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SEISMIC PERFORMANCE OF DIFFERENT TYPES OF TUBE SYSTEMS IN SEISMIC ZONE III OF INDIA

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Abstract: As all of you know day by day need of high-rise building is increases. As there is lots of parameters should be consider while designing of high-rise building. Safety is one of the important factors for than any other thing for human life. Along with safety we need to achieve economic structure. So, in design of high-rise building means technical parameters considers while designing. The various kinds of loads act on building and that building able to sustained that much amount of load. The effective load on building is seismic load and wind load are considered while designing. So, in this project new terms introduced as tube system is subsequent for high rise structure. Comparatively study of different types of tube systems and compute the how is this better for structure. In this project consider G+20 stories structure design by using ETABS software and study and compare the base reaction, story displacement, story stiffness for RC Structure and Tube Systems Structure. Computing the most suitable system for tall structure.

Index Terms **- Tube structure, Tube in tube, Bundle in tube, Framed tube, and Braced tube system, Time history analysis**

INTRODUCTION

Now a day there is need for multi-storied building due to overcrowding of cities. Multi-storied buildings are used for office, complex, residential flats etc. These multistoried buildings can be transformed into tall buildings in order to achieve more floor space but occupy less land space. Over the past few years' 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.

- **Framed tube system:** Framed tube structural system consists of closely spaced exterior columns that are rigidly connected with deep spandrel beams running continuously along each facade and around the building corners. This arrangement increases the beam and column stiffness by decreasing the clear span dimensions.
- **Tube in tube system:** This system is also known as hull and core and consists of core tube inside the structure which holds services such as utility and lifts. The inner and outer tubes interact horizontally as the shear and flexural components of a wall frame structure. They have the advantage of increased lateral stiffness.
- **Braced tube system:** Trussed also known as braced tube system are similar to the framed tube but have fewer exterior column spaces further apart. To compensate for the fewer columns, bracings are introduced to tie the column together. By interconnecting all the exterior column, it forms rigid box which is capable of resisting latera shear by axial in its member rather than through flexure,bending or curving.
- **Bundled tube system:** The bundled tube systems involves, instead of one tube, several individual tubes interconnected to form a multi-cell tube. Together they work to resist the lateral load and overturning moments. Not only is this system economically efficient but it also allows for more versatile building designs adopting interesting shapes and bundled in dynamic groupings rather than being simply box-like towers.

❖ Need of seismic study:

The **2021 Assam earthquake** struck 11 km (7 miles) away from Dhekjajuli, Assam, India on April 28, 2021 with a moment magnitude of 6.0 at 34.0 km (21.1 mi) depth. The quake struck with an epicenter 140 km (86 miles) north of the main city of Guwahati. The tectonics of the Assam region is dominated by convergence of the India, Burma and Eurasian plates. Major fault structures like the main frontal thrust, Main Boundary Thrust and main central thrust, all splay branches of main Himalayan thrust, accommodate the shortening rate as India is pushing into Asia. The large 8.6 M_w Assam Tibet earthquake in 1950 was a megathrust

earthquake that resulted from a rupture along the Main Himalayan Thrust and Main Frontal Thrust. 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 behavior 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 behavior of the RC Buildings.

❖ Objectives of study:

1. To analysed the seismic performance of different types of tube systems in seismic zone III of India using ETABS software.
2. Analysed and compare the impact of seismic and wind loads on tube-in- tube, bundled tube system, framed tube and braced tube system.
3. To study and compare the lateral base reaction, story displacement, story stiffness for RC Structure and Tube Systems Structure.
4. To determine the most suitable system for tall structure.

2. LITERATURE REVIEW

1.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
In this paper concluded that Tube Structures strongly resists earthquake forces as compare to Conventional Moment resisting frame. Both Tube Structures strongly support the earthquake design philosophy of Strong Column and Weak Beam. Tube in Tube Structure reduces maximum displacement about 38% as compared to maximum displacement of Conventional Moment resisting frame for seismic zones IV.Frame Tube Structure reduces maximum displacement about 27% as compared to maximum displacement of Conventional Moment resisting frame for seismic zones IV.

2.Ajit Kurey, Sanket Hanjage, Muzhir Chause, Saurabh Gawande, 'Comparative Study of Tube in Tube System and Bundled Tube System for High Rise Building', International Journal of creative research thought, June 2021
In this study the aim is to investigate the safe, effective and economical structural system between Tube in Tube system and Bundled tube system. The ETABS models of Tube in Tube and Bundled tube system which is G+20+Terrace story, are considered for analysis. The modeling and analysis of the building has been done by using structure analysis tool ETABS2018.both the building models are subjected to gravity as well as seismic loading, and analyze by using Equivalent static and Response spectrum analysis method.

3.Syed Musthafa Khadri, 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
In this research, 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 is done to find most efficient structure to improve system's lateral stability. The tubes in tube structures with shear wall are comparatively more efficient in resisting wind loads than that of seismic loads compare to other models.

4.Patil. Kiran Kumar, Chandan Kumar. Balaji. K.V.G.D, B. Santhosh Kumar, 'seismic performance of bundled tube structures in seismic zone IV & zoneV of India', International Journal of Advanced Research in Engineering and Technology, June 2022
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 is established with the higher specific performance of peak characteristics is found in comparison with the framed tube structure for the similar seismic characteristics.

3. METHODOLOGY

- For the study reinforced concrete structure is considered, having G+20 stories height of each floor is considered as 3 m height.
- For the reference base model, a regular reinforced concrete moment resisting frame model is considered.
- 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.
- The floor height is kept constant for all models in order to get consistent results.
- To understand the behaviour under lateral loads the loads are applied as per IS 1893: 2016 for seismic and IS 875:2015 (part III) for wind are used.
- Based on the results and responses from applied gravity, Wind and seismic loads, conclusion will be made

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 system structure
- Model 5- Bundle tube system structure

Modelling Data:

1)Width – 30 m, Length – 30m
2)Location: Location of the building is assumed to be in Pune region (Zone III)
3)Grade of steel – Fe 415 & Grade of concrete M30
4)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.

Structural member sizes:

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

2)Uniform slab thickness of 200 mm is adopted.

Story	Size of Column (mm)
Ground to 5th floor	850x850
6th to 10th Floor	700x700
11th to 15th floor	550x550
16thto 20th floor	400x400

Models of ETABS as following:

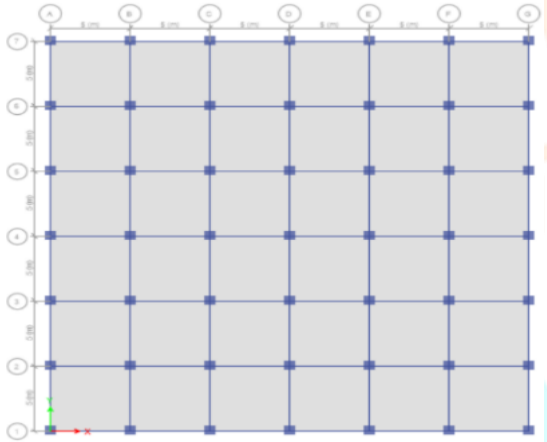

Fig 3.1 Plan of Conventional RC Structure

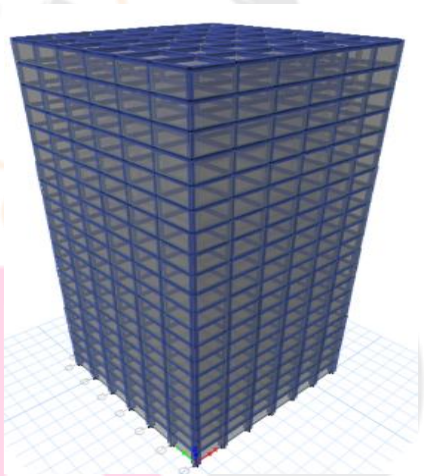

Fig 3.2 3D view of Conventional RC Structure

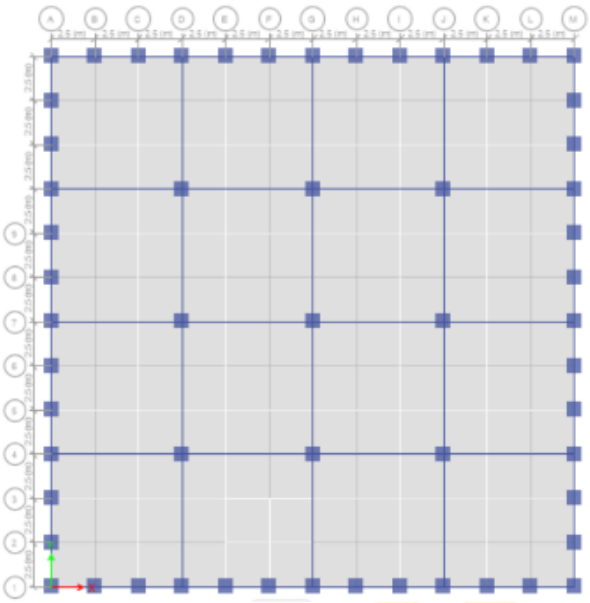

Fig 3.3 Plan of Frame Tube system structure

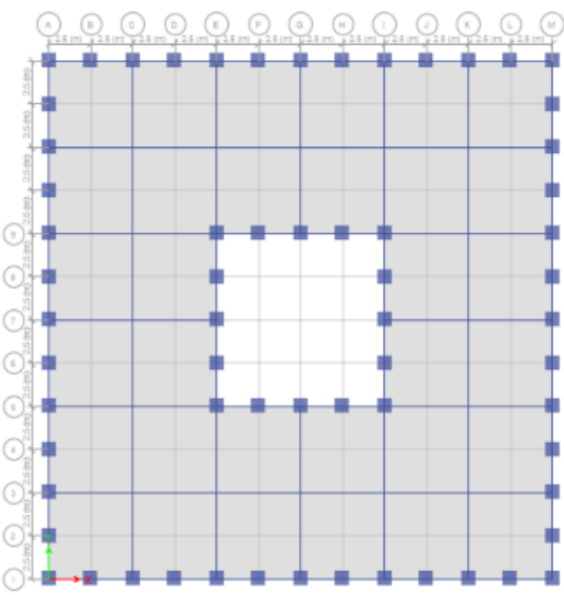

Fig 3.4 Plan of Tube in Tube system structure

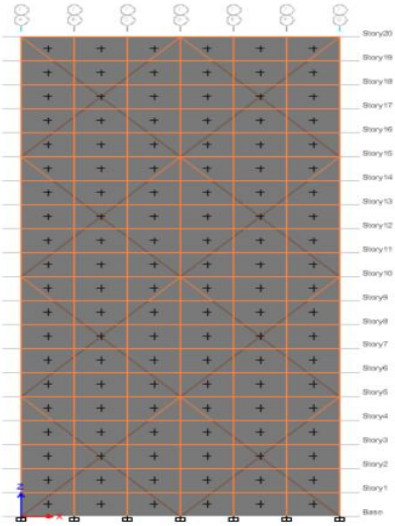

Fig.3.5 Elevation view of Braced tube system

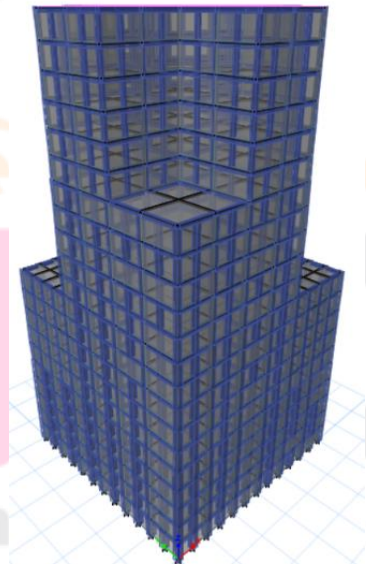

Fig.3.6 3D view of Bundle tube system

4. RESULTS AND DISCUSSION:

4.1 STOREY DISPLACEMENT:

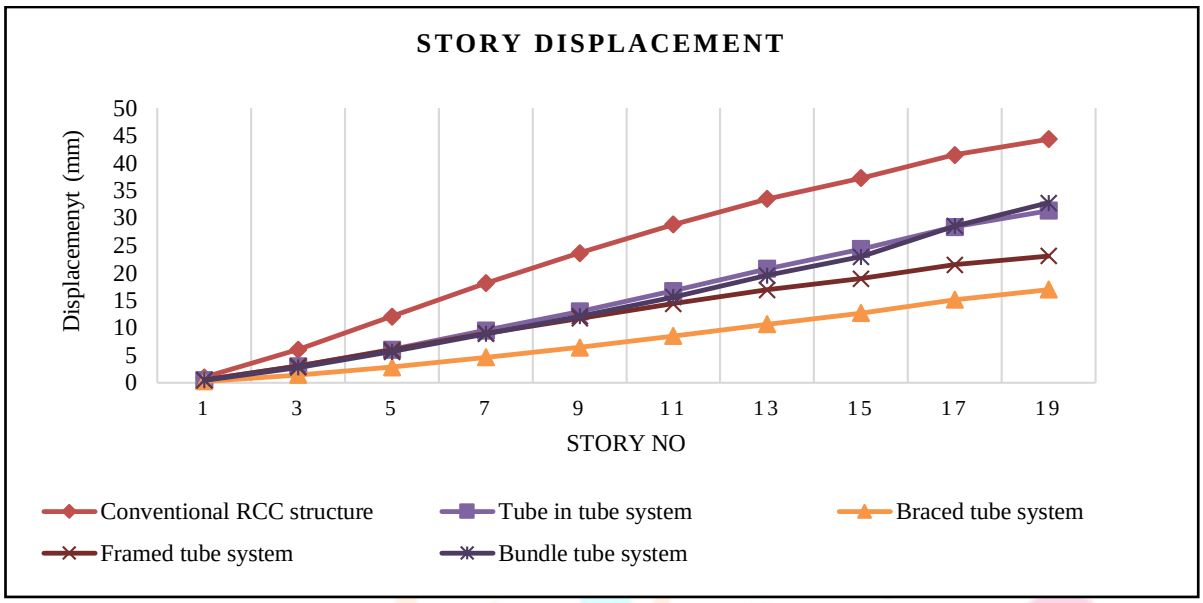

Figure 4.1: Story Displacement for different Tube Systems

- 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 storey 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).

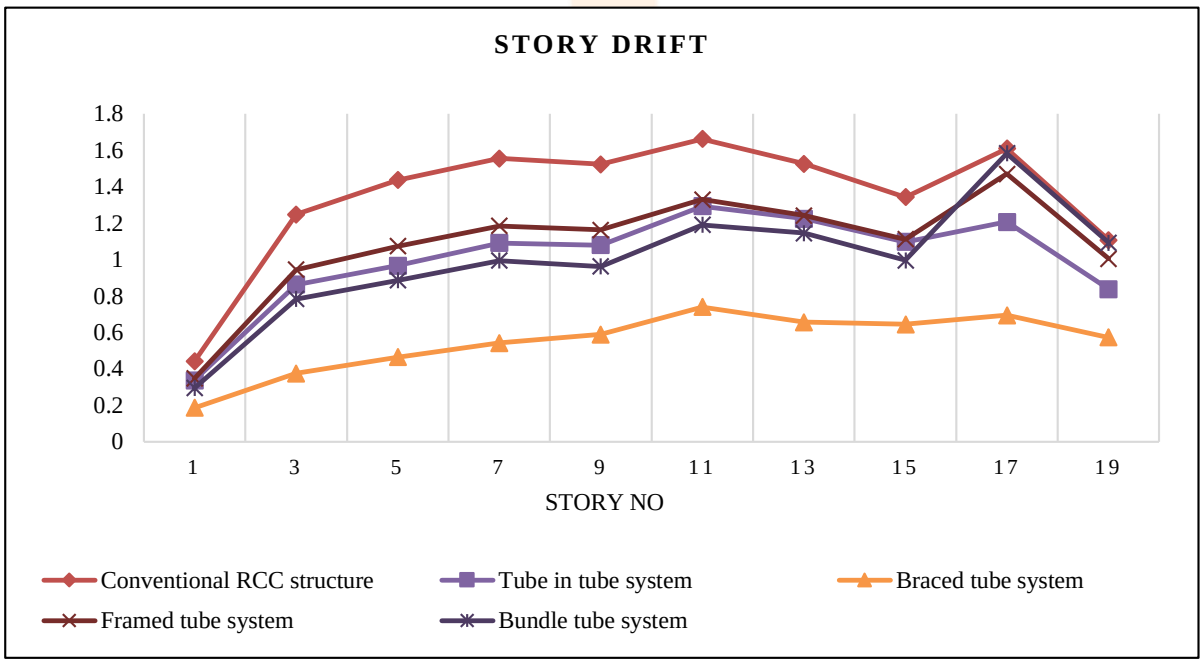

Figure 4.2: Story Drift for different Tube Systems

- 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. Tube in tube show intermediate effect of story drift.
- 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 REACTION:

Base reaction 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.

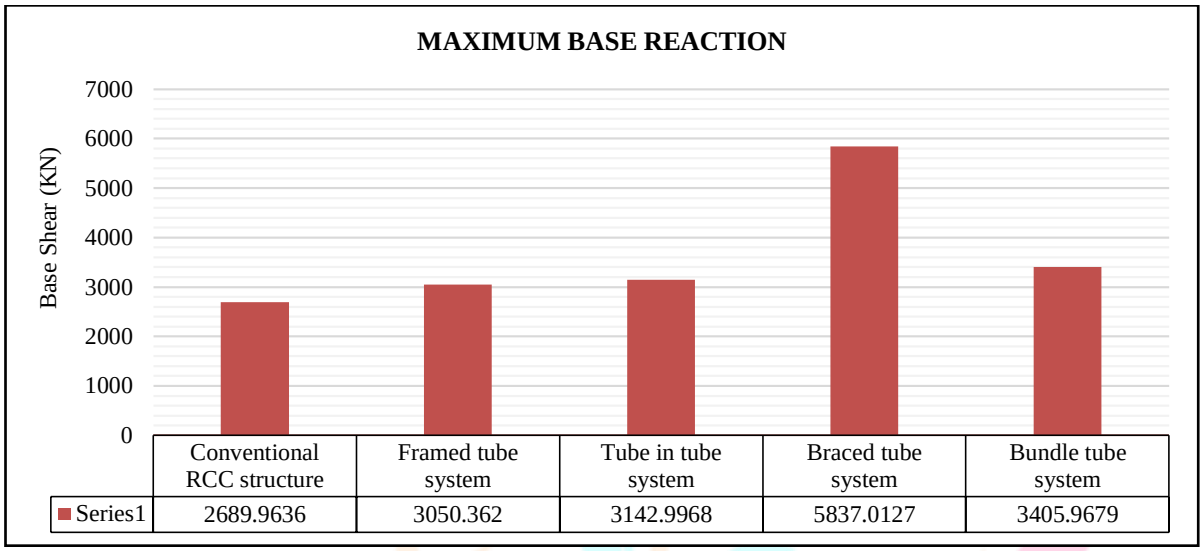

Figure 4.3: Base shear for different Tube Systems

- The bases shear value for Conventional RC structure is least and that of Braced tube system is maximum.
- It can be observed that the base shear of Frame tube system is increased by 13.39%, Tube in tube by 16.8%, Braced tube by 116.9%, Bundle tube by 26.61% compared to Conventional RC structure.

4.4 MAXIMUM BASE MOMENT:

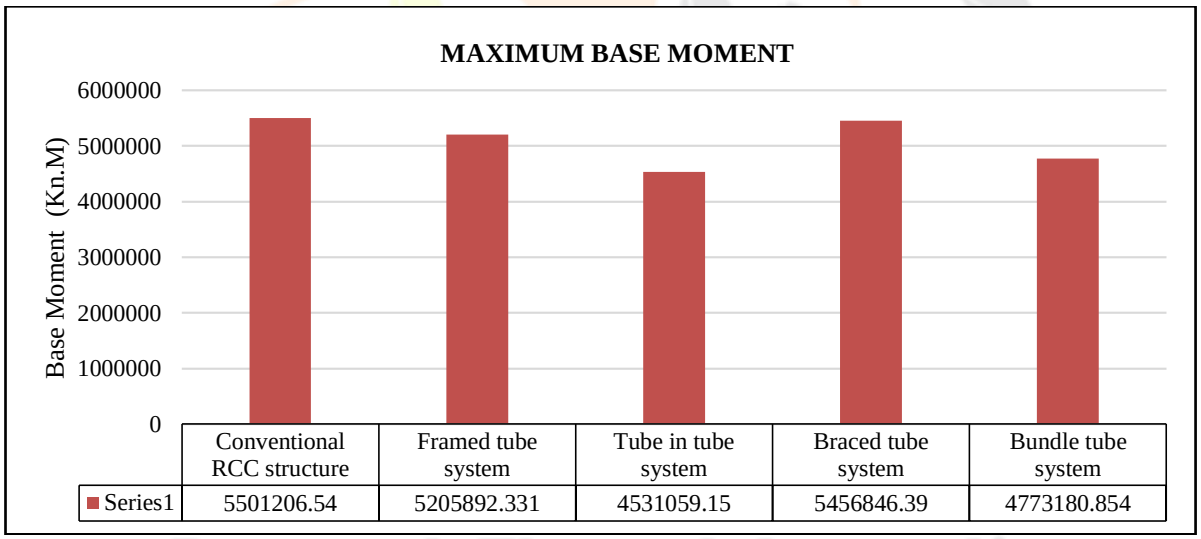

Figure 4.4: Base Moments for different Tube Systems

- The base moment value for Conventional RC structure is more and that Tube in tube 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 tube in 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 5.3%, Tube in tube by 17.6%, Braced tube by 0.8%, Bundle tube by 13.23% compared to Conventional RC structure.

4.5 MAXIMUM STORY STIFFNESS:

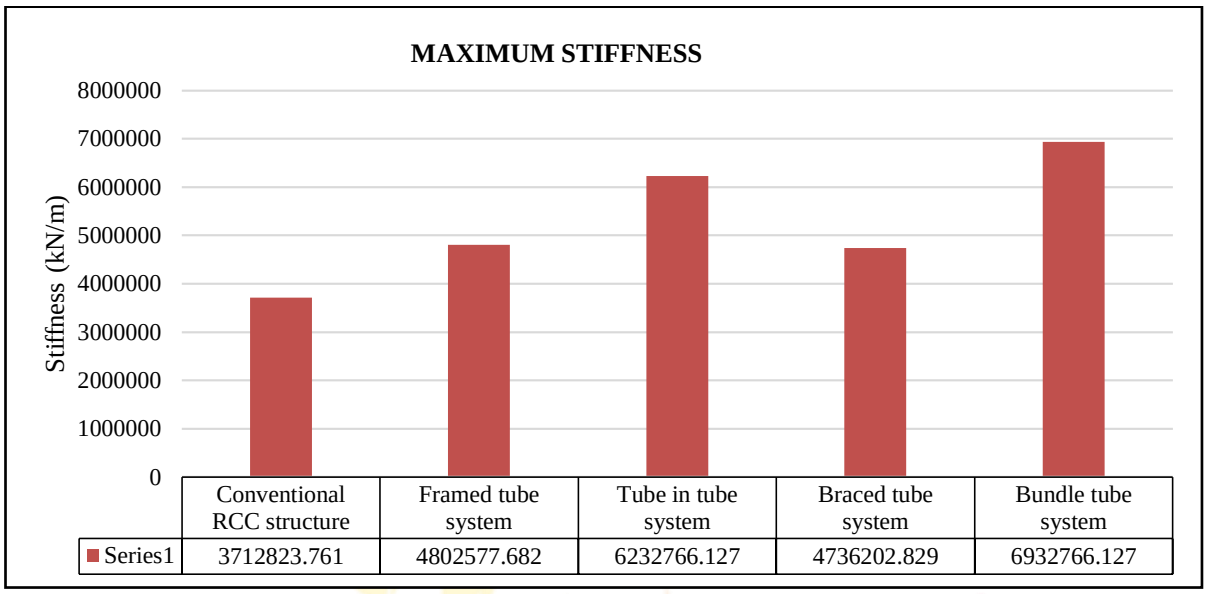

Figure 4.5: Maximum stiffness for different Tube Systems

- 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 29.35%, Tube in tube by 67.87%, Braced tube by 27.56%, Bundle tube by 108.1% compared to Conventional RC structure.

5. CONCLUSION:

1) 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 8.96% in both X and Y directions respectively. It is found to be more efficient among all the systems.

3) Base reaction: The base reaction 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. It means it is more stable to sustain the load.

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. Tube in tube system shows maximum base moment reduction as compared to all other systems.

4) 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.

5) Braced tube system found to be most suitable system for resisting both gravity and lateral loads.

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