Study of Seismic Behavior of Plan Irregular Building with different Tubular Systems

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Abstract- In this research, by keeping the same floor plan and number of stories models of conventional RCC building, Frame tube, Bundle tube and RCC tube in tube system are made and behavior of structure subjected to static as well as dynamic loading is analyzed. Considering, G+30 story, models of Conventional L-shaped building (CL), Frame tube L-Shaped building (FT), Bundle tube L-shape building (BT) & Tube in Tube L-shaped building (TT) models are made and analyzed using ETAB 2020 software. The parameters like story displacement, story drift, story shear is considered and the results of CL, FT, BT and T&T buildings are compared. From, the results it is seen that by using different tubular structure we can effectively reduce the effect of lateral loads on a plan irregular structure.

Index Terms: Conventional L building (CL), Frame tube structure (FT), Bundle tube structure (BT), Tube in Tube structure (TT).

I. INTRODUCTION

In the recent days, major cities are experiencing the shortage of land due to growing population which leads to an increase in the construction of tall buildings and in the other hand in view of economic power there is competitiveness in mankind to have the tallest building which makes the way of opportunities in the building profession. As these tall buildings are critical to resist lateral loads, structural engineer has been challenged to meet drift requirement and to minimize the effect. Due to limited area and the increasing expansion of urbanization it is feasible to expand in vertical direction than in horizontal direction. And due to increasing vertical urbanization it is important to adopt to more stable structure.

Here, tubular structure is come into a picture, in which columns are placed closely at the periphery of the structure. Also, here different types of tubular structure can be used. Compared to conventional structure the Tubular structure is more stable when subjected to lateral load as well as gravity loads. Using an appropriate tubular structural system, a good seismic performance of buildings can be achieved.

While special moment resisting frame is the most commonly used as lateral load resisting structural system, other structural systems also are commonly used like structural walls, frame-wall system, and braced frame system. Sometimes, even more redundant structural systems are necessary, e.g., Frame tube, Bundled Tube & Tube in Tube systems are required in many structures to improve performance of a structure when subjected to earthquake loading.

Use of this structural system depends on the plan as well as vertical symmetricity or irregularity of building, size of structure, loading on the structure and other design requirements of the building. Previously, traditional methods were available for constructing high-rise buildings, which restrict the stories of the building as it’s difficult to minimize the effect of lateral loads on a structure. These low-rise structures generally designed for gravity loads, and then checked resistance to lateral loading. However, tall building which is design for gravity loading can’t resist lateral forces effectively. Therefore, use of special type of structural system which can resist gravity as well as lateral load is required.

II LITERATURE REVIEW

Hideo [1] Approximate solution proposed in his paper is simple and fast, also results are validated by comparing them with fem code Nastran. Peter C [2] he proposed efficient method for determining the global deflection behavior of a tube-in-tube structure.

Mohammad Sarcheshmehpour [3] Research conclude that by increasing the building height, the internal tube mainly functions as a resisting element for the gravitational rather than lateral loads. Kang-Kun Lee [4] The research primarily focuses on modification of Reisner's function. Primary objective of this paper is to verify simplicity, accuracy and overall stability of this proposed method. Barbara [5] Proposed a review on seismic behavior of irregular building. Since 2002, it shows research on irregular building is still very lively topic and lots of research is yet to be done on this. H. Haji-Kazemi [6] Advance and easy to use computer-based program is prepared and main advantage of this method is its accuracy. Shear lag effect of frame tube structure is analyze in this method. Rony Kar. et al [7] Octagonal tall building is analyze using ANSYS software. Key focus of this research is to identify wind interference effect on three tall buildings situated nearby. Vijaya Bhaskar Reddy S. et al [8] For sorter building shear wall prove to be more effective an economical as compare to frame tube system but incase of high rise it's almost opposite. The objectives of the research are:

- To study the seismic analysis of G+29 storey plan irregular building using various Tubular system by using Response Spectrum Method.
- To compare the Storey shear, Storey Drift and Displacement of Conventional R.C Frame, Frame tube, Bundle tube and Tube & Tube structures using ETABS Software.
- To find out most vulnerable structure among CL, FT, BT & Tube in Tube.

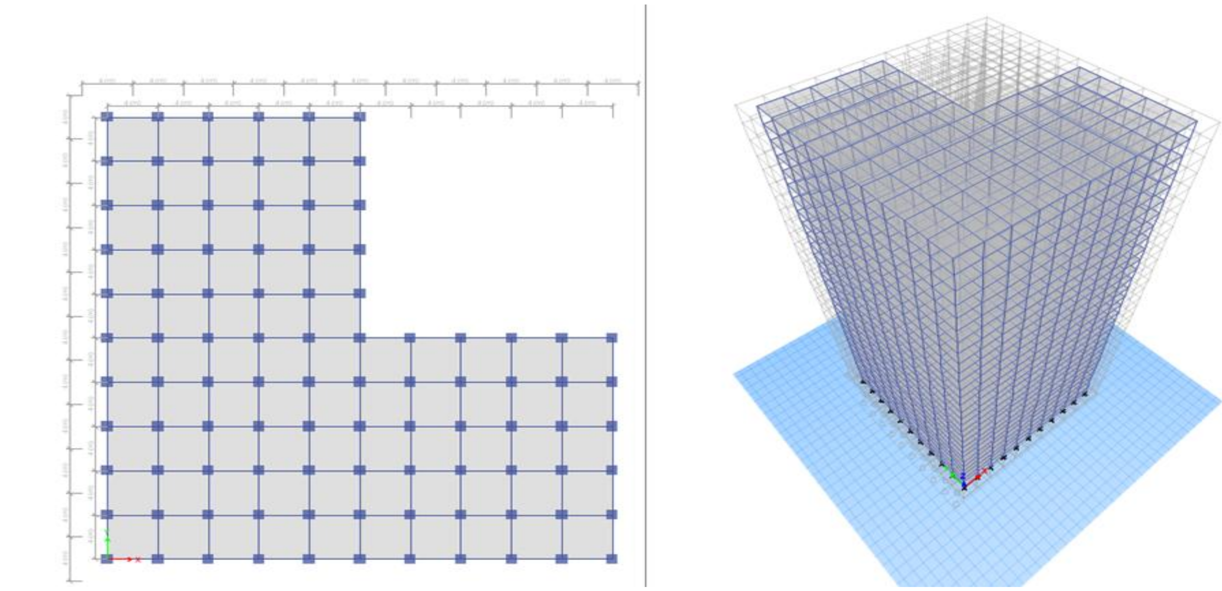
III. SYSTEM DEVELOPMENT

In present work, a detailed comparative analysis is performed on a plan irregular RC structure using the Etabs software. The focus of the analysis was to assess the structural behavior of the RC frame under the influence of various tubular systems. The study specifically investigated a G+30 RCC frame with four unique models: a typical conventional RCC building, a Frame tube system, a Bundle tube system, and an RCC tube in tube system. These models are carefully chosen to represent different design approaches and their respective responses to seismic forces. For seismic analysis of structure, response spectrum method is used which is linear dynamic methods. Also by keeping the same floor plan (40X40m) of L shapeand number of stories (G+29) models of conventional RCC building, Frame tube, Bundle tube and RCC tube in tube system are made to study seismic behavior of structure subjected to seismic loading. The conventional L (CL) building model is used in this work as a base model to compare various parameters such as, story displacement, story drift, story shear, and so on for Frame tube structure (FT), Bundle tube structure (BT) & Tube in tube structure (TT).

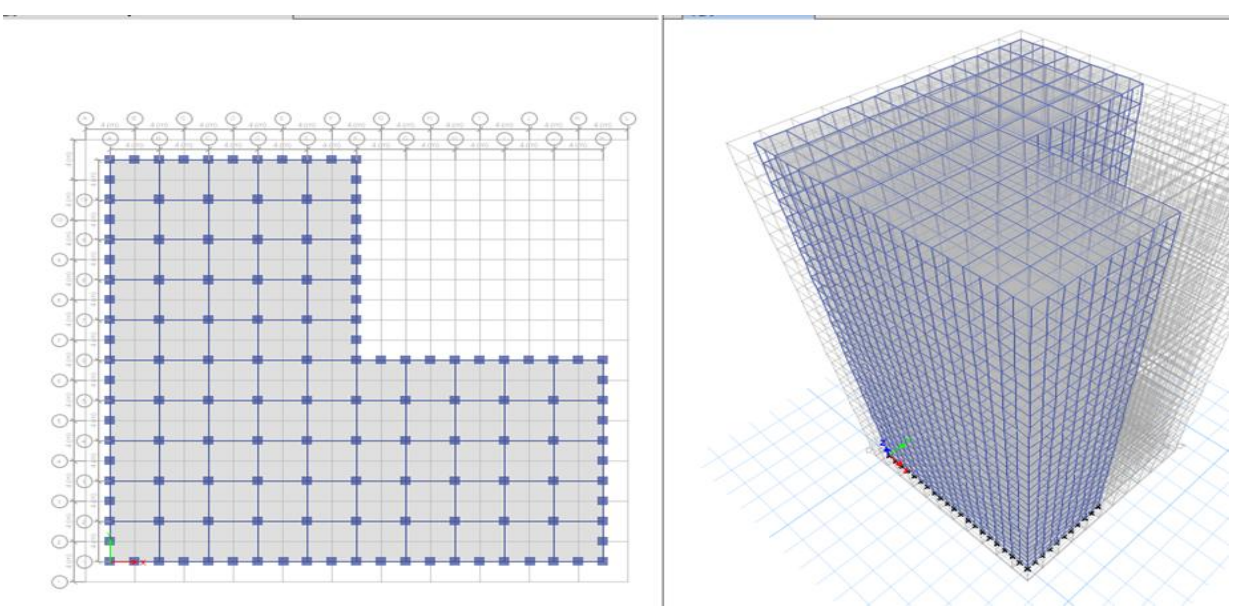
LIST OF MODELS	DESCRIPTION
Model 1 (M1)	Conventional L (CL)- It is a simple RCC structure in which external peripheral columns & internal columns are placed at 4m distance, this model is considered as base model for comparing different parameters due to seismic effect.
Model 2 (M2)	Frame tube structure (FT)- In this model internal columns are placed same as in conventional L model that is 4m & outer peripheral columns are placed closely at 2m distance to resist the lateral load effect on the structure. Due placement of outer columns closely size of outer peripheral column is reduced from 900x900 mm to 500x500 mm.
Model 3 (M3)	Bundle tube structure (BT)- This model is considered in the form of three-square plan bundle in same L shape plan and each bundle outer columns are placed columns are placed closely and inner column in bundle is paced at same 4m distance additional to other structure shear wall of 250mm is placed at center core of structure.
Model 4 (M4)	Tube in tube structure (TT)-Tube in Tube structure is same as Bundle tube structure but only difference is that columns are placed closely in outer as well as internal periphery of the model.

Type of structure	Conventional L (CL)	Frame tube (FT)	Bundle tube (BT)	Tube in tube (TT)
Moment resisting frame	OMRF	OMRF	SMRF	SMRF
No. Of story	30	30	30	30
Height of each story	3m	3m	3m	3m
Height of base story	1.5m	1.5m	1.5m	1.5m
Thickness of slab	125mm	125mm	125mm	125mm
Concrete grade	M40	M40	M40	M40

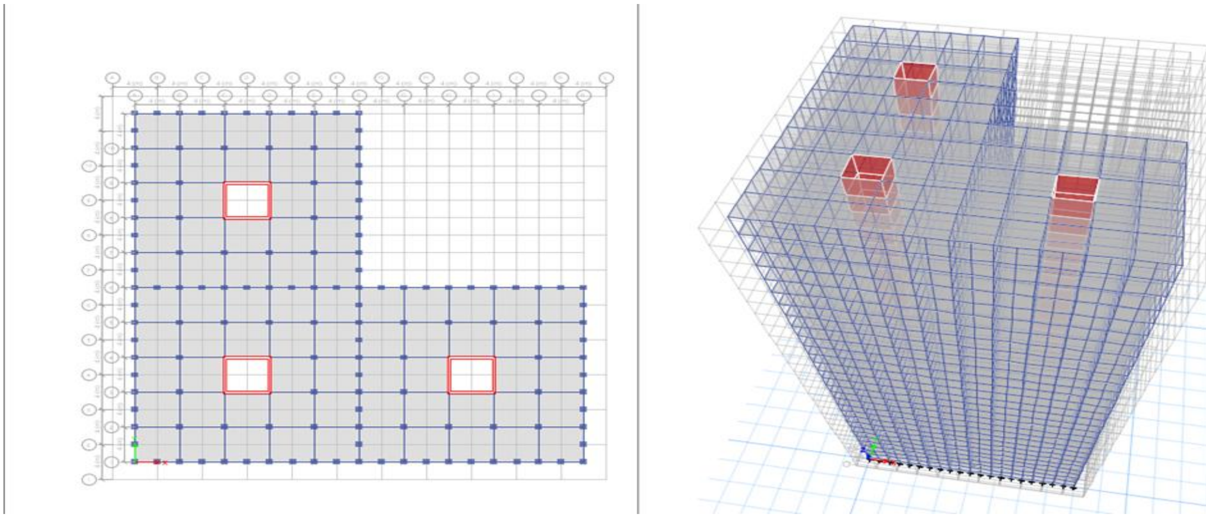
Steel grade	Fe500	Fe500	Fe500	Fe500
Size of beam	300X450mm	Internal-230x400mm External-300x400mm	Internal-230x400mm External-300x400mm	Internal-230x400mm External-300x400mm
Size of column	900X900mm	Up to 15 Story- 600x600mm Above 15 Story- 500x500mm	Up to 15 Story- 600x600mm Above 15 Story- 500x500mm	Up to 15 Story- 600x600mm Above 15 Story- 500x500mm
Thickness of shear wall	NA	NA	250mm	250mm
Seismic analysis	Response spectrum	Response spectrum	Response spectrum	Response spectrum
Seismic zone	V	V	V	V
Importance factor	1.2	1.2	1.2	1.2
Response reduction factor	3	3	5	5
Type of soil	Medium	Medium	Medium	Medium



M1: Conventional L-Shape building
Fig. 1: Plan & 3D Model of L shaped Conventional building

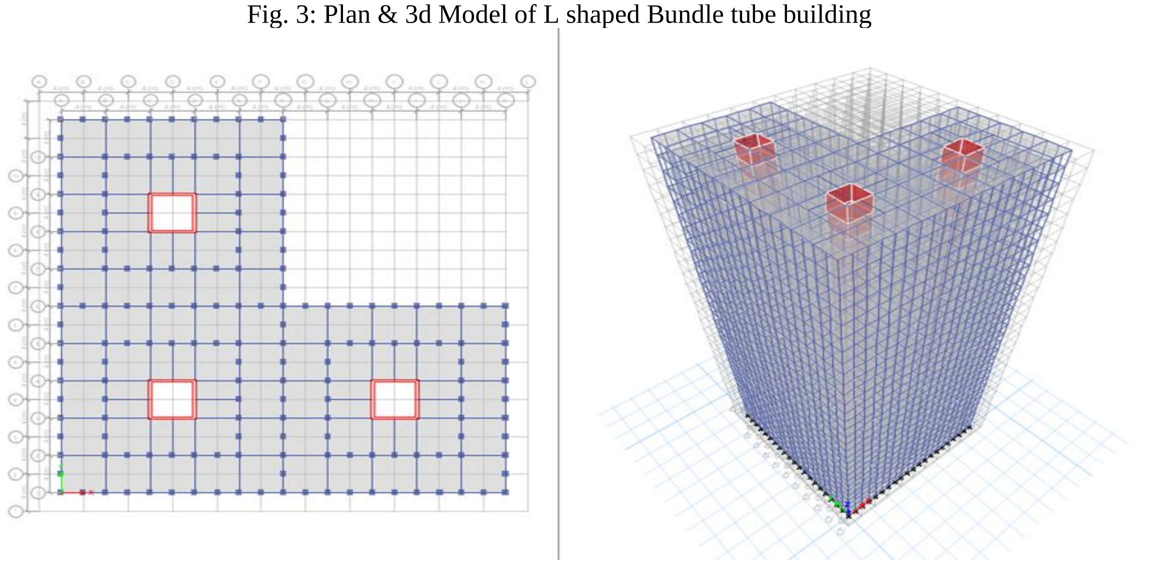


M2: Frame tube L-Shape building
Fig. 2: Plan & 3D Model of L shaped Frame Tube building



M3: Bundle tube building

Fig. 3: Plan & 3d Model of L shaped Bundle tube building



M4: Tube in tube structure

Fig. 4: Plan & 3d Model of L shaped Tube in tube building

IV. RESULT AND DISCUSSION

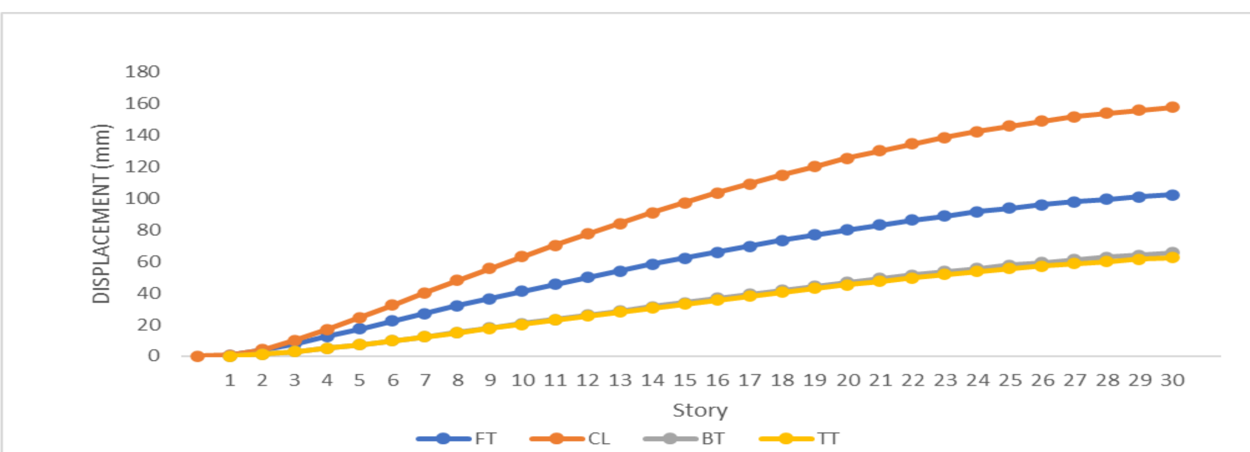


Fig.5: Displacement in X direction for CL, FT, BT and T&T

Figure.5 shows, Displacement of structure in X direction for each story of CL, FT, BT, TT model. Maximum Displacement in X direction for CL, FT, BT and T&T is, 157.60, 102.11, 65.42 & 62.59 mm respectively. According to IS Code 1893-2016 maximum allowed displacement is H/500 which is 180mm so in our case all building models are safe in displacement criteria in X-direction. This reduction in displacement is due to increase in stiffness.

FT, BT and T&T have 35.20%, 58.48% and 60.28% decrease in story displacement respectively, in X direction as compare to Conventional L shape structure

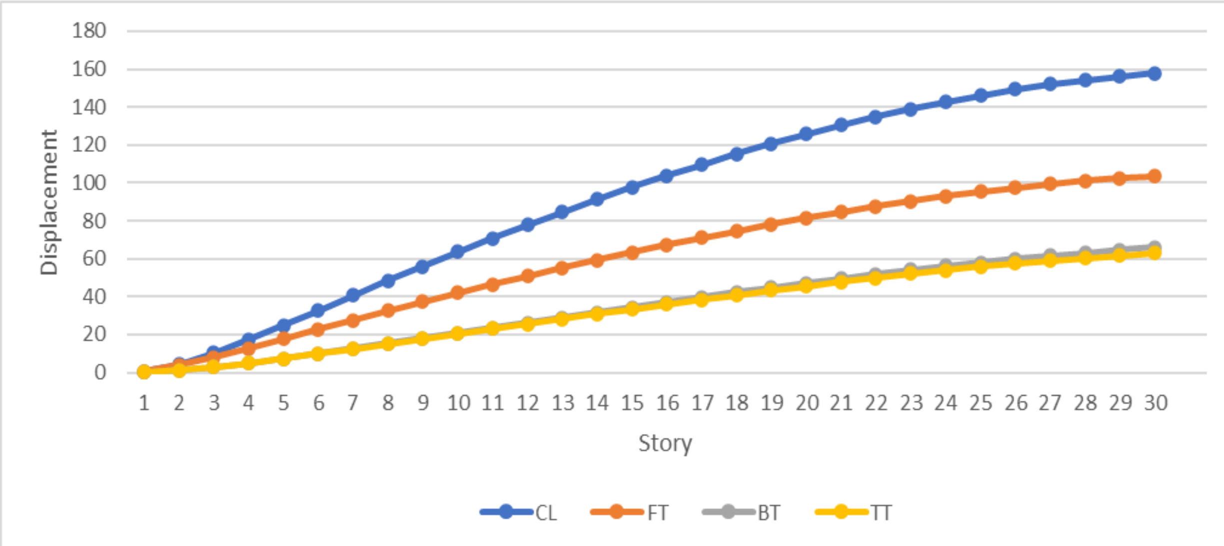


Fig.6: Displacement in Y direction for FT, CL, BT and T&T

Figure 6. shows, Displacement of structure in Y direction for each story of CL, FT, BT, TT model. Maximum Displacement in Y direction for CL, FT, BT and T&T is 157.80, 103.11, 65.82, 62.59 mm respectively. According to IS Code 1893-2016 maximum allowed displacement is H/500 which is 180mm in our case all building models are safe in displacement criteria in Y-direction. FT, T&T and BT have 34.65%, 58.28% and 60.33% decrease in story displacement respectively, in Y direction as compare to Conventional L shape structure.

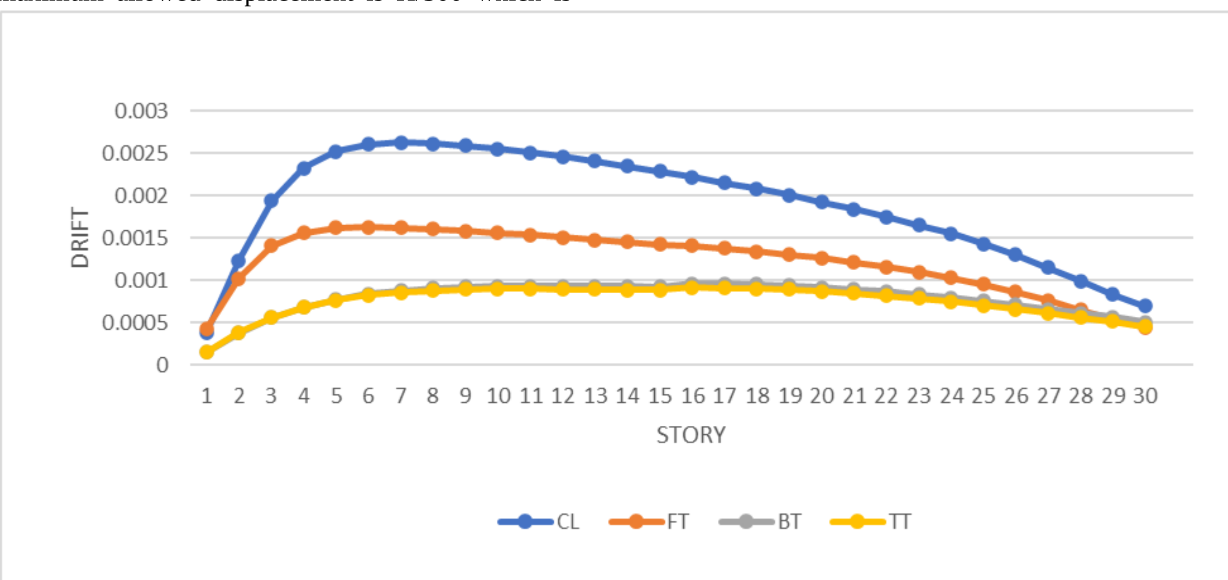


Fig.7: Story drift in X direction for FT, CL, BT and T&T.

Figure 7 shows, Story drift of structure in X direction for each story of CL, FT, BT, TT model. Maximum Story drift in X direction for CL, FT, BT and T&T is 0.0026, 0.0016, 0.00094, 0.00090 respectively. According to IS Code 1893-2016 maximum allowed story drift is 0.004 times story height which is 0.012 so in our case all building models are safe in story drift criteria in X-direction.

FT, BT and T&T have 38.46%, 63.83% and 65.38% decrease in story drift respectively, in X direction as compare to Conventional L shape structure.

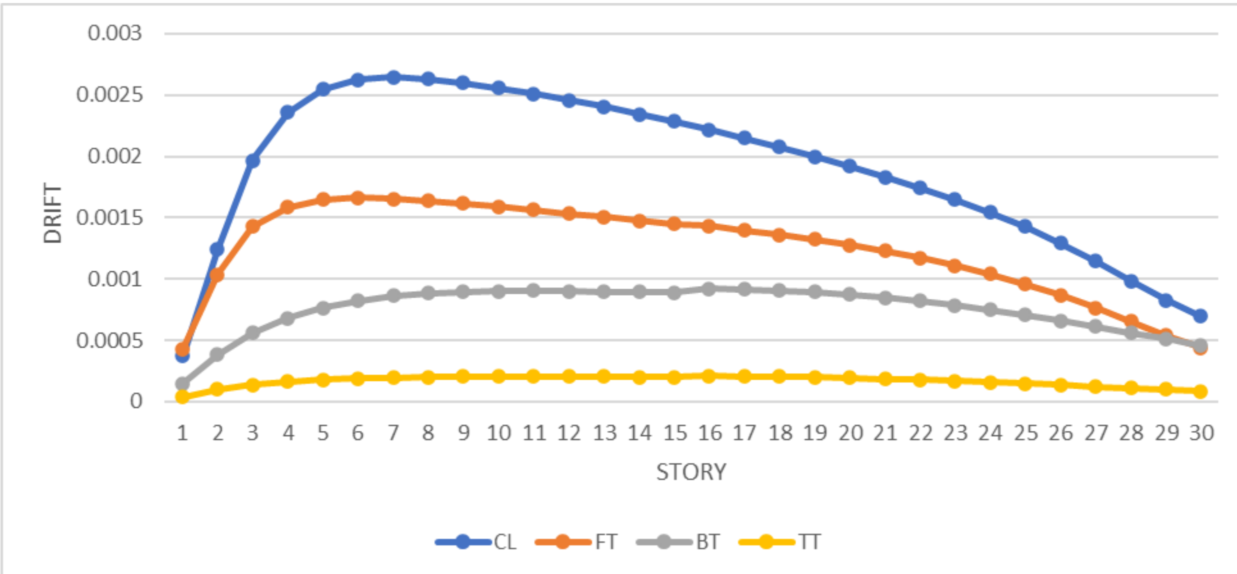


Fig.8: Story drift in Y direction for FT, CL, BT and T&T

Figure 8 shows, Story drift of structure in Y direction for each story of CL, FT, BT, TT model. Maximum Story drift in Y direction for CL, FT, BT and T&T is 0.0026, 0.0016, 0.0009, 0.0002 respectively. According to IS Code 1893-2016 maximum allowed story drift is 0.004 times story height which is 0.012 so in our case all building models are safe in story drift criteria in Y-direction.

FT, BT and T&T have 38.46%, 65.38% and 92.30% decrease in story drift respectively in Y direction as compare to Conventional L shape structure

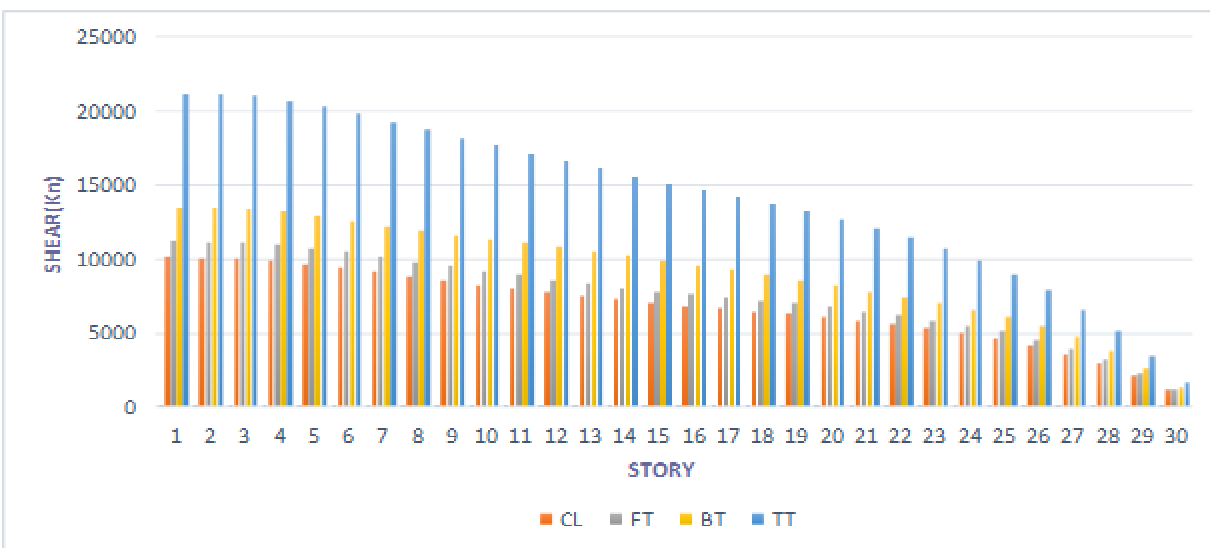


Fig.9: Story shear in X direction for FT, CL, BT and T&T

Figure 9 shows, story shear of structure in X direction for each story of CL, FT, BT & TT model. Maximum story shear in X direction is 10082.8, 11171.95, 13525, 21165KN. The reduction in story shear in FT model is due to provision closely spaced column in outerperiphery and for BT & TT is due to combine effect of closely spaced column and provision of shear wall.

FT, BT and T&T have 36.09%, 47.21% and 52.34% decrease in story shear respectively, in X direction as compare to Conventional L shape structure.

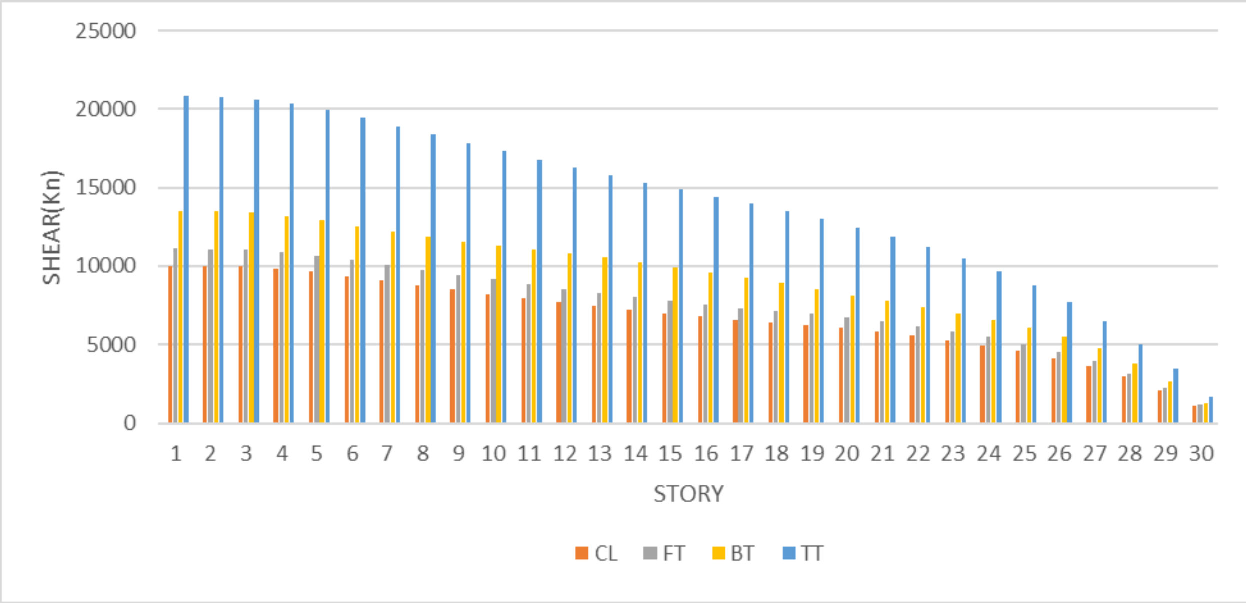


Fig.10: Story shear in Y direction for FT, CL, BT and T&T

Figure 10 shows, story shear of structure in Y direction for each story of CL, FT, BT & TT model. Maximum story shear in X direction is 10032.8, 11101.9, 13493, 20806 KN. The reduction in story shear in FT model is due to provision closely spaced column in outer periphery and for BT & TT is due to combine effect of closely spaced column and provision of shear wall.

FT, BT and T&T have 35.14%, 46.64% and 51.77% decrease in story shear respectively, in Y direction as compare to Conventional L shape structure.

V. CONCLUSION

1. It is observed that story displacement in X direction significantly reduce in Tube in Tube structure as compare to Conventional L, this reduction in displacement actively contributes to the overall structural stability and helps to resistance the overturning moments formed due to eccentricity of seismic forces.
2. A noteworthy observation is the reduction in story displacement along the Y-axis. Specifically, the displacement decreases substantially in Tube in Tube structure as compare to Conventional L due to increase stiffness of structure.
3. The substantial reduction in story drift in X direction of Tube in Tube structure ultimately shows improvement in the structure resilience and helps to maintain the structural integrity.
4. Story drift along Y direction is significantly decrease for Tube in Tube structure as compare to Bundle Tube structure due to the increase in overall stiffness of structure.
5. Importantly, story shear in X direction and Y direction of Tube in Tube structure is more, as compared to conventional L shape structure. While Tube in Tube structure is more effective and helps in reducing effects of lateral forces acting on structure.
6. Taken together the above observation study indicates that the optimal performance of a structure can be increased by using appropriate tubular system against lateral forces, Tube in Tube structural system is consider as a more

effective method in reducing lateral effect on structure due to seismic activity and bundle tube is considered as a modest between tube in tube and conventional structure.

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