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Comparative Seismic Analysis of Conventional and RCC Tube in Tube Structure with Pentagonal and Hexagonal Geometry Subjected To Lateral Loads in Different Zones

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Abstract: Earthquake-resistant design of structures is an innovative developments and trends which are coming up. High raised buildings are less resistant to seismic forces. The tube in tube structural system consists of an exterior framed tube with a central core tube which is connected by floor slabs, also known as hull and core overcomes this difficulty in an effective manner. An RCC pentagonal and hexagonal tube in tube structure is compared with conventional 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 behaviour 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; seismic analysis; Pentagonal; hexagonal; multi-storey building

I. INTRODUCTION

The rapid increase in population and alarmingly decreasing habitable land poses a serious global threat. Hence the idea of vertical city concept is the latest trend i.e. the human habitat contained in skyscrapers[1]. As this ideology is realized, there comes a new challenge as high raised buildings need to be more stable[2]. 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[3]. 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.

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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[4].

The stiffness increases with increase in the resistance of the structure. In tube in tube structures, the hull consists of closely spaced columns that are held together by spandrel beams through moment connections which increase the rigidity of the frame.

II. STRUCTURAL MODELLING AND ANALYSIS

A 20 Storey tube in tube structure with pentagonal and hexagonal geometry is analyzed and compared with its conventional counterparts. Table I 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[4] 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[4]. Fig 1 shows the 3D view of hexagonal and pentagonal buildings.

Table I. Parameters for analysis

Plan configuration	Pentagonal and Hexagonal
No. of stories	G+19 (20 storey)
Floor Height	4 m
Total height	80 m
Type of Building	Residential
Grade of 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/m^2
Floor Load	2 kN/m^2
Roof Load	1.5 kN/m^2
Soil Type	Medium
Importance factor (IF)	1
Response reduction factor	5

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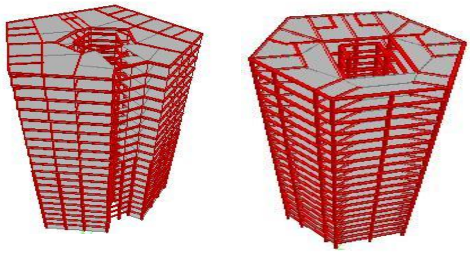

Fig. 1 3D view of pentagonal and hexagonal tube in tube structure

III. ANALYSIS AND RESULT

Structural modelling of the framed tube-in-tube structure and the RCC structure is done using STAAD.PRO for 2 geometrical configurations[5]. The pentagonal shape and the hexagonal shape tube in tube structure are compared with pentagonal and hexagonal shape conventional RCC structural system[6]. All buildings in the configuration have 20 number of stories[7]. The floor height is kept constant for all buildings viz. 4 m. The lighting, ventilation and service criteria are allowed through central core for all buildings. The Zone II to V are denoted as Z2 to Z5 respectively.

DISPALCEMENT: The variation of displacement in pentagonal and hexagonal configuration in different seismic zones is shown in Fig.2 and Fig. 3.

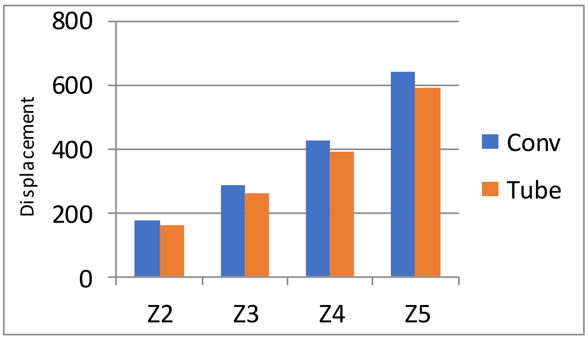

Fig. 2 Variation of displacement in pentagonal configuration in different seismic zones

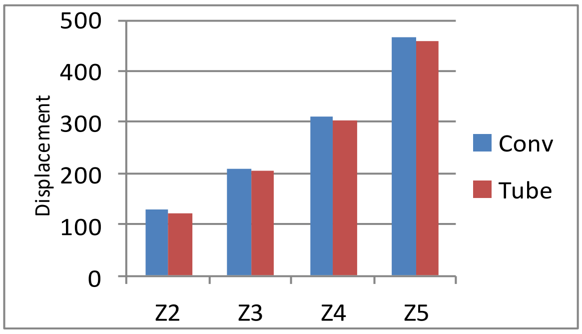

Fig. 3 Variation of displacement in hexagonal configuration in different seismic zones

DRIFT: The variation of drift in pentagonal and hexagonal configuration in different seismic zones is shown in Fig.4 and Fig. 5.

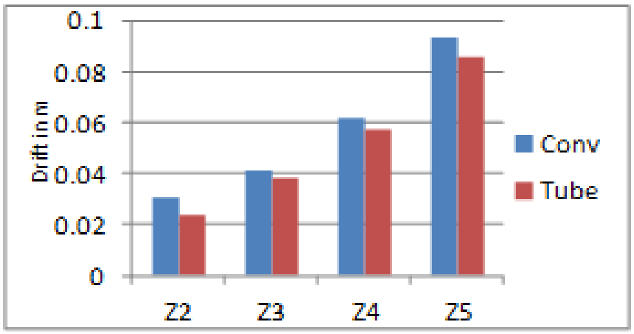

Fig.4 Variation of drift in pentagonal configuration in different seismic zones

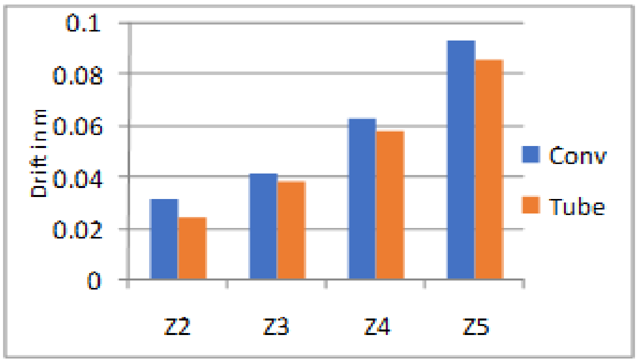

Fig.5 Variation of drift in hexagonal configuration in different seismic zones

TIME PERIOD: The variation of time period in pentagonal and hexagonal configuration in different seismic zones is shown in Fig.6 and Fig. 7.

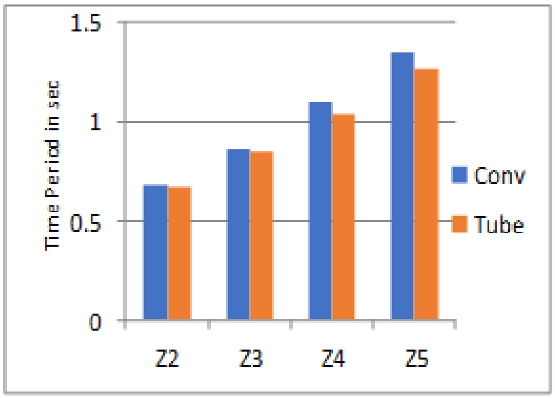

Fig.6 Variation of time period in pentagonal configuration in different seismic zones

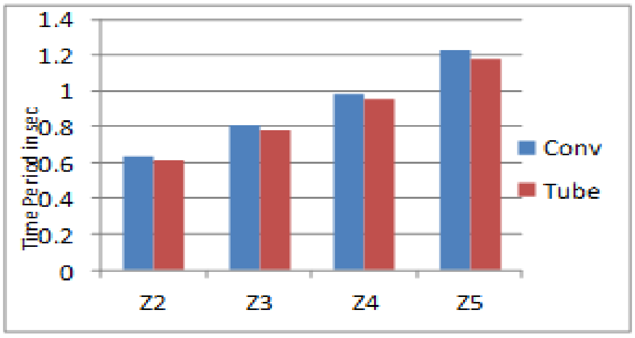

Fig.7 Variation of time period in hexagonal configuration in different seismic zones

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BASE SHEAR: The variation of base shear in pentagonal and hexagonal configuration in different seismic zones is shown in Fig.8 and Fig.9.

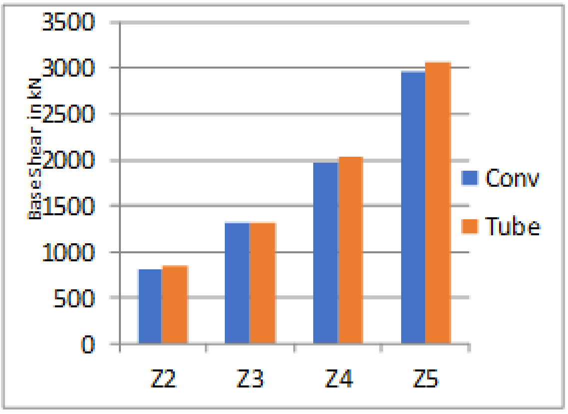

Fig.8 Variation of base shear in pentagonal configuration in different seismic zones

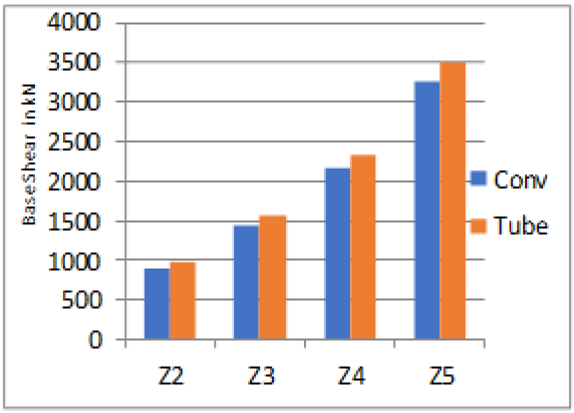

Fig.9 Variation of base shear in pentagonal configuration in different seismic zones

IV. CONCLUSION

- 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 is best suited for lateral loads and the tube – in – tube pentagonal geometry shows a vulnerable behaviour 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.
- Hexagonal geometry with tube in tube shows higher base shear and is suitable 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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