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Comparative Analysis of Behaviour of RCC Pentagonal and Hexagonal Tube in Tube Structural System and the Conventional RCC Pentagonal and Hexagonal Structure Subjected to Lateral Loads in Different Seismic Zones

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Abstract - Earthquake-resistant design of structures has grown into a truly multi-disciplinary field of engineering wherein many innovative developments and trends are coming up. The nature of the structural system of high raised buildings is a critical influencing factor of the earthquake resisting capability of the structure. The tube in tube structural system is becoming increasingly popular among tall buildings as an effective structural system in resisting lateral loads such as wind and seismic loads. A tube in tube structure consists of an exterior framed tube with a central core tube which is connected by floor slabs, also known as hull and core respectively. An RCC pentagonal and hexagonal tube in tube structure and the conventional RCC pentagonal and hexagonal structure is subjected to rigorous seismic analysis and is compared to infer the relative resistance to seismic loads. The analysis is performed systematically in STAAD.Pro. This analysis is carried out for different seismic zones (Zone II to Zone V). The results from the analysis ascertain the behavior of tube in tube and conventional structure when subjected to earthquakes. From this study, we also establish the most vulnerable tube in tube structure against their conventional complements.

Index Terms - Tube in tube structures, RCC Structures, seismic analysis, Pentagonal, hexagonal, comparative analysis, seismic zones

1 Introduction

The rapid increase in population and alarmingly decreasing habitable l
and poses a serious global threat. Hence the idea of vertical city concept is the latest trend i.e. the human habitat contained in skyscrapers. As this ideology is realized, there comes new challenges as high raised buildings need to be more stable. The two most serious forces that disrupt the stability of high raised buildings are wind and seismic forces. In this study, we will focus on the seismic forces affecting the high raised buildings. There is no structure which is entirely resistant to damage from earthquakes, however the prime aim of earthquake-resistant structures is to perform better when subjected to seismic activity as compared to their conventional counterparts. This paper deals with determining the relative resistance of a tube in tube RCC pentagonal and hexagonal structure and its conventional RCC counterparts when subjected to seismic activity.

This study is based on the principle that, as the stiffness of the structure increases, the resistance of the structure increases proportionately. In tube structures, the exterior hull consists of closely spaced columns that are held together by beams called as spandrel beams through moment connections. This assembly of columns and beams increases the rigidity of the frame.

2 Structural Modelling & Analysis

A 20 Storey pentagonal and hexagonal tube-in-tube structure is analyzed and compared with its conventional counterparts.
Table 1 shows the different modelling and loading parameters which have been used for the analysis. The analysis is carried out in STAAD.PRO and the loading conditions are taken according to IS codebooks (IS 875 part I and Part II for dead load and live loads and IS:1893 for seismic loading conditions).

2.1 Modelling

Model 1 – Pentagonal tube-in-tube

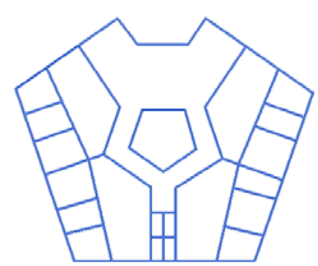

Fig.1 – Plan view of pentagonal tube in tube structure

Plan configuration	Pentagonal and hexagonal
No. of stories	G+19 (20 storey)
Height of each floor	4 m
Total height of building	80 m
Building type	Residential
Grade of structural steel	415 grade
Grade of concrete	M20
Column size	500 mm x 500 mm
Beam size	300 mm x 600 mm
Slabs	215 mm thick
Load due to floor finish	1 kN/m2
Load on typical floor	2 kN/m2
Load on roof	1.5 kN/m2
Soil type	Medium
Importance factor	1
Response reduction factor	5

Table 1: Parameters for analysis

Model 2 – Hexagonal tube in tube structure

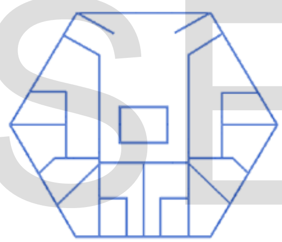

Fig.2 – Plan view of Hexagonal tube in tube structure

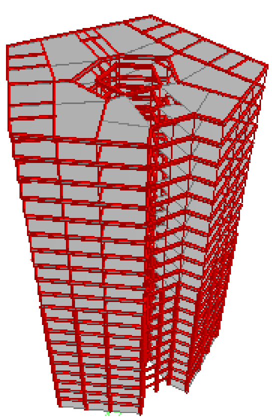

Fig.3 – 3D view of pentagonal tube in tube structure

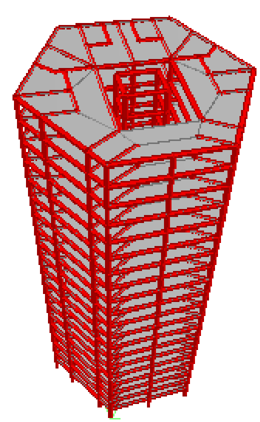

Fig.4 – 3D view of Hexagonal tube in tube structure

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LYSIS RESULT AND DISCUSSION

Structural modeling of the framed tube-in-tube structure and the RCC structure is done using STAAD.PRO for 2 geometrical configurations. The pentagonal shape and the hexagonal shape tube in tube structure is compared with pentagonal and hexagonal shape conventional RCC structural system. All buildings in the configuration has 20 number of stories. To obtain consistent results, the floor height is kept constant for all buildings viz. 4 m. A central core is permitted for lighting, ventilation and service criteria for all buildings. The results obtained from the rigorous analysis has been tabulated and arranged graphically for the parameters considered viz. displacement, drift, time period and base shear.

3.1 DISPLACEMENT

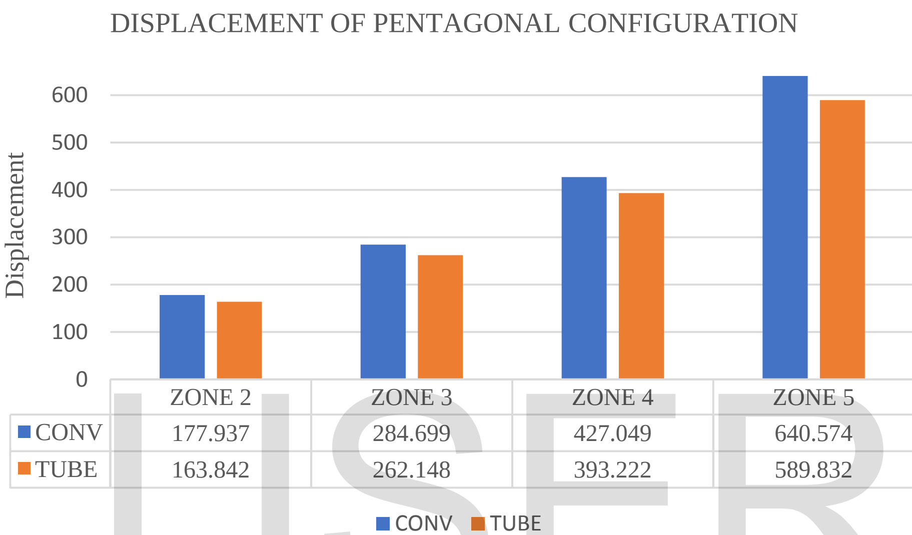


Fig.5 – Variation of displacement in pentagonal configuration in different seismic zones

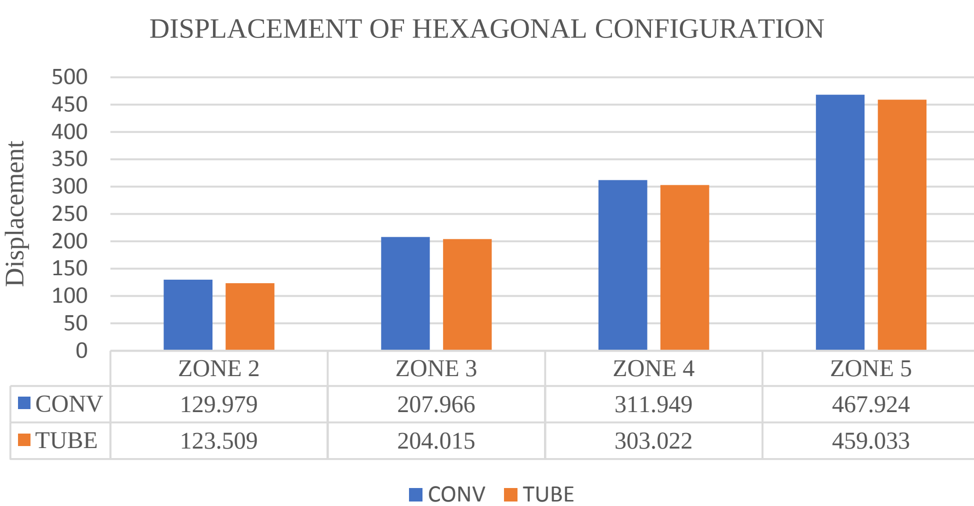
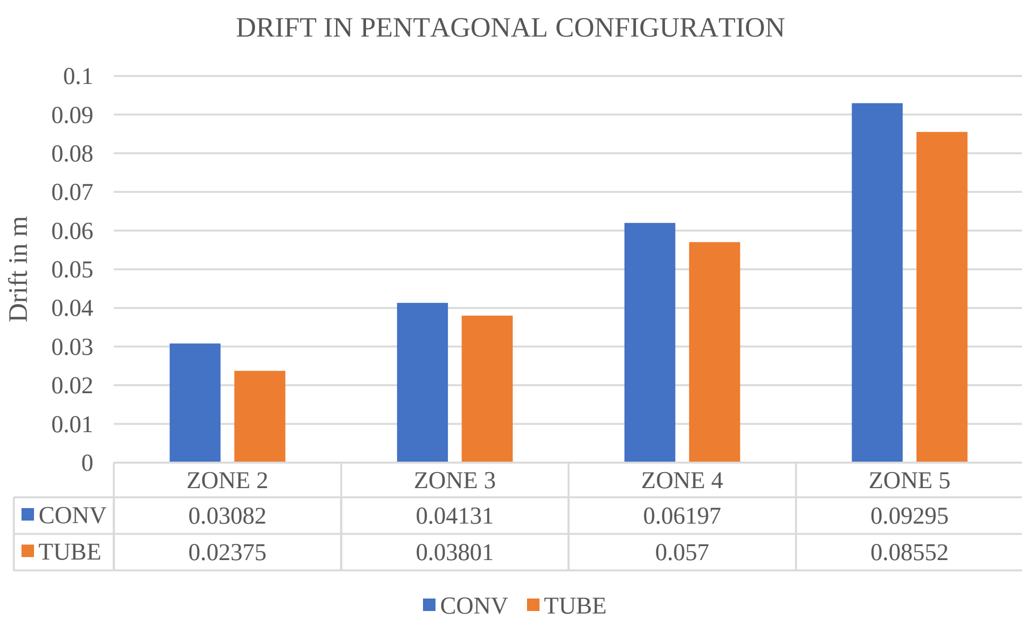


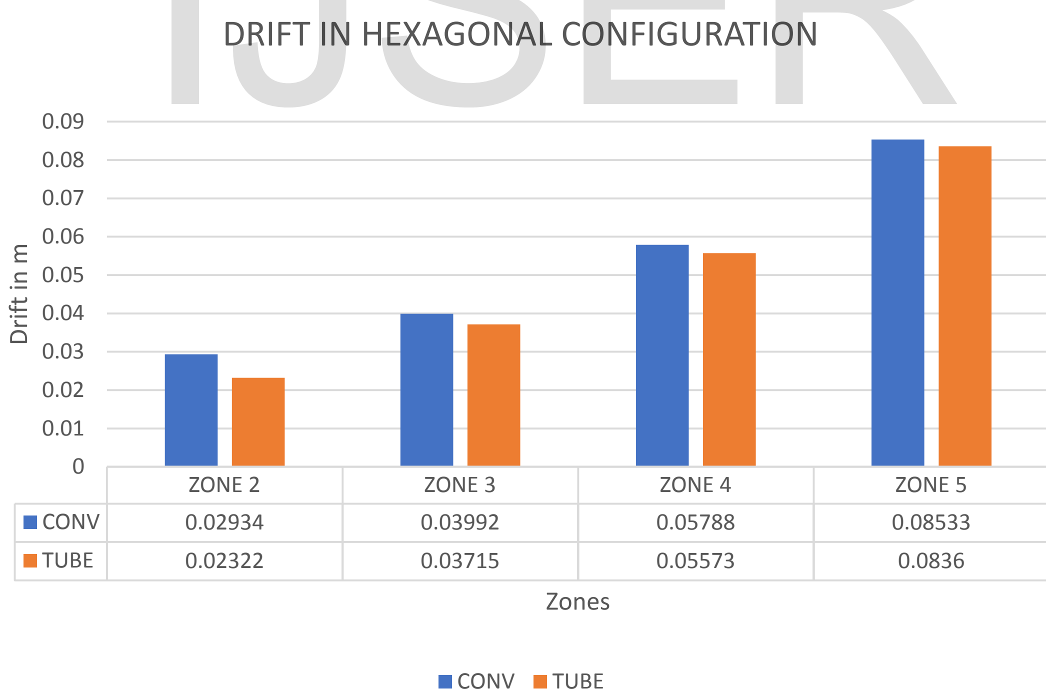
Fig.6 – Variation of displacement in hexagonal configuration in different seismic zones

3.2 DRIFT



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
CONV	0.03082	0.04131	0.06197	0.09295
TUBE	0.02375	0.03801	0.057	0.08552

Fig.7 – Variation of drift in pentagonal configuration in different seismic zones



	ZONE 2	ZONE 3	ZONE 4	ZONE 5
CONV	0.02934	0.03992	0.05788	0.08533
TUBE	0.02322	0.03715	0.05573	0.0836

Fig.8 – Variation of drift in hexagonal configuration in different seismic zones

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3.3 Time Period

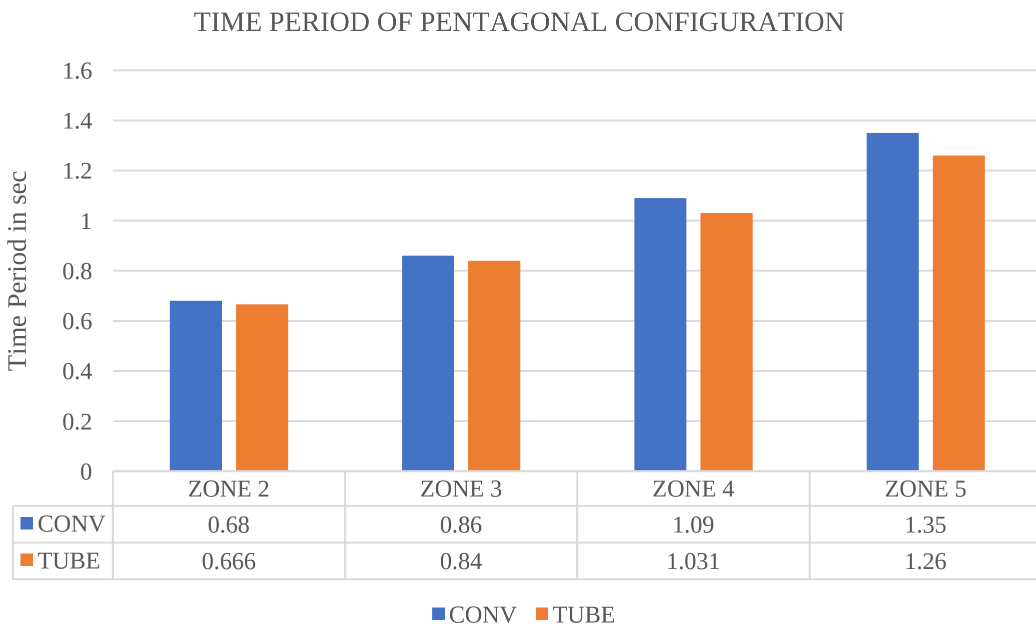

Fig.9 – Time period of pentagonal configuration in different seismic zones

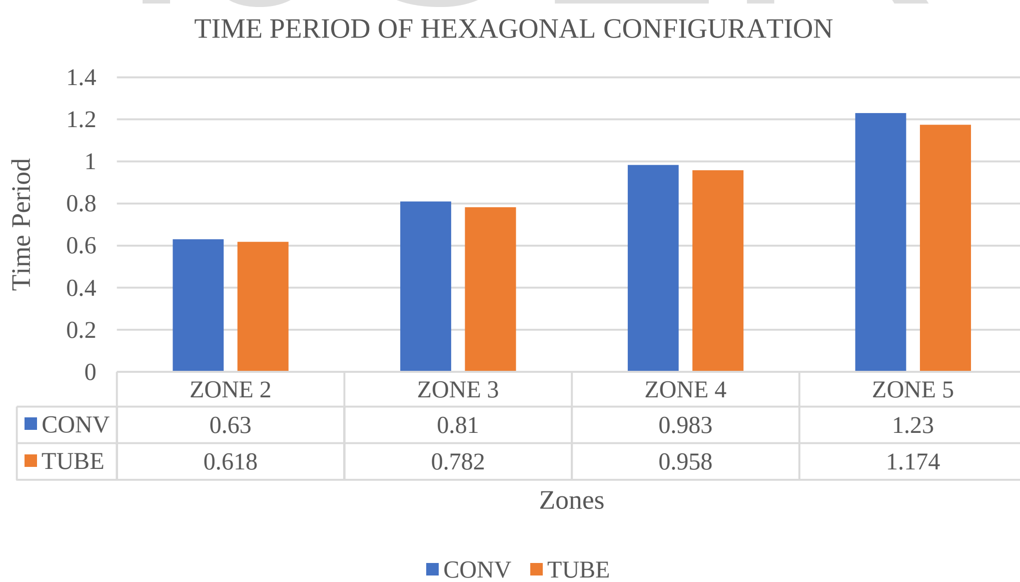

Fig.10 – Time period of hexagonal configuration in different seismic zones

3.4 Base Shear

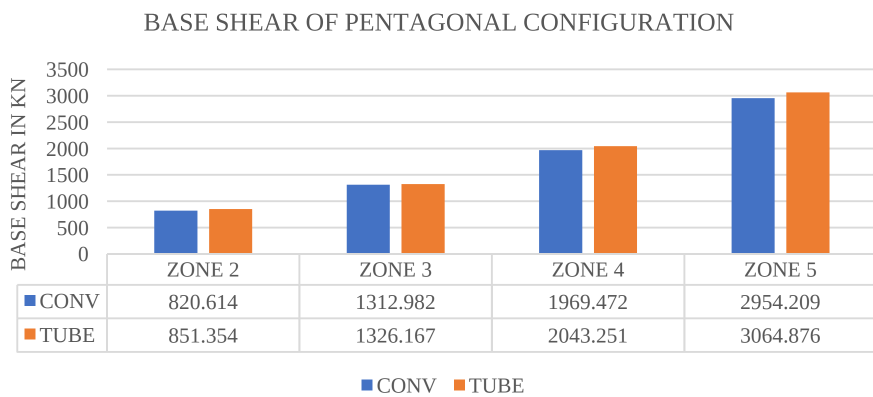

Fig.11 – Base shear of Pentagonal configuration in different seismic zones

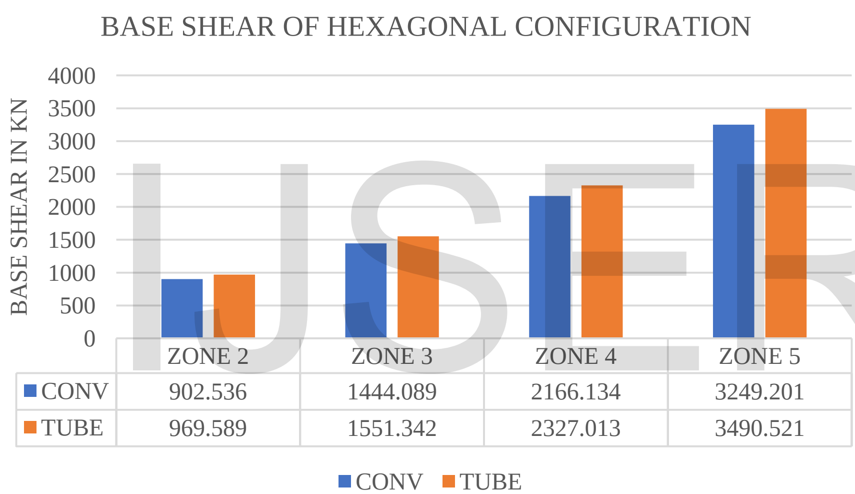

Fig.12 – Base shear of hexagonal configuration in different seismic zones

4 Conclusion

From the above study, we can conclude that the tube-in-tube structural system will get maximum reduction in displacement, drift and natural frequency when compared to conventional structural system.

Compared to conventional structural system, tube-in-tube will fare better for lateral loads and the tube – in – tube pentagonal geometry is the most vulnerable towards lateral loads. Hexagonal tube-in-tube structural system reduces the displacement by 24.6% when compared with pentagonal tube in tube structural system.

Hexagonal tube-in-tube structural system reduces the drift by 22.3% when compared with pentagonal tube in tube structural system.

From the results of base shear, we got higher value in hexagonal tube-in-tube structure, hence it is good for seismic design. It was found that as the number of faces (sides) of a structure increases base shear increases. So hexagonal tube – in - tube framed structure performs better in seismic zones.

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