



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 5, May 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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Comparative Study of Different Types of Tube Systems for High Rise Structure

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ABSTRACT: Now a day there is need for multi-storied building due to overcrowding of cities. Multistoried buildings are used for office, complex, residential flats etc. These multi-storeyed buildings can be transformed into tall buildings in order to achieve more floor space but occupy less land space. Over the past few year's tubular structures are becoming a common feature in tall buildings. Tube structures are particularly suitable for all tall buildings. A tubular structural system is used in high-rise buildings to resist lateral loads like wind and seismic forces. The rigid frame is assembly of columns and beams form result in dense and strong structural 'Tube' around the exterior. The mostly widely used tube systems are Framed tube system, Tube in tube system, Bundle tube system, Braced tubed systems. Different systems show different patterns of design and loading so structural engineers plays vital role during design of tubular structure in high rising building.

In the design of tall buildings, lateral loads play predominant role. The lateral loads are wind load and seismic load. The seismic analysis is carried out by using Time history method. The modelling and analysis are done using ETABS software. The different types of tube systems for high rise structure are modelled and compared with the conventional moment resisting frame Structure. The Analysis and comparisons are made for characteristics such as maximum displacement, base shear, story drift of these structures.

KEYWORDS: Tube structure, Framed tube, Tube in tube, Bundle in tube and Braced tube system, Time history analysis, seismic load, wind load.

I. INTRODUCTION

In this ongoing era of civil engineering, a trend of high-rise buildings has acquired the entire construction industry. It is a challenge not only to the architects but also to the structural engineers to provide a strong design to the high-rise structures so as to make them sustainable to all kinds of loads and combinations of loads. High rise buildings are subjected to huge amount of lateral wind load and an earthquake load. Therefore, along with the gravity loads, wind load, earthquake load and their combinations are also considered in the structural design of the high-rise buildings. The tube is a structural engineering system that is used in high-rise buildings, enabling them to resist lateral loads from wind, seismic pressures and so on. It acts like a hollow cylinder, cantilevered perpendicular to the ground. This system was introduced by FazlurRahman Khan while at the architectural firm Skidmore, Owings & Merrill (SOM), in their Chicago office. The first example of the tube's use is the 43-story Khan designed DeWitt-Chestnut Apartment Building, since renamed Plaza on DeWitt, in Chicago finished in 1966. The tube system can be built using steel, concrete or composite construction. It can be used for commercial complexes, residential and mixed-use buildings. Modern high-rise buildings of the tube system exhibit a considerable degree of shear-lag with consequential reduction in structural efficiency. The "tube" comprises closely spaced columns that are connected at each floor level by deep spandrel beams. Lateral loads can be resisted by this stiff exterior framing, interior columns can be located at the core and are fewer in number.

➤ Framed tube system:

In frame tube structural system, the exterior columns are spaced closely together and join with deep spandrel beam to resist lateral load more effectively. It can be used in any floor shape for high rise building. It gives more space in inner

for easily locomotion. It is just like exterior load resisting system. The lateral load taken by exterior column so reducing the deflection in the members and it gives more load carrying capacity to the structure. The design of framed tube structure is easy as compared to conventional building.

Example: Aon Centre and W.T.C Towers

➤ **Tube in tube system:**

This system is also known as Hull and core system. In consist of two tubes like one is inner and another is outer. Outer tube resists the lateral load like wind load and inner tube is resist the gravity load So, the inner and outer tube periphery consist of closely spaced column and remaining is vacant space. This vacant space gives easy way for parking and all other purpose. The Core is useful for staircase, lifts, Ducts or service core. Stiffness of structure is increased by providing Tube in tube system. Core framing leads to gain in rentable space. It is efficient to reducing the overturning moment. In this system, the inner and outer tubes interact horizontally as shear and flexural components.

Example: World Trade centre Twin tower

➤ **Braced tube system:**

Braced tube system also known as Trussed tube system. It is just like a framed tube system, but in braced tube system exterior columns spaced apart as compared to framed tube system. Different types of bracings and shear wall are using for column connection. This interconnection makes braced tube system more rigid. Diagonal of braced tube are connected to the column at each intersection, they virtually eliminate the effect of shear lag in flange and web. As a result, the structure behaves under lateral loads more like a braced frame reducing bending in the members of the frame. In braced tube structure, the braces transfer axial load from more highly stressed columns to less highly stressed columns and eliminates difference between load stresses in columns. Hence, spacing of the column can be increased and depth of girders will be less as compared to conventional building.

Example: Chicago’s John Hancock building, The Citigroup Centre, Bank of China Tower

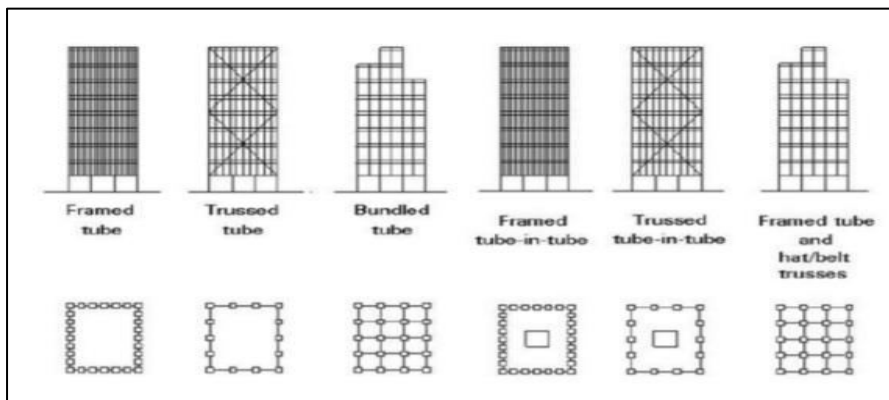


Fig.1 Different Types of Tube Structural Systems And their Variations

➤ **Bundled tube system:**

Bundle tube system is consisting of assembly of multiple individual tubes. It can take account any kind of floor space. For high rise structure it is most efficient system. In this system, internal webs if introduced will greatly reduce the shear lag in the flange beams. It provides the rigidity needed to limit the lateral sway from wind forces. Variations in the height of each individual tube also disrupt air currents, which reduces the stress of the wind on the structure. Bundle tube system gives different configuration of building as per requirements. The bundle tube design was not only highly efficient in economic terms, but it was also innovative in its potential for versatile formulation of architectural space. Efficient towers no longer had to be box-like; the tube units could take on various shapes and could be bundled together in different sorts of groupings.

Example: Sears Tower

1.1 Seismic Design:

Structural design of buildings for seismic loading is primarily concerned with structural safety during major earthquakes, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural behaviour under large inelastic deformations. Behaviour under this loading is fundamentally different from wind or gravity loading, requiring much more detailed analysis to assure acceptable seismic performance beyond the elastic range. Some structural damage can be expected when the building experiences design ground motions because almost all building codes allow inelastic energy dissipation in structural systems

1.2 Need of Seismic Analysis:

A large number of reinforced concrete multistorey frame buildings were heavily damaged and many of them collapsed completely in Bhuj earthquake of 2001 in the towns of Katch District (viz., Bhuj, Bhachao, Anjar, Gandhidham and Rapar) and other district towns including Surat and Ahmadabad. In Ahmadabad alone situated at more than 250 kilometres away from the Epicentre of the earthquake, 69 buildings collapsed killing about 700 persons. Earlier, in the earthquake at Kobe (Japan 1995) large number of multistorey RC frame buildings of pre 1981 code-based design was severely damaged due to various deficiencies. Such behaviour is normally unexpected of RC frame buildings in MSK Intensity VIII and VII areas as happened in Katch earthquake of January 26, 2001. The aim of this Project is to bring out the main contributing factors which lead to poor performance during the earthquake and to make recommendations which should be taken into account in designing the multistorey reinforced concrete buildings so as to achieve their adequate safe behaviour under future earthquakes. The Indian Standard Code IS: 1893 was suitably updated in 2002 and 2016 so as to address the various design issues brought out in the earthquake behaviour of the RC Buildings.

1.3 Objectives of study:

- Comparative study of Tall RC Structure and Tube system structure using ETABS software.
- Analysed and compare the impact of seismic and wind loads on tube-in-tube, bundled tube system, framed tube and braced tube system.
- To study and compare the lateral base reaction, base shear, story displacement, story stiffness for RC Structure and Tube Systems Structure.
- Results compared between the all types of tube systems for high-rise structure.
- Results To determine the most suitable system for tall structure.

II. RELATED WORK

1. AbdulHalimEtemadAditya Kumar Tiwary, 'Comparison of tubular, outrigger and bracing system for stabilization of high-rise buildings', in this paper comparison of tubular, outrigger and latera bracing systems have been studied on a 42-story concrete building by using standard package ETABS 2016. In this paper structural efficiency of tubular, outrigger and bracing systems have been analysed. In this paper comparison of three systems have been evaluated to find their efficiency in term of their structural performance.
2. In literature 'Comparative Study of Tube in Tube Structure and Frame Tube Structure' considered the Frame Tube Structure and Tube in Tube Structure are modelled and compared with the conventional moment resisting frame Structure. The Analysis and comparisons are made for characteristics such as maximum displacement and Storey Drift of these structures. The study of seismic behaviour of tube structures is carried for these structures for zone IV. In this study reinforced concrete structure is considered, having 33 stories of height 115.5m each floor is considered as 3.5m height.
3. ShilpaBalakrishnan studied Comparative Study on Tube in Tube and Tubed Mega Frames on Different Building Geometry Using ETABS. She gave brief explanation about tube in tube structures are formed by connecting peripheral frame tube and inner core tube so closely, it is not seen as a solid system but it acts like a solid surface. In tubed mega frames instead of one central tube several vertical tubes are carrying the lateral loads. Comparison based on different geometry of building.
4. Dr.Kiran T, PoojaPatil studied about Comparative Analysis of RC Structure and Tube in Tube Structure with And Without Shear Walls. In this literature concluded that RC structure is found to be most vulnerable system in resisting lateral forces among all the systems considered for the study. Also, Tube-In-Tube with peripheral shear walls in very tall structures is found to be most suitable system for resisting both gravity and lateral loads.
5. SyedMusthafaKhadri gave A Comparative Study of Frame Tube, Tube in Tube and Bundled Tube Structures Subjected to Lateral Load Under Different Zones. In this research, researchers investigated a frame tube and tube-in-tube structural comparison, bundle tube structure and bundle tube structures with shear wall under Zone III and

Zone V had done to find most efficient structure to improve system's lateral stability and discovered that shear wall bundles had more lateral stability than other types of tube constructions.

6. Seismic performance of bundled tube structures in seismic zone IV & zone V of India. Seismic performance of the 150m tall rectangular plan Bundle tube and framed tube structures have been performed with the CQC method in Response spectrum method in Seismic zone 4 and Zone 5 of IS 1893-2016 code provisions. With the high flexibility to terminate the tubes at required heights of the structure, the bundled tube structure can be selected in tall buildings. This statement established with the higher specific performance of peak characteristics is found in comparison with the framed tube structure for the similar seismic characteristics.
7. AkhilBabu studied Design and Analysis of RC Tube in Tube Structure using ETABS Subjected to Wind Load.in this paper concluded that Tube in tube is a superior structural solution for tall buildings than tubular construction. t is evident from the results above that tube-in-tube systems can withstand the enormous lateral loads of a whole skyscraper. The study concludes that by incorporating a shear core into the middle area of a structure, its performance can be enhanced. Therefore, it will behave as a tube-in-tube configuration.
8. AmanthagiriCharan, ShrihariSaduwale gave Comparison of Tube Frame and Tube in Tube Frame Structures for Different Plan Configurations. i.e., rectangularshaped and U-shaped structures, which are 60 m above the ground modelled and analysed. Response spectrum analysis performed in order to computed 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.

III. METHODOLOGY

1. For the study reinforced concrete structure is considered, having G+25 stories height of each floor is considered as 3 m height.
2. For the reference base model, a regular reinforced concrete moment resisting frame model is considered.
3. Different types of tube system i.e., Tube in tube, Braced tube, Bundle Tube and Frame tube systems are modelled with reference to base model by using ETABS Software.
4. The floor height is kept constant for all models in order to get consistent results.
5. To understand the behaviour under lateral loads the loads are applied as per IS 1893: 2016 for seismic and IS 875:2015 for wind are used.
6. Based on the results and responses from applied gravity, Wind and seismic loads, conclusion will be made.

3.1 For this study, the following models are considered:

- Model 1- Conventional RC structure
- Model 2- Frame Tube system structure
- Model 3- Tube in tube system structure
- Model 4- Braced tube systemstructure
- Model 5- Bundle tube system structure

3.2 Modelling Data:

- Width – 30 m, Length – 30m
- Location: Location of the building is assumed to be in Pune region
- Grade of steel – Fe500 & Grade of concrete M30
- Standard code and specification: IS 456:2000 Code of practice for Plain and Reinforced Cement Concrete& IS 875:2015(Part 1 to 5) for Design Loads

3.2.A Structural membersizes:

It is assumed that both beams and columns are uniform section for similar story for the height of building.

- Uniform slab thickness of 200 mm is adopted.

Story	Size of Column (mm)
Ground to 5 th floor	1000x1000
6 th to 10 th Floor	850x850
11 th to 15 th floor	700x700
16 th to 20 th floor	550x550
21 st to 25 ^h floor	400x400

- Adopt uniform beam size of 300x600mm

3.2.B Loading: Following loading is considered while performing the analysis

Following loading conditions same for all models.

- Dead load and live load:**

Table3.2.1 Dead and live load

Live Load	3 KN/m ²
Dead load	
Self-weight of slab	5 KN/m ²
Floor Finish	1 KN/m ²
Total dead load on slab	6 KN/m ²

- Wind Load:**

Table3.2.2 Wind load

IS	IS 875-part III- 2015
Basic wind speed	39 m/s
Risk coefficient (K_1)	1
Terrain category factor (K_2)	0.98
Topography factor (K_3)	1
C _{pe} (External wind coefficient)	±0.7
C _{pi} (Internal wind Coefficient)	±0.2

Seismic Load:

Table3.2.3 Seismic load

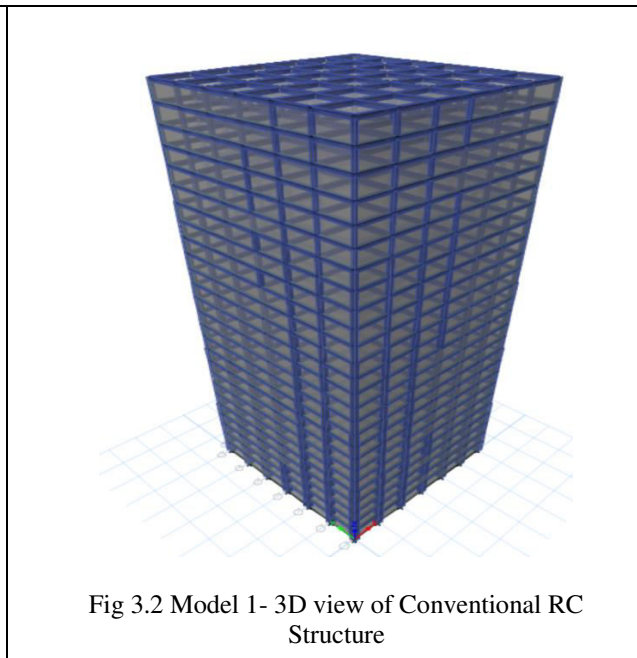
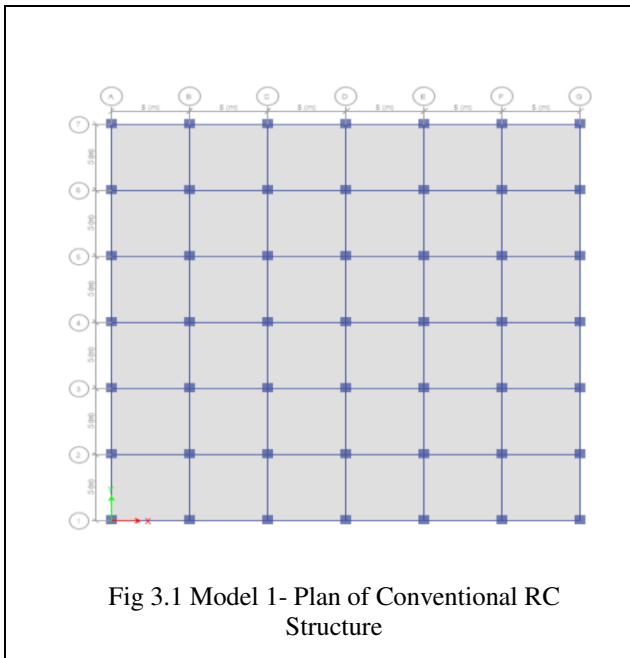
IS	IS 1893:2016
Zone	III
Zone Factor	0.16
Soil type	Medium
Importance Factor	1.5
Response Reduction Factor	5
Damping factor	0.05

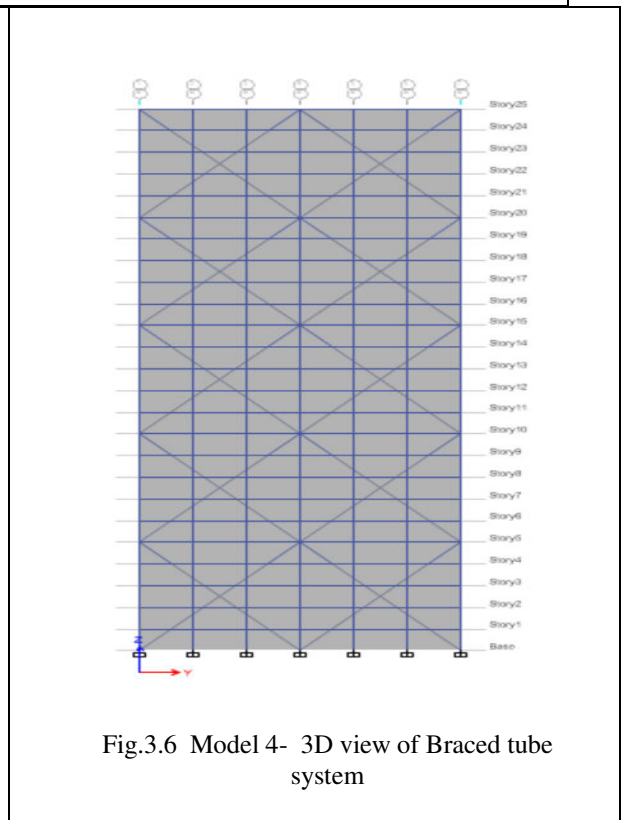
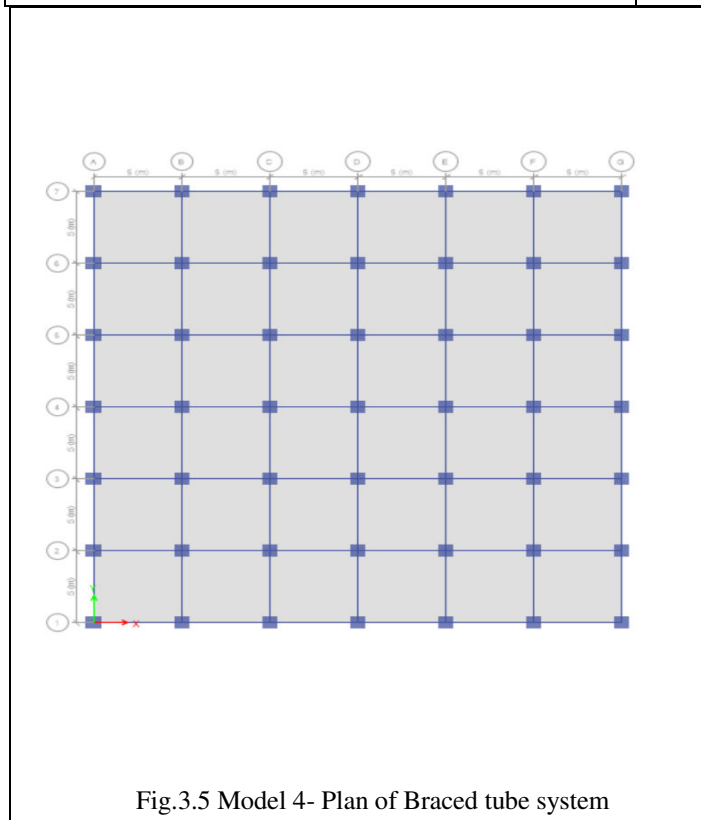
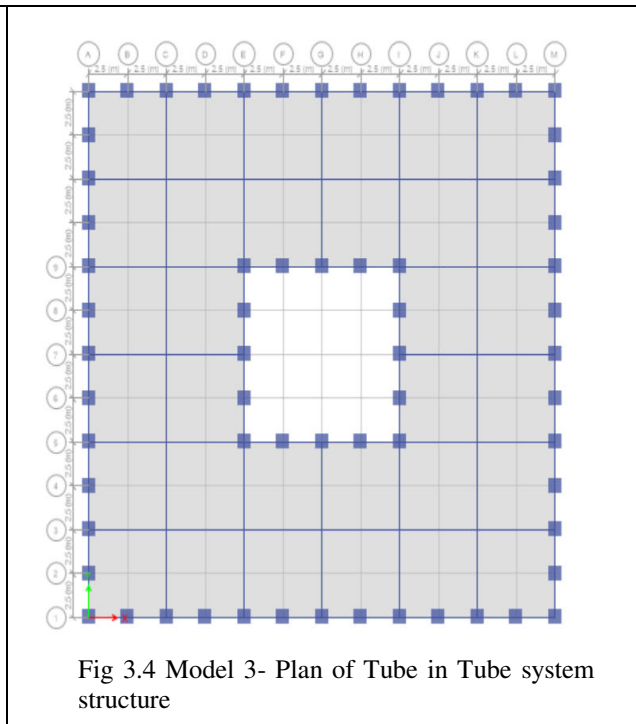
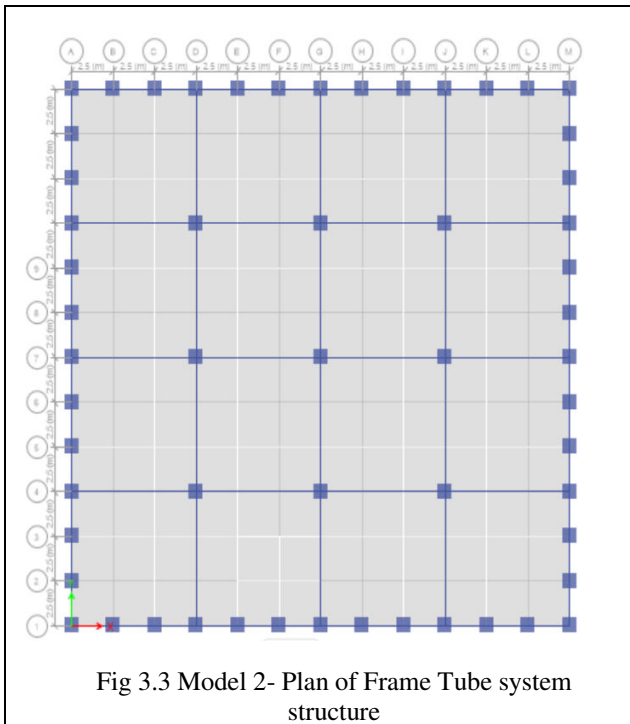
Time History Analysis:

Time history analysis is done by considering the Earthquake data of BhujGroundmotion earthquake as Nonlinear Model with scale factor (i.e., $1.g/2R$)

The load combination considered which mentioned in seismic analysis as per IS 1893:2016

- Model 1- Conventional RC structure
- Model 2- Frame Tube system structure
- Model 3- Tube in tube system structure
- Model 4- Braced tube system structure
- Model 5- Bundle tube system structure





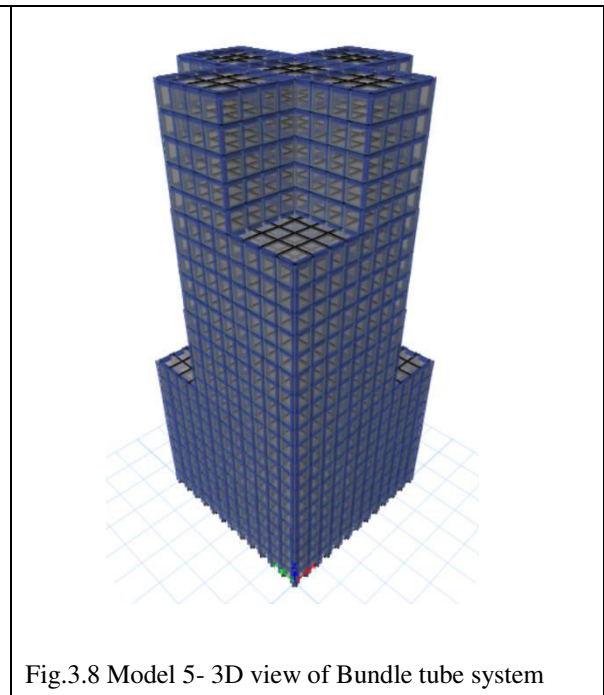
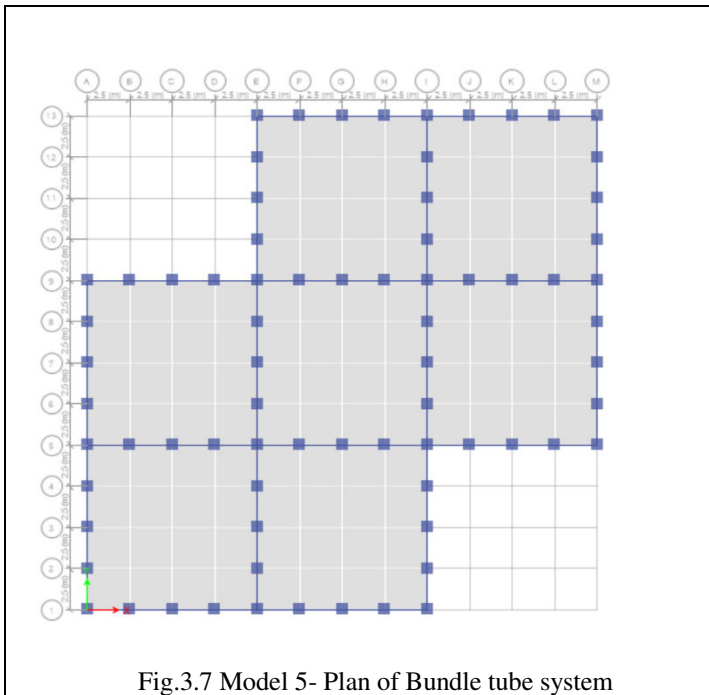


Fig.3.7 Model 5- Plan of Bundle tube system

Fig.3.8 Model 5- 3D view of Bundle tube system

IV. EXPERIMENTAL RESULTS

4.1 Storey displacement:

Storey displacement is the total displacement of any storey with respect to the ground and its maximum permissible limit is prescribed in IS 1893-2002.

As per IS: 1893-2016 the permissible limit for displacement is given by $h/250$, Where 'h' is the total height of building in millimetres (mm). For the present study the permissible limit for displacement is $(78000/250) \text{ mm} = 312 \text{ mm}$

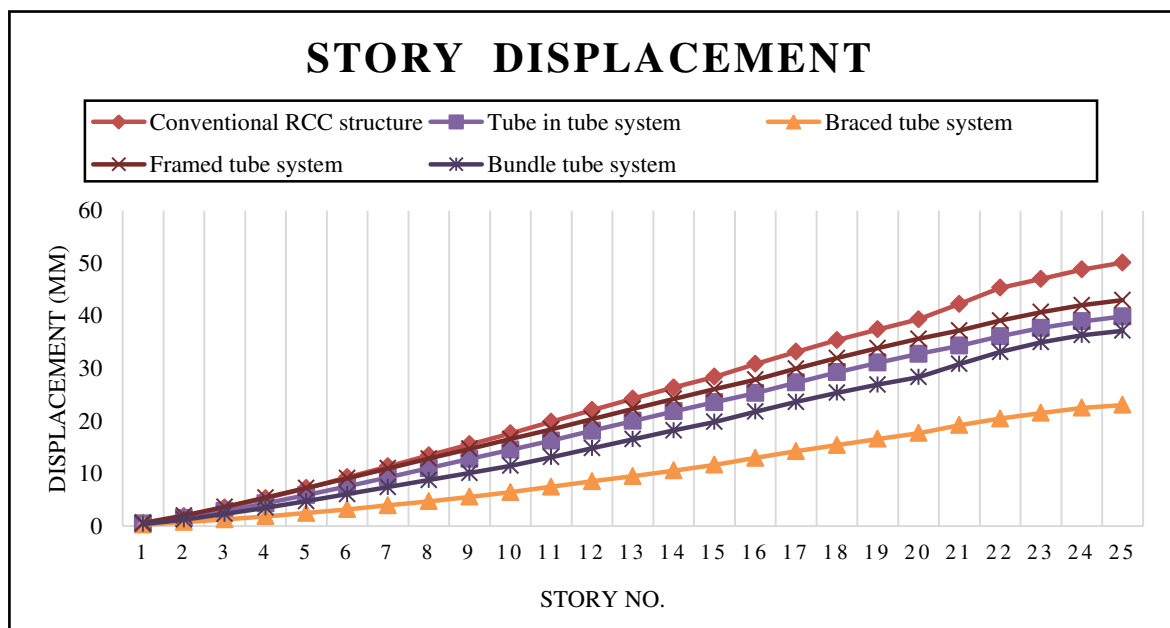


Figure 4.1: Story Displacement for different Tube Systems

Conventional RCC structure	Tube in tube system	Braced tube system	Framed tube system	Bundle tube system
50.128	39.883	23.048	42.988	37.179

Table 4.1 Maximum storey displacement(mm)

- From above graph it is clearly seen that displacement of conventional RC structure is more than any other system. Braced tube system shows less displacement.

4.2 Story Drift:

Storey drift is the lateral displacement of one storey with respect to the above or the below storey.

As per IS: 1893(Part 1)-2002, the story drift in any storey due to specified lateral force, shall not exceed 0.004 times the storey height. And for the present study the maximum values of storey drift should not exceed 12mm (0.004x3000).

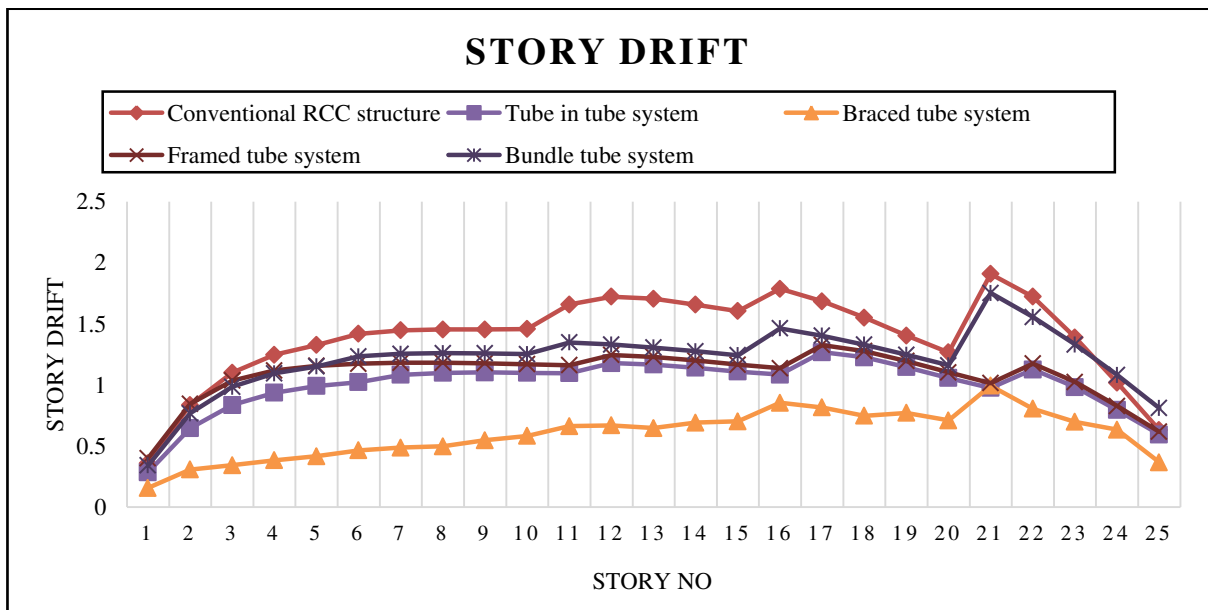
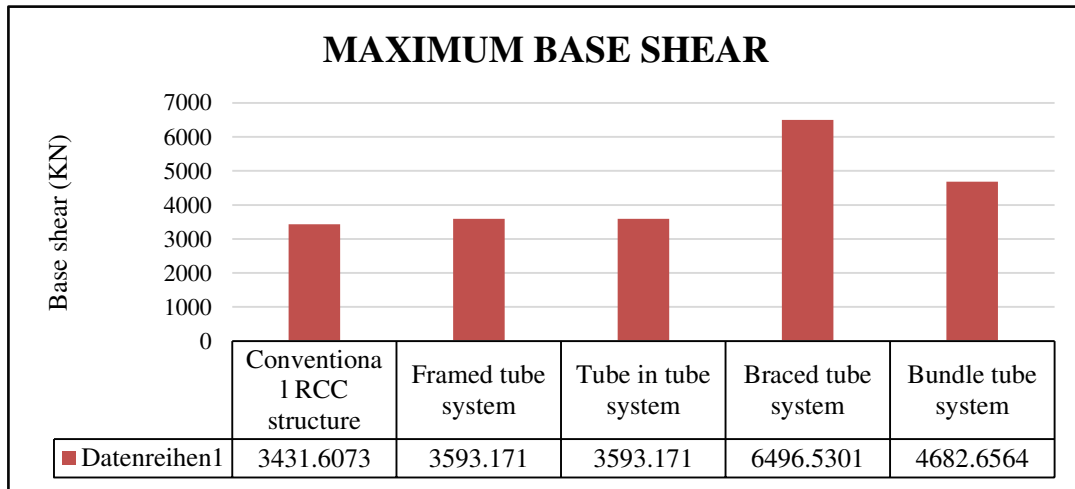


Figure 4.2: Story Drift for different Tube Systems

- The story drift increases from the bottom story to certain story and the gradually decreases at the top story.
- The maximum story drift Conventional RC structure is maximum and that of Braced tube system least compared to the rest of the models.
- As Braced tube system is found to have least story drift among all the models, it is best suited for resisting lateral forces effectively.

4.3 Base Shear:

Base shear is the maximum lateral force at the base of structure due to seismic load. It is calculated using the seismic zone, soil materials and building code lateral force equations.



The bases shear value for Conventional RC structure is least and that of Braced tube system is maximum.

- The base shear of Conventional RC structure is least and it is least stiff among all the models.
- The base shear of Braced tube system is maximum and is much stiffer among all the models.
- It can be observed that the base shear of Frame tube system is increased by 4.7%, Tube in tube by 4.7%, Braced tube by 89.3%, Bundle tube by 36.4% compared to Conventional RC structure.

4.4 Maximum Base Moment:

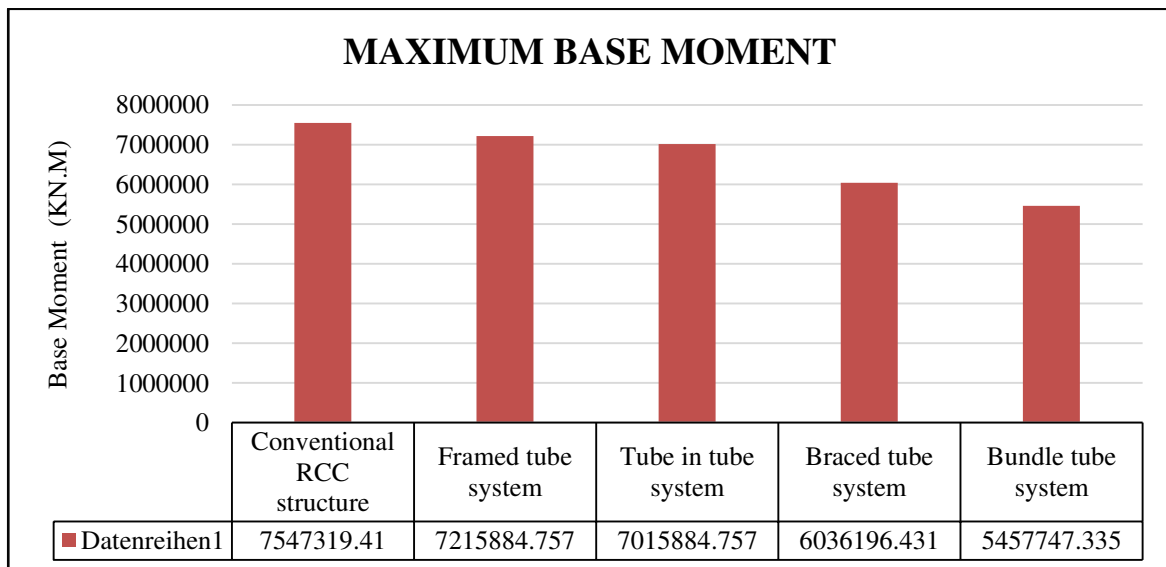


Figure 4.4: Base Moments for different Tube Systems

- The base moment value for Conventional RC structure is more and that Bundle tube system is minimum.
- The base moment of Conventional RC structure is maximum and it is least stiff among all the models.
- The base moment of Bundle tube system is maximum and is much stiffer among all the models.
- It can be observed that the base moment of Frame tube system is decreased by 4.4%, Tube in tube by 7.04%, Braced tube by 20.02%, Bundle tube by 23.71% compared to Conventional RC structure.

4.5 Maximum Story Stiffness:

Stiffness is one kind of the strength of the structure. It defined as force per displacement as maximum stiffness means more rigid structure.

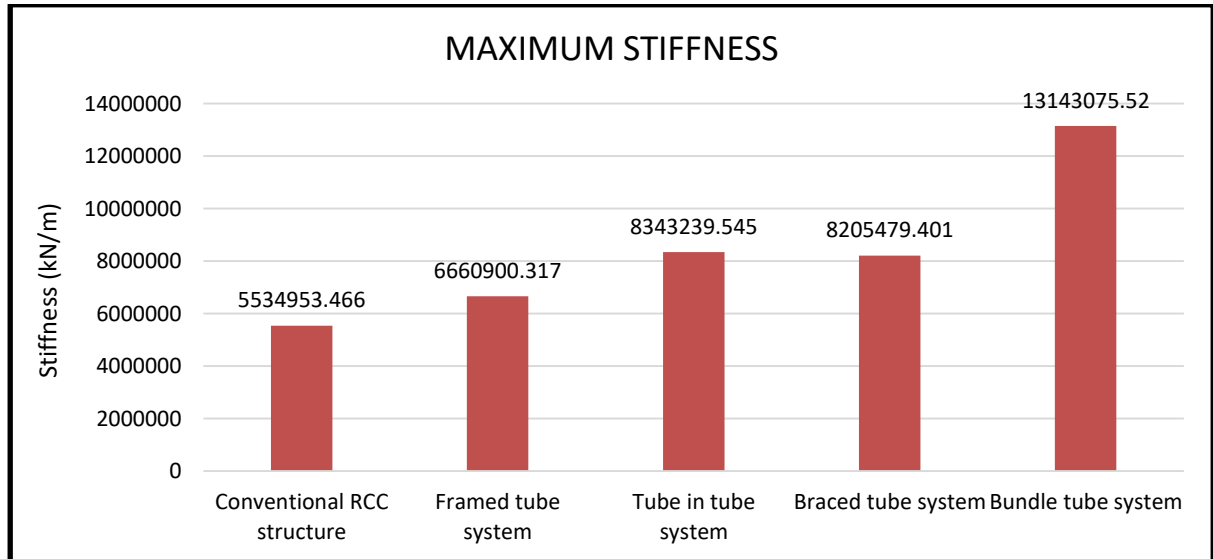


Figure 4.5: Maximum stiffness for different Tube Systems

- The Stiffness value for Conventional RC structure is less and Bundle tube system having maximum.
- The Stiffness of Conventional RC structure is Minimum and its strength is least all among them.
- The Stiffness of Bundle tube system is maximum and its strength is more than any other tube system.
- It can be observed that the Stiffness of Frame tube system is increased by 20.3%, Tube in tube by 50.7%, Braced tube by 48.24%, Bundle tube by 137.4% compared to Conventional RC structure.

V. CONCLUSION

1. We have Storey displacement: All the structures are found to have the permissible displacement values as per IS :1893-2016 for zone III and IS 875 Part (III):2015 From the Time history analysis, it is found that Braced tube structure has maximum reduction in the displacement value. This shows that this system is best in resisting lateral loads among rest of the systems. And RC structure has maximum values of displacement and is least recommended for tall buildings.
2. Storey drift: All the structures are found to have the permissible displacement values as per IS 1893-2016. Braced tube system has the least storey drift compared to the other system. The storey drift got reduced by 7.69% in both X and Y directions respectively. It is found to be more efficient among all the systems.
3. Base shear: The base shear of Braced tube is maximum due to increase in seismic weight of the structure on the addition of the bracings. This parameter depends on the amount of irregularity in the structure subjected to less damage the shear is maximum.
4. Base moment: Base moment of conventional RC structure is maximum as compared to the all types of Tube systems. It means that Tube system is more efficient in moment resisting capacity. Bundle tube system shows maximum base moment reduction as compared to all other systems.
5. Maximum Story Stiffness: Bundle Tube system shows maximum stiffness as compared to Frame, Tube in tube and braced tube system. Maximum stiffness means maximum strength of structure so bundle tube system is more rigid.

6. RC structure is found to be most vulnerable system in resisting lateral forces among all the systems considered for the study.

7. Braced tube and Bundle tube are found to be most suitable system for resisting both gravity and lateral loads.

We have applied our algorithm on many images and found that it successfully detect the text region.

REFERENCES

- [1] Lavanya.T, SathyanarayanaSridhar.R ,‘Dynamic analysis of tube-in-tube tall buildings’, International Research Journal of Engineering and Technology, April 2017
- [2] Abdul HalimEtemad, Aditya Kumar Tiwary, ‘Comparison of tubular, outrigger and bracing system for stabilization of high-rise buildings’, International Journal of Civil Engineering and Technology, March 2019
- [3] Suraj R Wadagule , Vishwanath R Charantimath, ‘Comparative Study of Tube in Tube Structure and Frame Tube Structure’, International Research Journal of Engineering and Technology, July 2019
- [4] Adil G. Khatri, RupaliGoud, GauravAwasthi, ‘Performance of Tube in Tube Structures: A Review’, Science Direct, Sept 2019
- [5] ShilpaBalakrishnan, Rona Maria James, ‘Comparative Study on Tube In Tube And Tubed Mega Frames On Different Building Geometry Using ETABS’, International Journal of Applied Engineering Research, Dec 2019
- [6] Dr. Kiran T, PoojaAnnaraoPatil, ‘Comparative analysis of RC structure and tube in tube structure with and without shear walls’, International Research Journal of Modernization in Engineering Technology and Science, April 2021
- [7] Syed MusthafaKhadri, B.K.Kolhapure, ‘ A comparative study of frame tube, tube in tube and bundled tube structures subjected to lateral load under different zones’ International Research Journal of Engineering and Technology, Oct 2021
- [8] PatilKiran Kumar, Chandan Kumar. Balaji. K.V.G.D, B. Santhosh Kumar, ‘Seismic performance of bundled tube structures in seismic zone IV & zone V of India’, International Journal of Advanced Research in Engineering and Technology, June 2022
- [9] AkhilBabu, Reni Kuruvilla, ‘Design and Analysis of RC Tube in Tube Structure using ETABS Subjected to Wind Load’, International Journal of Engineering Research & Technology (IJERT), June 2022
- [10] Amanthagiri Charan1, ShrihariSaduware, KhajaKamranuddin, ‘Comparison of Tube Frame and Tube in Tube Frame Structures for Different Plan Configurations’, International Journal of Research in Engineering, Science and Management, July 2022



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