International Journal of Research in Engineering, Science and Management
Volume 5, Issue 7, July 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Comparison of Tube Frame and Tube in Tube Frame Structures for Different Plan Configurations

Amanthagiri Charan[1*], Shrihari Saduwale[2], Khaja Kamranuddin[3]

[1]M.Tech. Student, Department of Civil Engineering, Vidya Jyothi Institute of Technology, Hyderabad, India
[2]Professor, Department of Civil Engineering, Vidya Jyothi Institute of Technology, Hyderabad, India
[3]Assistant Professor, Department of Civil Engineering, Vidya Jyothi Institute of Technology, Hyderabad, India

***Abstract*: As time has passed, we have noticed that the population is steadily increasing, and the demand for a home is a basic human need, therefore instead of extending along the area, engineers have created vertical extension. As we begin to build the structures vertically upwards, lateral pressures will act on the reinforced concrete Frame. As a result, it is important to resist the forces operating laterally on the frame. In this study, we will evaluate the lateral force operating on a regular (rectangular shaped) and irregular (U shaped) structure with 22 floors, and compare it to two distinct structural systems, namely a framed tube structural system and tube in tube structural system. Response spectrum analysis will be performed in order to compute the results by ETABS V 18.0.1. The study as a whole is a preliminary attempt to assess the effect of vertical forces operating on RC buildings in terms of dynamic parameters such as Story Displacement, Base Shear and Story Drift. ETABS is integrated with all of the major analysis engines, such as static, dynamic, linear, and non-linear, and this software is used to analyse and design buildings, particularly RCC and steel structures, because of the facilities provided in this software at the modelling stage, the buildings can be modelled as per the arrangement of the project members in practise. Gravity loads such as dead and live loads shall be examined in accordance with IS 875 Parts 1 and 2, and horizontal loading impacts such as seismic/earthquake and wind loads will be assessed in accordance with IS 1893 and IS 875 Part 3.**

***Keywords*: Tube in Tube, 2 cellars + 20 floors building, Response spectrum analysis.**

1. Introduction

A. Tubes

For tall and high-rise buildings, use of a braced frames and structural walls alone may not be sufficient to control the overall lateral displacement as well as the forces. In such a case, more rigid structural systems are required.

The structural area one such system where columns area closely spaced along the perimeter thereby increasing the number of columns in the perimeter forming a tube.

It looks like a hollow cantilevered structure. The interior columns can be reduced and can be designed to take only the gravity loads since the outer tube is highly stiff and resists all of the lateral loads.

Different type of tub structural system are used such as

- Framed Tube
- Tube in a tube (hull and core)
- Bundled tube
- Hybrids tube system

B. Tube-in-Tube System

This system is a structural system associated with an outer tube around the outside and a tube structure is termed the inner core (a concrete core wall or a tube in steel frame). The inner core and outer tube are usually connected by the floor diaphragm; they may be connected via outriggers in other circumstances. They operate together to withstand side loads like earthquake and wind. They also belong to the system of gravity resistance. There is some misunderstanding about the concepts of tube-in-tube and framed tube systems. The inner and outer tubes are a pair of soft tubing in the tube-in-tubes system, and in particular, the outer tube is not that rigid. The external piping is stronger in a framed structure because it consists of narrow spaced columns joined with spandrel beams that produce a highly steep external pipeline. However, many large structures use hybrid lateral stability systems with the fast development of the modern construction technology. It is not so crucial to distinguish these two terms.

2. Literature Review

Lavanya T, Sathyanarayana Sridhar R (2017). Worked on the Dynamic analysis of Tube-in-tube Tall buildings, and an approximate procedure is generated by developing simple methodology for the free vibration analysis of tall buildings based on Transfer Matrix Approach with the aid of FORTRAN programming to solve the complex problems with ease and develop simplified solutions in the form of Design.

Shilpa Balakrishnan, Rona Maria James(2019). Comparative Study on Tube in Tube and Tubed Mega Frames on Different Building Geometry Using ETAB.

Heidbrecht and Stafford Smith (1973) Obtained natural frequencies from the solution of a governing differential equation for a range of values of the structural parameters affecting the behavior.

Coull and Bose (1975), Coull and Ahmed (1978), developed

*Corresponding author: amathagiricharan@gmail.com

an orthotropic membrane analogy of transforming the framework panels into equivalent orthotropic membranes each with elastic properties so chosen to represent the axial and shear behavior of the actual framework. They analyzed the equivalent membrane tubes by assuming the bending stress distributions to be cubic and parabolic on the web and flange panels respectively and using energy formulation to derive the governing differential equations

Khan and Stafford Smith (1976) have also developed an orthotropic membrane analogy for simplified analysis of framework panels by using finite element analysis.

Wang Q (1996) obtained a formula for calculating the natural frequencies of tube-in-tube structures in tall buildings directly from the fourth-order Sturm-Liouville differential equations. In another study, numerical solutions of eigenvalues for free vibration of tube-in-tube structures by using modified ODE solver for eigen value problem was presented by him based on an existing Ordinary Differential Equation (ODE) solver.

3. Methodology

A. Geometrical and Material Data

Both the rectangular-shaped and U-shaped structures, which are 60 m above the ground, will be utilize for modeling and analysis. The Structure's height is computed using the regulations of the Indian Standard code book for High raised structures, namely ISI16700:2017 clause 3.14 and tables1 and 2. These constructions have dimensions of 55m X 28m and ware chosen from clauses 5.1.2 and 5.2.2. for the analysis of 60 floor structures, a total of 1400sq.m of plan area will be required. The dimensions for a rectangular shape and the same as for a U-shaped form, and the A/L ratio form IS 1893:1:2002 pg. 19 and figure3 (i.e., plan imperfections). For the construction, M25 grade concrete and Fe500 grade of steel are used. The projects will be carried out on Indian terrain in seismic Zone 2.

B. Model Specification of Project

Table 1
Material properties

Parameter	Values
Material	Concrete
Grade of concrete	M25
Grade of steel	HYSD500

Table 2
Building configuration

Parameter	Assumed Data
Number of storeys	Cellars-2 Storeys-20
Utility of Building	Residential
Number of bays along X-direction	12
Number of bays along Y-direction	8
Storey height	3m
Height of building	66m
Bay width along X-direction	5m
Bay width along Y-direction	4m

Table 3
Section properties

Parameter	Values
Beam size	500mm x 230mm
Column size	425mm x 425mm
Slab thickness	150mm

Table 4
Seismic data for 2 Cellar+20 building

Parameter	Values
Seismic zone	Zone II
Seismic zone factor, Z	0.10
Importance Factor, I	1
Response reduction factor, R	3
Site type	Medium stiff (II)

Table 5
Wind load data

Parameter	Values
Wind speed	44 m/s
Terrain category	2
Importance factor	1
Risk factor	1

C. Different Structural Systems Plan and 3D Models

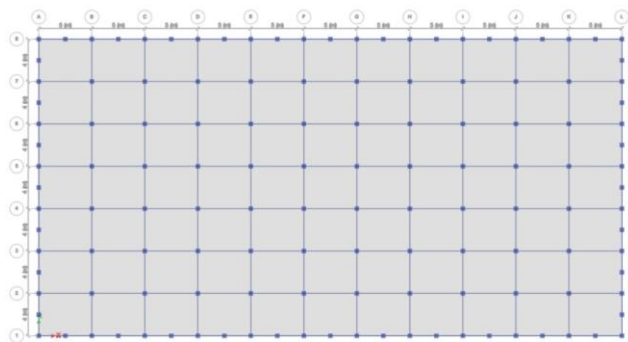

Fig. 1. Tube frame Structural system rectangular shape building

Table 6
Storey displacement tube frame structural system rectangular shape building

Storey Level	Displacement in X- Direction	Displacement in Y- Direction
Story2	7.052	14.132
Story7	29.337	60.224
Story12	46.382	96.411
Story17	58.135	120.27
Story22	65.519	130.639

Table 7
Storey drift tube frame structural system rectangular shape building

Storey Level	Drift value
Story2	0.002365
Story7	0.001089
Story12	0.00093
Story17	0.0006
Story22	0.000207

Table 8
Storey displacement tube frame structural system U shape building

Storey Level	Displacement in X- Direction	Displacement in Y- Direction
Story2	12.812	21.103
Story7	59.148	96.769
Story12	95.711	158.511
Story17	120.019	201.73
Story22	130.957	224.089

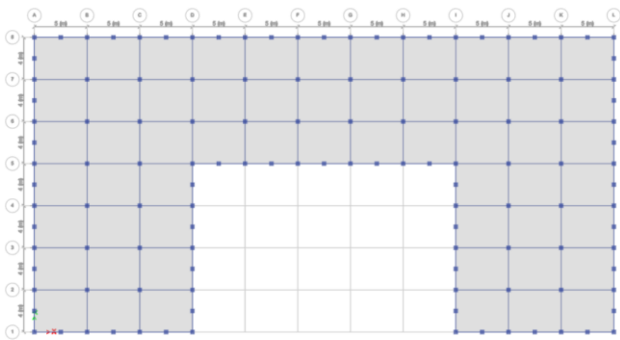

Fig. 2. Tube frame structural system U shape building

Table 9
Storey drift tube frame structural system U shape building

Storey Level	Drift value
Story2	0.001933
Story7	0.001918
Story12	0.002235
Story17	0.002262
Story22	0.000944

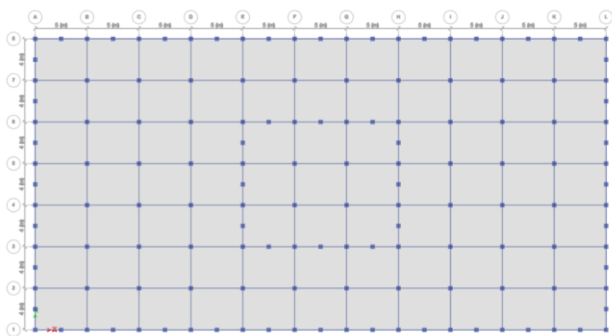

Fig. 3. Tube in Tube frame structural system rectangular shape building

Table 10
Storey displacement Tube in Tube frame structural system rectangular shape building

Storey Level	Displacement in X- Direction	Displacement in Y- Direction
Story2	6.628	13.212
Story7	27.121	55.254
Story12	42.826	88.302
Story17	56.25	110.108
Story22	63.423	119.616

Table 11
Storey Drift Tube in Tube frame structural system rectangular shape building

Storey Level	Drift value
Story2	0.00271
Story7	0.002601
Story12	0.001919
Story17	0.001134
Story22	0.000325

Table 12
Storey Displacement Tube frame structural system U shape building

Storey Level	Displacement in X- Direction	Displacement in Y- Direction
Story2	8.522	13.297
Story7	35.17	53.688
Story12	56.2	86.717
Story17	70.111	109.846
Story22	76.282	121.824

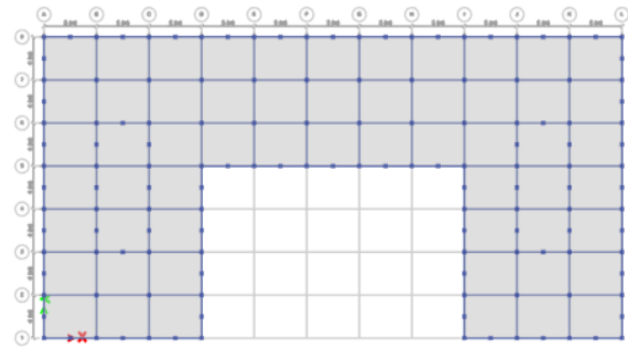

Fig. 4. Tube frame structural system U shape building

Table 13
Storey Drift Tube frame structural system U shape building

Storey Level	Drift value
Story2	0.003187
Story7	0.002965
Story12	0.002146
Story17	0.001224
Story22	0.000536

4. Results and Discussion

A. Storey Displacement

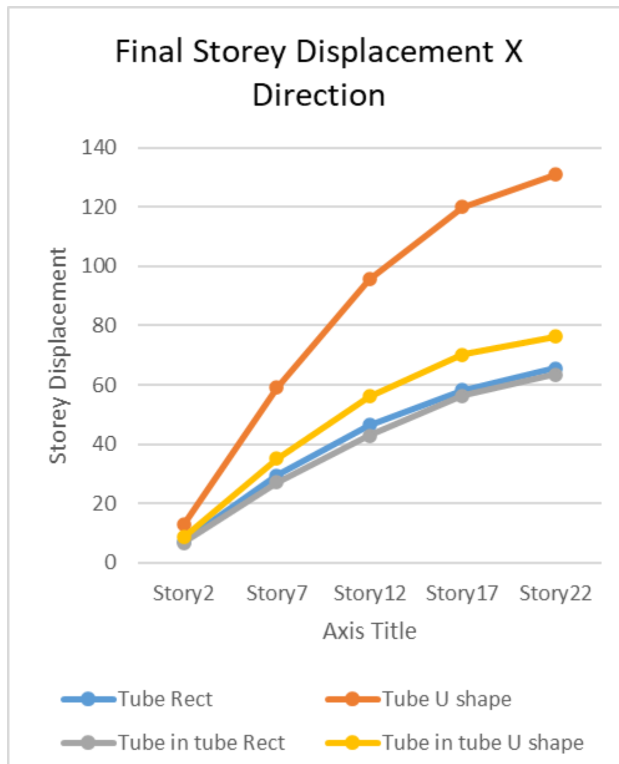

Fig. 5. Graphical representation of Storey displacement in X-Direction

- The Behaviour of a graph shows high displacement values for Tube U shape structure in strorey level 22.
- The maximum Storey displacements for the Tube U shape Structure is 130.957 mm along X-direction whereas in Y-direction is 224.089 mm which are the highest displacement values among all cases.
- Tube in tube rectangle structure has shown lesser displacement values at storey level 22 compared to

other structures which is 63.423 mm in X-Direction and 119.616 mm in Y-Direction.

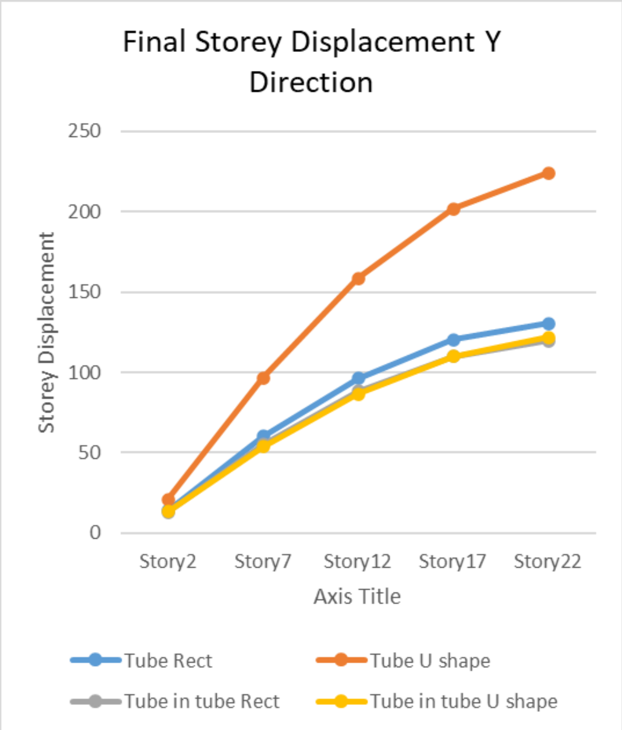

Fig. 6. Graphical representation of Storey displacement in X-Direction

B. Storey Drift

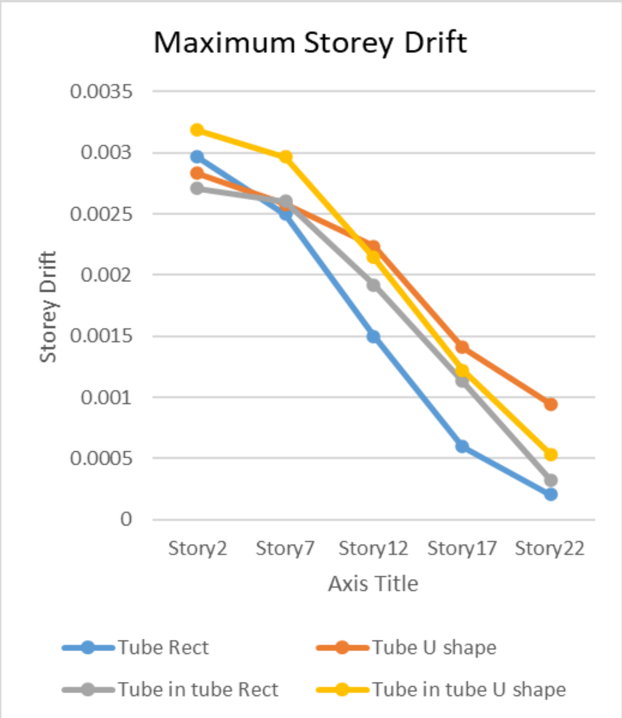

Fig. 7. Graphical representation of Maximum Storey Drift

- From the graph, it seems that the storey drift is maximum for the structure with Tube in tube U shape.
- The lowest value of storey drift is observed in the Tube rectangular structure.

5. Conclusion

- To analyze the building structures and determine storey drift and displacement, the response spectrum approach is applied.
- Under Seismic Zone II, the behaviour of multi-storey buildings with different geometric configurations are analyzed.
- In all circumstances, displacement rises from lower to the higher storey of the building.
- Lesser column sizes can be adopted when Tube U shape structured is considered.
- Tube in tube rectangular structure has shown a balanced constant change in value rather than any other structure type.

References

[1] Wang, Q. (1996). Sturm-Liouville Equation for Free Vibration of a Tube-in-Tube Tall Building. Journal of Sound and Vibration, vol. 191, no. 9, 349-355.
[2] Stafford Smith, B. & Coul, A. (1991). Tall Building Structures: Analysis and Design. Wiley, New York.
[3] Coul, A. & Bose, B. (1975). Simplified Analysis of Framed-Tube Structures. Journal of the structural Division-ASCE, 101(11), pp. 2223-2240.
[4] Lavanya T, Sathyanarayana Sridhar R., (2017). Dynamic analysis of Tube-in-tube tall buildings.
[5] Shilpa Balakrishnan, Rona Maria James (2019). Comparative Study on Tube in Tube and Tubed Mega Frames on Different Building Geometry Using ETABS.
[6] Lee, W.H. (2007). Free Vibration Analysis for Tube-in-Tube Tall Buildings. Journal of Sound and Vibration, vol. 303, 2007, 287-304.
[7] Ghasemzhadeh, H. & Samani, H.R. (2010). Estimating Frequency of Vibration for Tubular Tall Buildings. Fourteenth ECEE.
[8] Bureau of Indian Standards IS 1893-2002, Part- 1, Criteria for Earthquake Resistant Design of Structures.