ. WL. X	82.26 mm	80.44mm	73.79mm	68.75mm
50-Story	Displ. Eq. X	58.25mm	92.77mm	128.69mm	184.85mm
	Displ. Resp. X	250.18mm	398.33mm	548.43mm	657.42mm
	Displ. WL. X	125.70mm	125.16mm	112.28mm	109.65
60-Story	Displ. Eq. X	87.49mm	137.28mm	200.5mm	297.12mm
	Displ. Resp. X	321.54mm	499.79mm	670.59mm	839.78mm
	Displ. WL. X	183.66mm	178.71mm	169.17mm	165.32mm

The seismic displacements and wind load displacements for the different building models (40-story, 50-story, and 60-story) are presented in Table 5.2 and Table 5.3. The results indicate that the maximum seismic displacement for all models is within the Indian regulatory limit (H/250). Similarly, the wind load displacements are well below the H/500 limit.

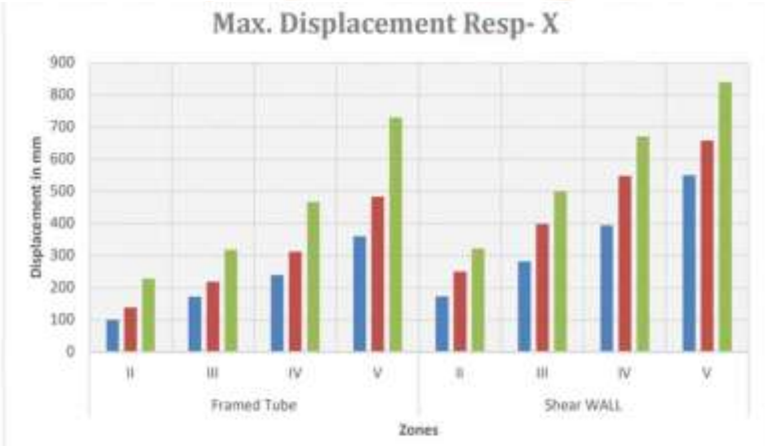

Figure 5.1: Comparison of lateral displacement

The comparison of lateral displacements across different zones for the framed tube structure is illustrated in Figure 5.1. It can be observed that as the seismic zone increases, both the seismic displacement and wind load displacement also increase. This trend highlights the importance of accounting for the seismic zone when designing high-rise structures.

5.3 Base shear:

Table 5.4: Maximum Story Shear for Framed Tube Structure

No. of Story	Zone	II	III	IV	V
40-Story	Story Shear Eq. X	3418kN	5683kN	9721kN	15097kN
	Story Shear Resp. X	26617kN	44721 kN	75081kN	114981kN
	Story Shear WL. X	8841kN	8841kN	8841kN	8841kN
50-Story	Story Shear Eq. X	3620kN	5868kN	9719kN	14954kN
	Story Shear Resp. X	29330kN	47716kN	76498kN	116608kN
	Story Shear WL. X	12157kN	12263kN	12157kN	12157kN
60-Story	Story Shear Eq. X	4240kN	6907.7kN	10777kN	17119kN
	Story Shear Resp. X	32306kN	53921kN	83351kN	127937kN
	Story Shear WL. X	15598kN	15258kN	15598kN	15598kN

Table 5.5: Maximum Story Shear for the Shear Wall Structure

No. of Story	Zone	II	III	IV	V
40-Story	Story Shear Eq. X	3635 kN	5989kN	9231kN	10309kN
	Story Shear Resp. X	26419 kN	44721kN	69372kN	109103kN
	Story Shear WL. X	7911kN	7911kN	7911kN	7911kN
50-Story	Story Shear Eq. X	3699kN	5919kN	9155kN	13507kN
	Story Shear Resp. X	31559kN	50632kN	81542kN	111151kN
	Story Shear WL. X	11152kN	11152kN	11152kN	11152kN
60-Story	Story Shear Eq. X	5322kN	8555kN	13314kN	20200kN
	Story Shear Resp. X	33198kN	52266kN	77708kN	120803kN
	Story Shear WL. X	14534kN	14534kN	14534kN	14534kN

Figure 5.2: Comparison of Story Shear

Base shear values are crucial for understanding the lateral forces acting on a building during seismic events. Figure 5.2 provides a comparison of story shear forces for the framed tube structures in different seismic zones. As expected, the base shear increases with higher seismic zones, reflecting the higher lateral forces experienced by the building.

5.4 Story Drift:

Storey drift signifies the horizontal displacement of a floor in relation to the floor immediately below it, brought about by external forces such as wind or earthquakes shown in table 5.6 and table 5.7. As per IS.1893-Part I 2016, the maximum allowable story drift is calculated as 0.004 times the story height, which for a 3.6-meter story height would be 0.0144 meters.

Table 5.6: Maximum Story Drift for Framed Tube Structure

No. of Story	Zone	II	III	IV	V
40-Story	Story Drift Eq. X	0.00016	0.000256	0.000346	0.000542
	Story Drift Resp. X	0.00093	0.001486	0.002063	0.003353
	Story Drift WL. X	0.00031	0.000309	0.000257	0.000277
50-Story	Story Drift Eq. X	0.000174	0.000279	0.000379	0.000583
	Story Drift Resp. X	0.000975	0.001557	0.002147	0.003424
	Story Drift WL. X	0.000469	0.000464	0.000385	0.000403
60-Story	Story Drift Eq. X	0.000243	0.000365	0.000489	0.000761
	Story Drift Resp. X	0.001309	0.001945	0.002664	0.004196
	Story Drift WL. X	0.000671	0.000588	0.00053	0.000542

Table 5.7: Maximum Story Drift for the Shear Wall Structure

No. of Story	Zone	II	III	IV	V
40-Story	Story Drift Eq. X	0.00040	0.00064	0.00090	0.00108
	Story Drift Resp. X	0.00154	0.00247	0.00347	0.00495
	Story Drift WL. X	0.00072	0.00069	0.00063	0.00060
50-Story	Story Drift Eq. X	0.00041	0.00066	0.00092	0.00131
	Story Drift Resp. X	0.00178	0.00284	0.00394	0.00469
	Story Drift WL. X	0.00088	0.00088	0.00078	0.00076
60-Story	Story Drift Eq. X	0.00051	0.00082	0.00118	0.00176
	Story Drift Resp. X	0.00192	0.00302	0.00400	0.00502
	Story Drift WL. X	0.00109	0.00107	0.00099	0.00097

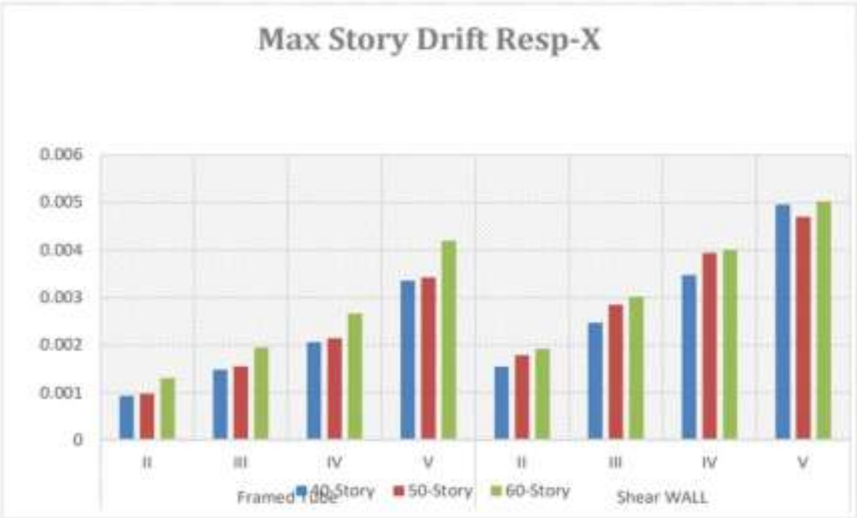

Figure 5.3: Comparison of Story Drift

Story drift, as shown in Figure 5.3, represents the relative horizontal movement between adjacent floors due to external forces. The comparison of story drift across different zones reveals that as the seismic zone increases, the story drift also increases, indicating higher inter-story displacements.

6.0 CONCLUSION

The conclusions from the study are as follows.

1. A framed tube structure's lateral displacement is 35.75% less than values derived from an analysis of a shear wall structure. This demonstrates that, compared to other systems, the Framed Tube Structure system is the most effective in resisting lateral loads.
2. All the structures demonstrate acceptable levels of story drift, meeting the criteria specified by IS 1893-2002. Comparing the results of the analysis of the shear wall structure to the values obtained from the analysis of the framed tube structure, the maximum storey drift is reduced by 34.77%.
3. The primary factor affecting the base shear of a framed tube structure is the rise in seismic weight. When contrasted with a shear wall structure, the base shear of a framed tube structure exhibited a relatively minor increase of 4.48%.
4. The axial force in corner columns of a framed tube structure is greater as compared to adjacent columns; this is called the shear lag effect in Framed Tube Structure. The axial force in the corner column is increased by 21% compared to the adjacent column.

7. REFERENCE

1. Ahmed R. H., Shaikhli H. I., & Wail A. M. 2021, Study of Different Tubular Systems on the Lateral Load Resistance. Periodicals of Engineering and Natural Sciences, 9(2), 672-681. ISSN 2303-4521. 2.
2. Ali M., & Moon K. S. 2007, Structural Developments in Tall Buildings: Current Trends and Future Prospects. Architectural Science Review, 50(3), 205-223.
3. Bureau of Indian Standard. 2000, IS 456: 2000, Indian Standard Plain and Reinforced Concrete - Code of Practice. New Delhi.
4. Bureau of Indian Standard. 2016, IS 1893(Part 1) - 2016, Indian Standard Code of Practice for Criteria for Earthquake Resistant Design of Structures. New Delhi.
5. Bureau of Indian Standard. 2017, IS 16700: 2017, Criteria for Structural Safety of Tall Concrete Buildings. New Delhi.
6. James C. A., Chen W., & Yen P. 1997, Seismic Behavior of a High-Strength Concrete Framed Tube. The Structural Design of Tall Buildings, 6, 333-350.
7. Kamgar R., & Rahgozar R. 2010, A Simple Approximate Method for Free Vibration Analysis of Framed Tube Structure. The Structural Design of Tall and Special Buildings, DOI: 10.1002/tal.743.
8. Khan F., & Amin, N. 1973, Analysis and Design of Framed Tube Structures for Tall Concrete Buildings. Structural Engineering, 51.
9. Kim J., Park, J., & Moon K.W. 2009, Seismic Performance of Tubular Structures with Buckling Restrained Braces. Structural Design of Tall and Special Buildings, 18, 351-370.
10. Kim Y. S., & Choi K. K. 2019, Seismic performance of high-rise buildings with various shear wall arrangements. Structures, 19, 309-318.