International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 4 ǁ 2022 ǁ PP. 07-13

A Comparative Study of Framed Structure, Frame Tube and Tube In Tube Structures Subjected To Lateral Load Under Zone Iii And Zone V

Priyanka[1], Shivanand C.G[2] , Dr. P. Prakash[3], Geetha L[4]

[1] MTECH. In Structural Engineering, Department of Civil Engineering, The Oxford College of Engineering Bangalore- 56006, India.
[2]Assistant professor, Department of Civil Engineering, The Oxford College of Engineering Bangalore- 560068, India.
Professor, Department of Construction Technology and Management, DSCE, Bangalore- 560068, India.
Assistant professor, Department of Construction Technology and Management, DSCE, Bangalore- 560068, India.

***Abstract** - This study aims to understand the effect of the earthquake on framed structure, frame tube and tube in tube structures. The main objective of the study is to understand the behavior of structure with respect to story drift, story shear and story displacement. The G+39 and G+29 storied Structure are acquired for dynamic analysis. Method adopted was Response spectrum method. For the purposes of analysis software used is ETAB'S. After analysis the results are compared between framed structure, frame tube and tube in tube structures. The comparative study of frame tube structure, tube in tube structure, framed structure under Zone III and Zone V and is to be done to find most efficient structure in order to resist the lateral loads of the combined system.*

Key Word: Framed structure, Frame tube, Tube in tube, ETABS.

Date of Submission: 01-04-2022 Date of acceptance: 14-04-2022

I. INTRODUCTION

Development of the country can be accomplished through proper planning and economic development as they are the vital reasons that encourage technological progress by dogging the use of the latest materials and technological systems. The main concept of tubular structures is to design the tall structure as a vacant cantilever vertical to the surface of ground which can resist the lateral loads. These structures consist of ring of columns at the edge of the structure are closely spaced columns and these columns are connected to each other by deep spandrel beams through moment connections. In this tube at the exterior of the building a very stiff moment resisting frame i.e. a tube is formed which provides the lateral resistance to the building or structures.
The tubular structures of much type have been developed to resist the lateral loads.

- **Frame tube**
- **Tube in tube**

1.1 Framed Tube

In this tube at the exterior of the building a very stiff moment resisting frame i.e. a tube is formed which provides the lateral resistance to the building or structures. This exterior framed tube consists of closely spaced columns at a distance of 6-12 ft between centers; these columns are connected to each other by deep spandrel beams. The peripheral framed tube and core columns or walls resist gravity or vertically downward loads while the lateral loads acts, at the face of the framed tube formed by closely set apart columns which acts as the webs, when aligned along the loading direction, and act as the flanges when the loading direction is normal to the tube surface .

Fig. 1.1 Chestnut Dewitt Apartments, Chicago, 1965

1.2 Tube In Tube

Tube in Tube structure is new technology with advancement to the framed tube structure in these structures along with an outer frame tube which is called as the Hull there is an additional internal elevator and service core frame tube called as Core. Both gravity and lateral loads are resisted by the Hull and Core together. In these types of structures outer framed tube hull acts as shear component and the inner core acts as the flexural component. In these structures generally high governing role of the structural tube is because of its abundantly greater structural depth.

Fig. 1.3 World Trade Centre, USA, 1972

II. METHODOLOGY

A high-rise building of G+39 and G+29 stories with framed structure, frame tube and tube in tube considered for analysis. Modal analysis and response spectrum analysis is carried out using the ETABS 2015 software. Seismic analysis of framed structure, frame tube and tube in tube structures considered for study.

2.1 Response spectrum analysis:

Response spectrum analysis is most widely used in seismic analysis of a structure. A response spectrum is a graphical representation of the peak or steady-state response (displacement, velocity or acceleration) of a series of oscillators of varying natural frequency. Response spectrum analysis is more optimistic for design purpose compared to static analysis. Typical Response spectrum curve as shown below.

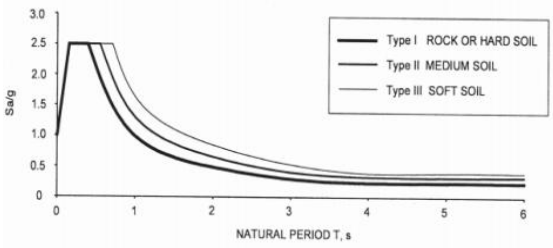


Fig:1.1.Response Spectrum analysis

2.2. BUILDING SPECIFICATIONS
2.2.1. Plan details

- (G+39) and (G+29) story building
- No. of bays along x direction - 8
- No. of bays along y direction - 8
- Spacing between two bays – 7.5m
- Story height - 3.5m
- Soil type - I (hard)
- Location – Zone III and Zone V
- Grade of concrete - M25
- Grade of steel - Fe415
- Response reduction factor – 5
- Impedance factor - 1.5

2.3. Modelling:

A high-rise building of G+39 and G+29 story with framed structure, frame tube and tube in tube analyzed using ETABS software. Model consists of G+39 and G+29 story with a typical floor height of 3.5 m. The building plan consists of 8 bays along the direction x and 8 bays along the direction y direction.

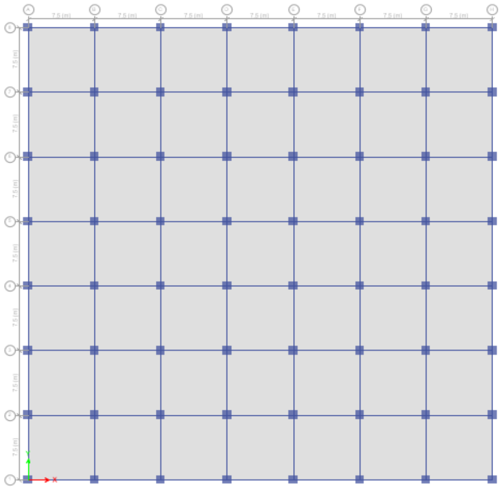


Fig: 1.2. Plan of a framed structure

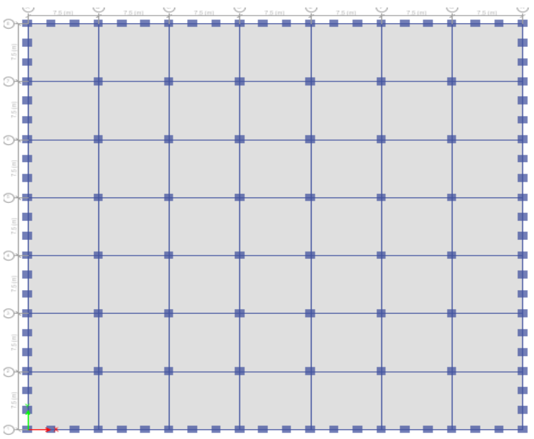


Fig: 1.3. Plan of a frame tube

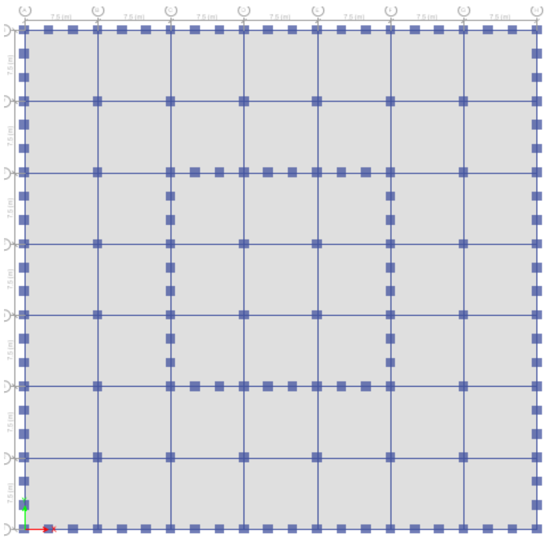


Fig: 1.3. Plane of tube in tube

2.4. Loads and dynamic parameters considered for study:

Dead loads and live loads are considered as per IS 875 Part III. The structural elements were designed in compliance with IS 456-2000 and IS 1893-2002, with regard to grades M 25 of concrete and Fe 415 of steel. The complex parameters considered for the study of the response spectrum method. Designed building dimensions are shown in Table.

Table-1. Details of Load

Dead load	Self Weight of Building
Live load	4 kN/m^2
Floor Finish	1 kN/m^2
Young's modulus of concrete	$25X10^6$ kN/m^2
Density of steel	76.59kN/m^3
Density of concrete	25kN/m^3

Dynamic parameters considered as per code IS 1893:2002 for analysis is shown below table. Seismic zone consider as III and zone V. Soil type considered as type 1 (it's a hard soil). Importance factor considered as 1.5 (commercial building). Response reduction factor is 5.

Table-2: Details of dynamic parameters.

Seimic zone	**III and V**
Soil type	**I (hard)**
Importance Factor	**1.5**
Response reduction factor	**5**

Table-3: Dimensions of Building Components

Column (G+39)	C1 – 1000mm x 1000mm (Ground to 10th floor) C2 – 800mm x 800mm (11th to 20th floor) C3 – 600mm x 600mm (21st to 30th floor) C4 – 500mm x 500mm (31st to 40th floor)
Column (G+29)	C1 – 1000mm x 1000mm (Ground to 10th floor) C2 – 800mm x 800mm (11th to 20th floor) C3 – 600mm x 600mm (21st to 30th floor)
Beam	300mm x 450mm
Slab	150mm thick

3. Modelling procedure of response spectrum analysis:

Step 1: Defining a response spectrum function

Define – function – Response spectrum functions – select code **-** add new function

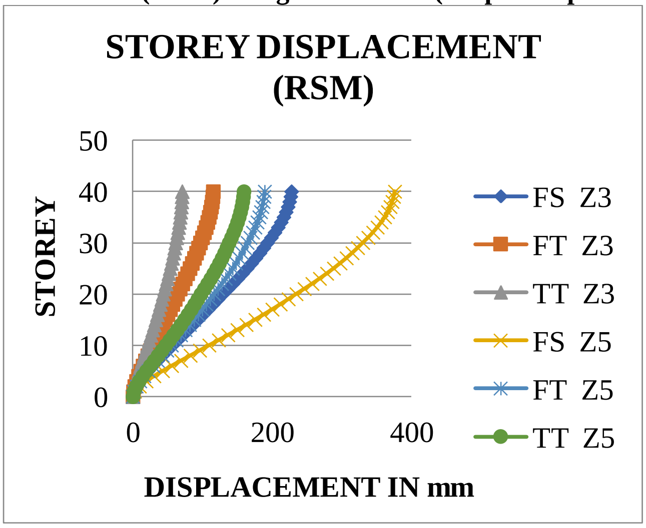
Step 2: Defining the load cases of RSA

Define – load cases - Add new case
Load case 1 – RSX
Load case 2 – RSY
scale factor = Ig /2R
Step 3: Run analysis
Step 4: Scaling up of base reactions of seismic analysis and response spectrum analysis After analysis, the base reaction of EQX and RSX load case are not same, by using below formula can make base reaction same.
Scale factor = BASE REACTION OF EQX/ BASE REACTION OF RSX x I_g /2R

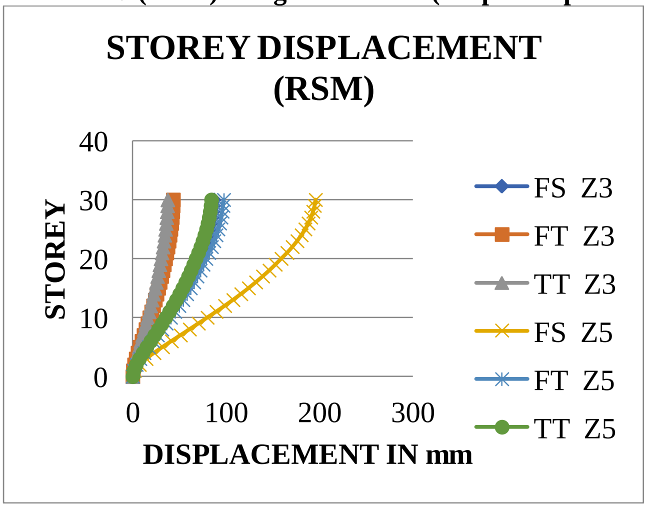
III. RESULTS AND DISCUSSION

General:
Earthquake load are considered for the analysis of all the models. ETABs software is used for the analysis of all the models. The results such as displacement, storey drift and base shear are considered for analysis.

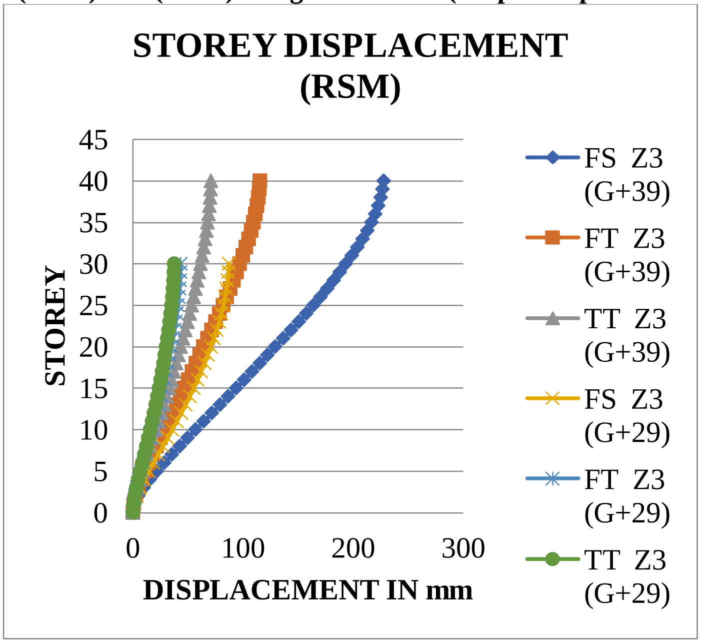
4.1 Storey wise displacements due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III AND Zone V (G+39) along X-direction (Response spectrum method).



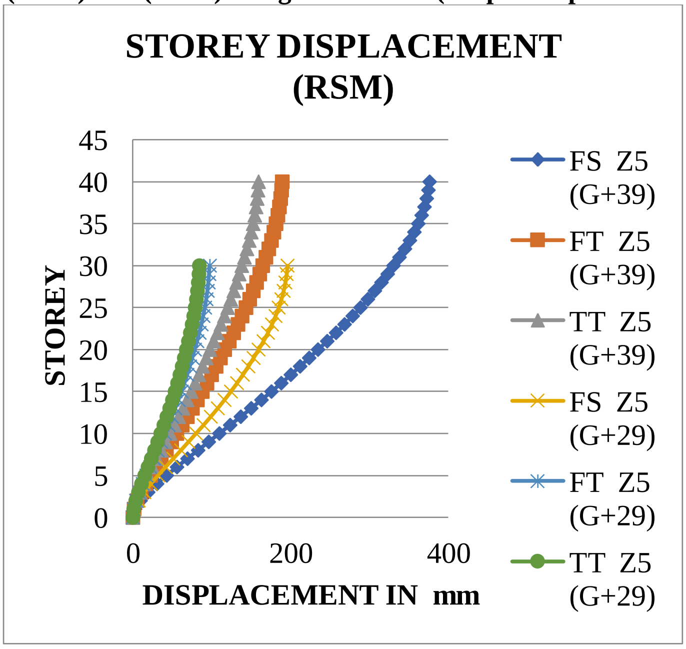
4.2 Storey wise displacements due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III AND Zone V (G+29) along X-direction (Response spectrum method).



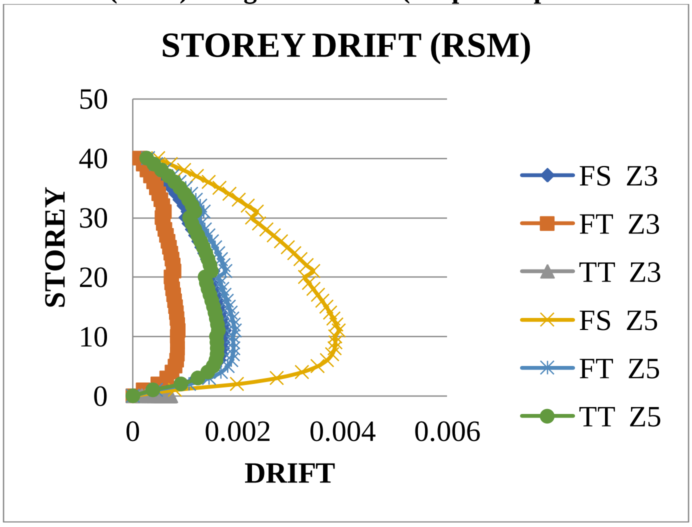
4.3 Storey wise displacements due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III (G+39) and (G+29) along X-direction (Response spectrum method).



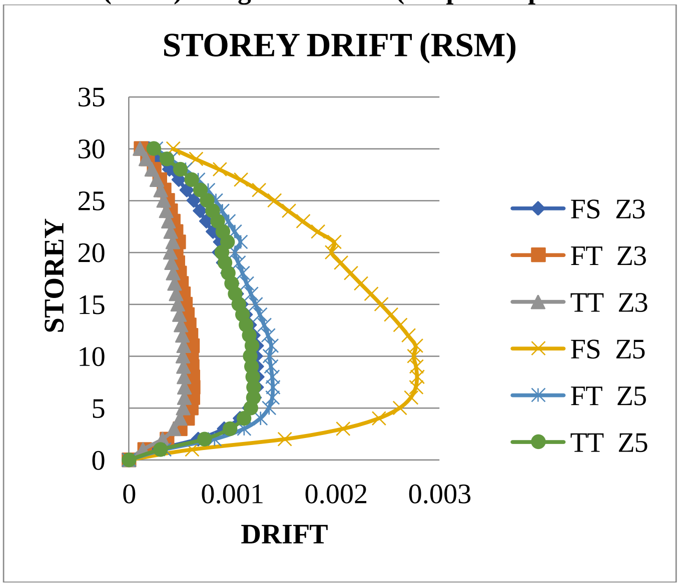
4.4 Storey wise displacements due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone V (G+39) and (G+29) along X-direction (Response spectrum method).



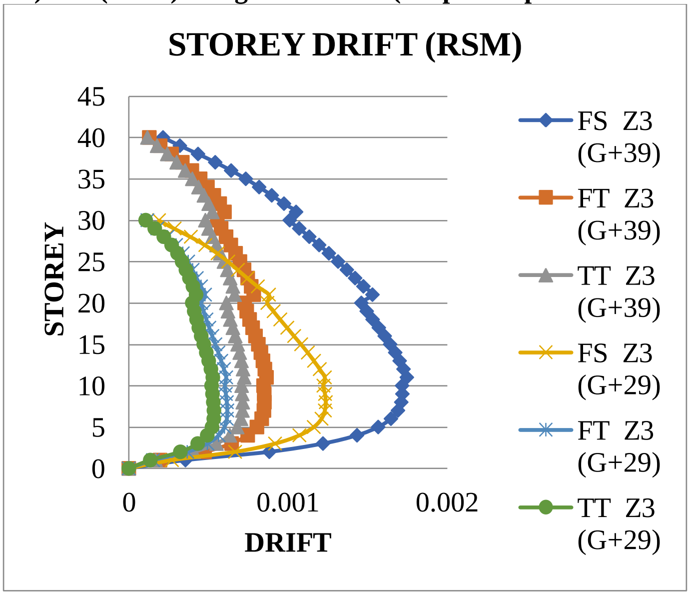
4.5 Storey wise drifts due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III AND Zone V (G+39) along X-direction (Response spectrum method).



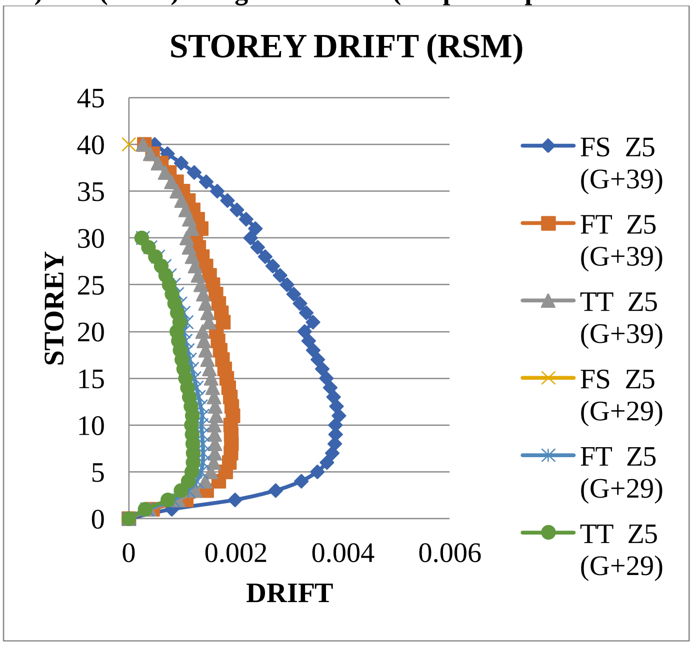
4.6 Storey wise drifts due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III AND Zone V (G+29) along X-direction (Response spectrum method).



4.7 Storey wise drifts due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone III (G+39) and (G+29) along X-direction (Response spectrum method).



4.8 Storey wise drifts due to seismic loads for Framed structure, Frame tube and Tube in tube in Zone V (G+39) and (G+29) along X-direction (Response spectrum method).



4.9 Comparison of maximum displacements of Frame structure, frame tube and tube in tube models due to seismic loads in Z0NE III and ZONE V (Response spectrum Method)

Table 4 : Maximum displacements for FS FT,TT (G+39)

MODELS	STOREY DISPLACEMENT (mm)	PERCENTAGE (%) CHANGE (COMPARED TO FS Z3)
FS Z3	227.751	0
FT Z3	115.316	49.37% (Decrease)
TT Z3	70.826	68.91% (Decrease)
FS Z5	376.165	39.46% (Increase)

FT Z5	189.341	16.87% (Decrease)
TT Z5	159.358	30.01% (Decrease)

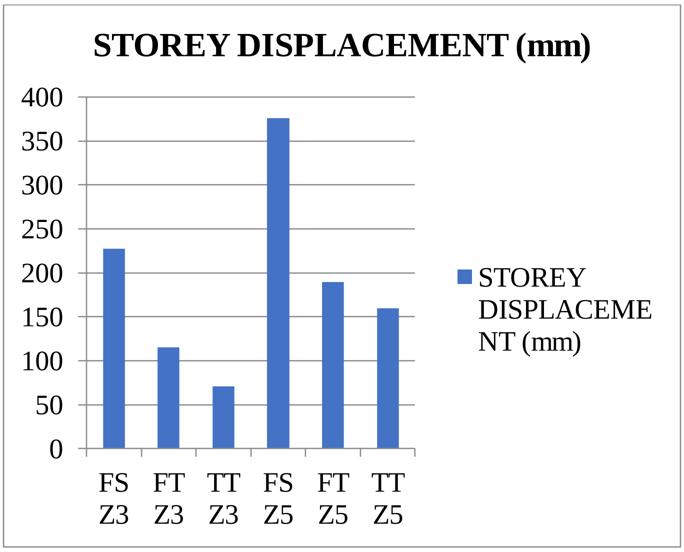


Fig 1: Maximum displacements for FS FT,TT (G+39)

The maximum storey displacements for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the frame structure at zone V model will have more displacements which is 376.165mm along X direction and the minimum displacements are obtained in tube in tube at zone III i.e. is 70.826mm.

Table 5: Maximum displacements for FS FT,TT (G+29)

MODELS	STOREY DISPLACEMENT (mm)	PERCENTAGE(%) CHANGE(COMPARED TO FS Z3)
FS Z3	87.112	0
FT Z3	43.385	50.20% (Decrease)
TT Z3	37.455	57.01%(Decrease)
FS Z5	196.002	55.56 (increase)
FT Z5	97.615	13.84 (increase)
TT Z5	84.274	3.26%(Decrease)

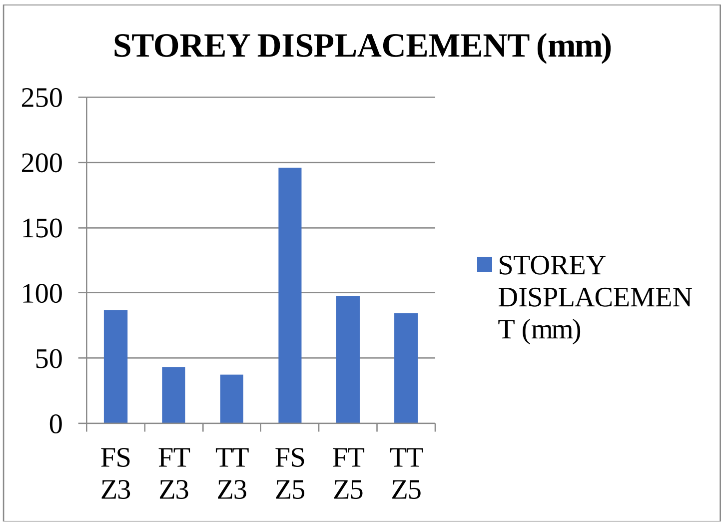


Fig 2: Maximum displacements for FS FT,TT (G+29)

Similarly, the maximum storey displacements for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the frame structure at zone V model will have more displacements which is 196.002mm along X direction and the minimum displacements are obtained in tube in tube at zone III i.e. is 37.455mm.

4.10 Comparison of maximum drifts of Frame structure, frame tube and tube in tube models due to seismic loads in Z0NE III and ZONE V (Response spectrum Method).

Table 6: Maximum drifts for FS FT,TT (G+39)

MODELS	STOREY DRIFT	PERCENTAGE (%) CHANGE (COMPARED TO FS Z3)
FS Z3	0.001747	0
FT Z3	0.000865	49.51%(Decrease)
TT Z3	0.000725	41.49%(Decrease)
FS Z5	0.00393	44.44% (Increase)
FT Z5	0.001946	10.23% (Increase)
TT Z5	0.001632	93.41% (Decrease)

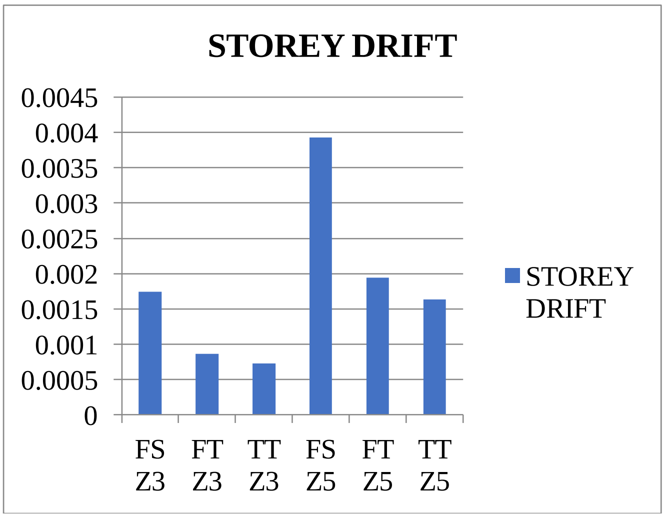


Fig 3: Maximum drifts for FS FT,TT (G+39)

The maximum storey drifts for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the frame structure at zone V model will have more drifts which is 0.00393 along X direction and the minimum drift ts are obtained in tube in tube at zone III i.e. is 0.000725.

Table 7: Maximum drifts for FS FT,TT (G+29)

MODELS	STOREY DRIFT	PERCENTAGE (%) CHANGE (COMPARED TO FS Z3)
FS Z3	0.001232	0
FT Z3	0.000619	50.24%(Decrease)
TT Z3	0.000532	43.18%(Decrease)
FS Z5	0.002785	22.6%(Increase)
FT Z5	0.001392	11.5%(Increase)
TT Z5	0.001176	95.45% (Decrease)

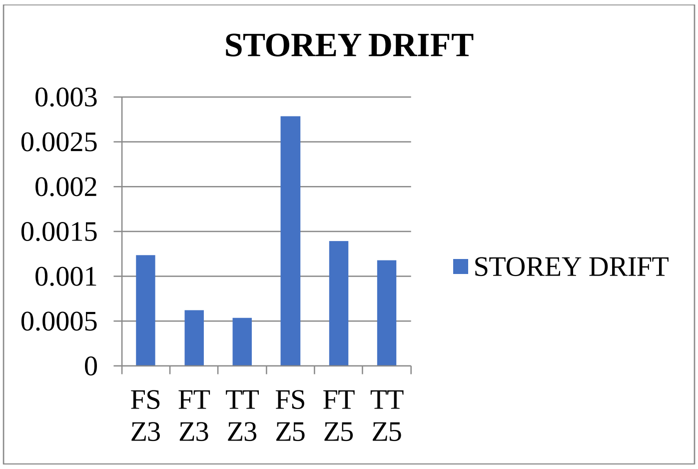


Fig 4: Maximum drifts for FS FT,TT (G+29)

The maximum storey drifts for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the frame structure at zone V model will have more drifts which is 0.002785 along X direction and the minimum drifts are obtained in tube in tube at zone III i.e. is 0.000532.

7.6 Comparison of base shear of Frame structure, frame tube and tube in tube models due to seismic loads in Z0NE III and ZONE V (Response spectrum Method).

Table 8: Base shear for FS FT,TT (G+39)

MODELS	BASE SHEAR (kN)	PERCENTAGE INCREASE COMPARED TO FS Z3
FS Z3	3833.32	0
FT Z3	4479.92	14.44%
TT Z3	4757.04	19.42%
FS Z5	8624.97	55.56%
FT Z5	10015.37	61.73%
TT Z5	10656.74	64.03%

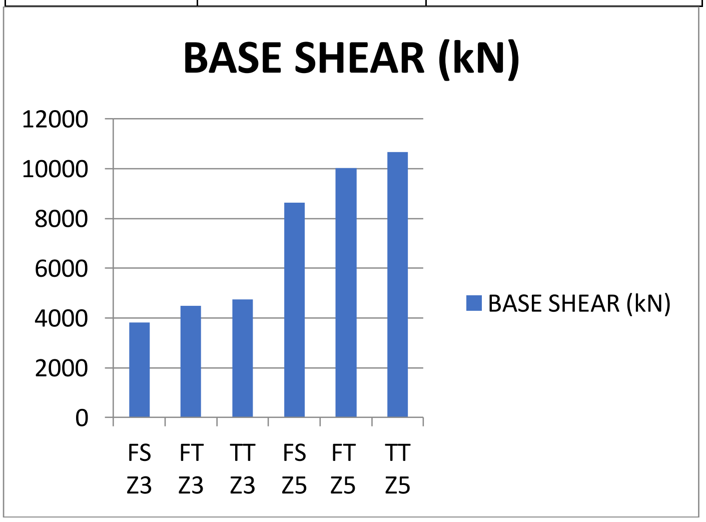


Fig 5: Base shear for FS FT,TT (G+39)

The base shear for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the tube in tube structure at zone V model will have more base shear which is 10656.74 along X direction and the minimum base shear obtained in framed structure i.e 3833.32 at zone III.

Table 9: Base shear for FS FT,TT (G+29)

MODELS	BASE SHEAR (kN)	PERCENTAGE INCREASE COMPARED TO FS Z3
FS Z3	2947.32	0
FT Z3	3543.79	16.84%
TT Z3	3862.62	23.7%
FS Z5	6683.98	55.91%
FT Z5	7918.61	62.78%
TT Z5	8685.86	66.07%

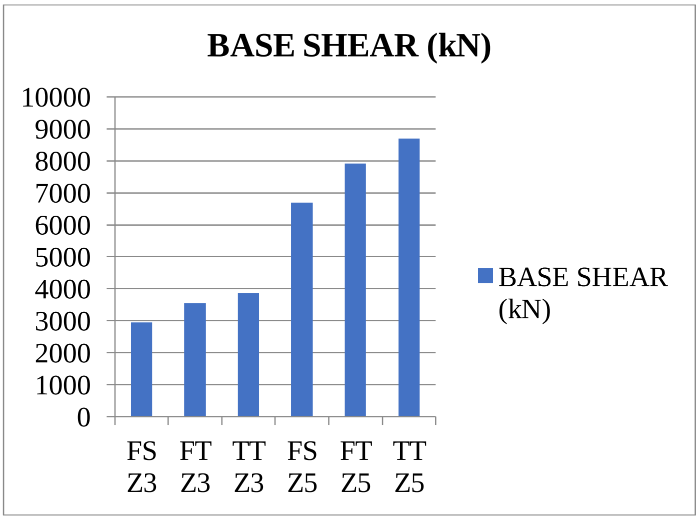


Fig 6: Base shear for FS FT,TT (G+29)

The base shear for seismic analysis from Response spectrum method is tabulated above. According to the results it can be seen that the tube in tube structure at zone V model will have more base shear which is 8685.86 along X direction and the minimum base shear obtained in framed structure i.e 2947.32 at zone III.

IV. CONCLUSION:

1. Framed structure, frame tube and tube in tube structures were compared by using parameters such as storey displacement, storey drift and base shear.
2. The results showed that the displacement values due to seismic loads for Framed structure zone V values are maximum i.e. 39.46% increases when compared to frame structure zone III at (G+39) .
3. Similarly, the results showed that the displacement values due to seismic loads for Framed structure zone V values are maximum i.e. 56.56% increases when compared to framed structure zone III at (G+29).
4. The results showed that the drift values due to seismic loads for Framed structure zone V values are maximum i.e. 44.44% increases when compared to framed structure zone III at (G+39).
5. Similarly, the results showed that the drift values due to seismic loads for Framed structure zone V values are maximum i.e. 22.6% increases when compared to framed structure zone III at (G+29).
6. The results showed that the base shear values due to seismic loads f tube in tube zone V values are maximum 64.03% more when compared to framed structure zone III (G+39).
7. Similarly, the results showed that the base shear values due to seismic loads for Tube in tube zone V values are maximum i.e. 66.07% when compared to framed structure zone III (G+29).
8. This study concludes that storey displacement, storey drift and base shear values are more in zone V as compared to zone III at (G+39) and (G+29).
9. This study also concludes that framed structure is having more displacement and drift compared to frame tube and tube in tube and tube in tube structure is having more base shear compared to framed structure and frame tube.

REFERENCES:

[1]. Suraj R Wadagule, Vishwanath R Charantimath "Comparative Study of Tube in Tube Structure and Frame Tube Structure" International Research Journal of Engineering and Technology (IRJET) (E-USSN: 2395-0056), 07th July 2019.

[2]. Archana J, Reshmi P R "Comparative Study on Tube in Tube Structures and Tube Mega Frames " International Journal of Innovative Research in Science, Engineering and Technology (ISSN: 2319-8753) 8th Aug 2016.

[3]. Nimmy Dileep et.al "Performance study of the tube in tube structure with different position of the inner tubes" International Journal of Management, Technology and Engineering (ISSN: 2249-7455) Feb 2019.

[4]. Shilpa Balakrishnan, Rona Maria James "Comparative Study on Tube In Tube And Tube Mega Frames On Different Building Geometry Using ETABS" International Journal of Applied Engineering (ISSN 0973-4562) 14th Nov 2019.

[5]. Mohammad Tabrez Shadulla "Analysis of Tube In Tube Structures with Different Size of Inner" International Journal of Engineering Research and Technology (IJERT) (ISSN: 2278-0181) 30th Jul 2018.

[6]. Mohan KT et.al., "Analysis of Different forms of Tube in Tube Structures Subjected to Lateral" International Journal of Science, Engineering and Technology (IJSETR) June 2016.

[7]. M. R. Jahanshahi et.al., "Analytical investigation on the performance of Tube in Tube Structures" International Journal of Applied Engineering (ISSN 0973-4562) 14th Nov 2019.

[8]. Basavanagouda A patil et.al., "Dynamic Analysis of Tall Tubular Steel Structure for Different Geometric Configuration" International Research Journal of Engineering and Technology (IRJET) (E-USSN: 2385-0096), 17th Aug 2018.

[9]. B Kusuma et.al., "Seismic analysis & design of high rise RC framed structures with irregularities " International Research Journal of Engineering and Technology (IRJET) (E-USSN: 2395-0056), 07th Jul 2019.

[10]. Thowdoju Deepthi, SB Shankar Rao "Study of Irregular RC building under Seismic Effect" International Journal of Structural and Civil Engineering Research. (ISSN 2319-6009) vol 3, May 2014.