PERFORMANCE BEHAVIOR OF TUBE MEGA FRAME STRUCTURE FOR HIGH -RISE MULTI-STOREY BUILDING USING ETABS

Ganesh Narayan Sharma[1], Vinod Kumar Modi[2], Imran Ali[3]

[1]PG Scholar, Department of Civil Engineering, Kautilya Institute of Technology & Engineering, Jaipur

[2] Assistant Professor, Department of Civil Engineering, Kautilya Institute of Technology & Engineering, Jaipur

[3]Assistant Professor, Department of Civil Engineering, Bhartiya Institute of Engineering & Technology, Sikar

Abstract: - High-rise structures require efficient lateral load-resisting systems to withstand wind and seismic forces. The Tube Mega Frame system is an advanced structural concept that enhances stiffness and reduces lateral displacements in tall buildings. This study investigates the performance of various structural systems, including Rigid Frame, Rigid Frame with Central Shear Wall Core, Tube-in-Tube Frame, Tube Mega Frame, Tube Mega Frame with Central Shear Wall Core, and Suspended Tube Frame. The objective is to compare their seismic and wind load responses, optimizing structural performance for high-rise construction. A detailed Response Spectrum Analysis (RSA) is conducted in ETABS, following the guidelines of IS 1893 (Part-1) 2016 for seismic analysis and IS 875 (Part-3) 2015 for wind load assessment. The study considers a wind speed of 47 m/s and models the structures in Earthquake Zone 4. Key parameters such as lateral displacement, inter-storey drift, base shear and fundamental time period are evaluated. The findings indicate that the Tube Mega Frame with Central Shear Wall Core exhibits superior lateral stiffness and reduced inter-storey drift compared to other systems. The Suspended Tube Frame also demonstrates significant structural efficiency, distributing loads effectively. The study provides valuable insights into selecting optimal structural systems for high-rise buildings, enhancing both safety and performance.

Keywords: Tube Mega Frame, High-Rise Structures, Response Spectrum Analysis, Seismic Performance, Wind Load, Structural Optimization, ETABS, IS 1893, IS 875, Lateral Stiffness

1. Introduction

The Tube Mega Frame Structure has become a viable solution because of its superior lateral stiffness, load-bearing capacity, and overall structural stability. The rapid urbanization and rising demand for high-rise buildings have prompted the development of innovative structural systems to ensure stability, efficiency, and resilience. This system integrates a number of interconnected tubular frames to form a rigid outer shell, reducing the need for internal columns while improving resistance to lateral forces like wind and seismic loads.

The development of high-rise structures has prompted the creation of a number of structural systems designed to provide efficiency, stability, and resistance to lateral forces including seismic loading and wind. Choosing the right structural system is essential for increasing structural performance, maximizing material use, and boosting general safety. Some trending systems are:

Rigid frame system, Braced frame system, Braced frame with shear wall system, Shear walled frame system, Framed tube system, Braced tube system, Outrigger system, Bundled tube system, Diagrid or hexagrid system, Tube Mega Frame Structure.

1. Braced Frame System: - A braced framed is commonly used in tall building structures to resist the lateral loads such as wind or seismic load. The members in braced frame are made up of steel which are used for tension and compression. In this structural system the beams and columns are design to carry vertical loads, and the bracing system carries the lateral loads. There are three types of bracing system

2. Diagrid Structure System: - Diagrid is an exterior structural system in which all perimeter vertical columns are eliminated and consist of only inclined column. On the façade of the building. In this type of structural system, the shear and overturning movement developed are resisted by axial action of these diagonals compared to building of vertical columns in framed tube structure.

3. Outrigger system: - The outrigger structural system is lateral load resisting system in which the external peripheral columns are tied to the central core with very stiff outriggers and belt truss at or more levels.

4. Tube Mega Frame Structure: - The Tube Mega Frame Structure is a cutting-edge structural structure intended to improve high-rise buildings' overall stability and effectiveness. Its strong outer tube framework, which is usually composed of deep beams and closely spaced columns, creates a hollow, tube-like exterior. This device functions as a cantilevered hollow tube that is secured at the foundation to successfully withstand lateral stresses, including seismic and wind forces.

Key Features:

1. The mega frame's substantial structural components greatly lessen lateral movement.
2. The perimeter tube structure maximizes interior space by reducing the requirement for internal columns.
3. The technology is ideal for supertall buildings because it improves stiffness and load distribution.

Concept of Tube Mega Frame Structures

The Tube Mega Frame Structure is a high-rise structural solution that uses a rigid external framework that functions similarly to a hollow tube to effectively withstand lateral and vertical loads. This idea was presented in order to improve stiffness, stability, and material efficiency while overcoming the drawbacks of conventional structural systems in tall buildings.

Advantages of Tube Mega Frame Structures:

1. High Lateral Stiffness: Effectively withstands seismic and wind pressures.
2. Material Efficiency: Uses less concrete and steel than traditional techniques.
3. Flexibility in architecture: This enables open floor plans with few internal obstacles

2. Literature Survey

Abhishek et. Al. 2023[1] investigated the seismic response with economic aspects and structural efficiency of tubed mega frames and tube in tube structures. This research shows that Tubed Mega Frames Economic systems achieve optimal material usage while proper load distribution through their design structure and Tube-in-Tube Structures enhance both structural strength and seismic protection capabilities. The research determines the need for integrated system frameworks which unite beneficial features of each framework in order to boost whole high-rise building operational quality.

Md. Ashraful Alam, Syed Ishtiaq Ahmad, and Md. Ashiqur Rahman 2021[2] in their research on Tall Building Structural Systems. Multiple modern structural frameworks for high-rise buildings including tube-based structures and outrigger systems with core-braced frameworks are researched by the researchers. Design freedom and structural efficiency must fuse together for architects because such alignment improves lateral stability through protective features which combine both appearance quality and operational sufficiency. The tube mega frame system stands as a top selection for modern high-rise construction methods because its basic tube framework creates robust protection against wind forces while also ensuring seismic protection.

Yahia Halabi, Wael Alladdad, Hu Xu and Hong GangLei 2020[3] introduced various theoretical approaches and technical methods that professionals used for designing optimal outrigger systems and belt-trusses in their initial structure phases and final solutions. The article contains tabulated data that consolidates evaluated study conclusions to display how different factors influence the optimal outrigger system topology and dimensioning. This evaluation establishes a foundation to develop exclusive standards that will guide the design of tall buildings that implement belt-trusses alongside outriggers. The development of more efficient techniques needs attention to improve ideal topology and size design approaches for the outrigger system. Future investigations need to determine the design potential of outrigger and belt-truss system components particularly regarding differential shortening and lock-in forces effects.

ReihanehTavakoli, Reza Kamgar, Reza Rahgozar 2019[4] studied seismic behavior of buildings incorporated with outrigger bracing elements and including soil-structure interaction effects. Studying the ideal location of outrigger systems together with belt truss systems was the purpose behind these tests. Basically, both systems exhibited larger base shear and overturning moment values during elastic analysis according to their findings. The height of belt truss placement at upper floors produced better results in terms of decreased roof displacement values.

3. Overview of work

In this research work on six different types of structures were analyzed in New Delhi zone i. e. seismic zone IV and wind zone IV (47 m/sec). Hence the analysis criteria were taken from IS 1893 (Part-1): 2016 and IS 875 (Part-3): 2015 for seismic and wind factors respectively.

For analysis of tall structures dynamic analysis (Response spectrum analysis) was preferred because it is more realistic and accurate prediction of the performance behavior of the structure. And for dynamic analysis, response spectrum function was defined as per IS 1893 (Part-1): 2016 for seismic zone IV in both x and y directions named as RS-X and RS-Y respectively.

4. Specifications for analysis

The design data which is used in analysis of building is as follows:

Bracing type	-	X-type
Modelling	-	Etabs software 18.1.1
Seismic Zone	-	Zone-IV
Located	-	Delhi
Live load	-	3.0 kN/m^2
Roof Live Load	-	1.5 kN/m^2
Floor finish	-	1.5 kN/m^2
Roof finish	-	1.5 kN/m^2
Earthquake load	-	As per IS 1893 (Part-1):2016
Wind load	-	As per IS 875 (Part-3):2015
Type of soil	-	Type II (Medium soil) as per 1893 (Part-1):2016
Storey height	-	3.0 m
Slab thickness	-	150 mm
Size of beams	-	400 mm x 600 mm
Size of columns	-	400 mm x 600 mm

5. Modelling and Analysis

A symmetrical floor plan of 45 m x 25 m shown in figure-1 of 30 storeys were considered for the modelling of all structures.
Model 01 is RCC structure with Rigid frame
Model 02 is Rigid frame with central shear wall core
Model 03 is Tube in tube frame
Model 04 is Tube mega frame
Model 05 is Tube mega frame with central shear wall core and
Model 06 is Suspended tube frame structure

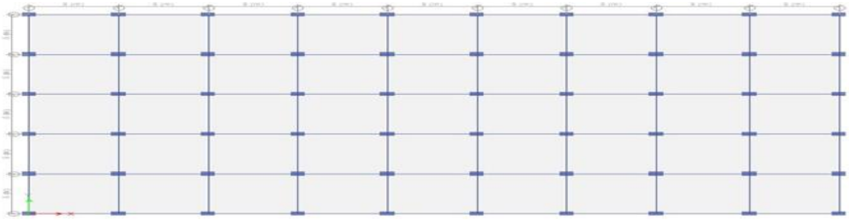
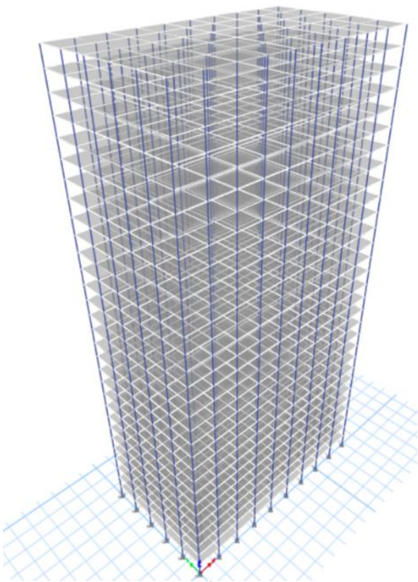
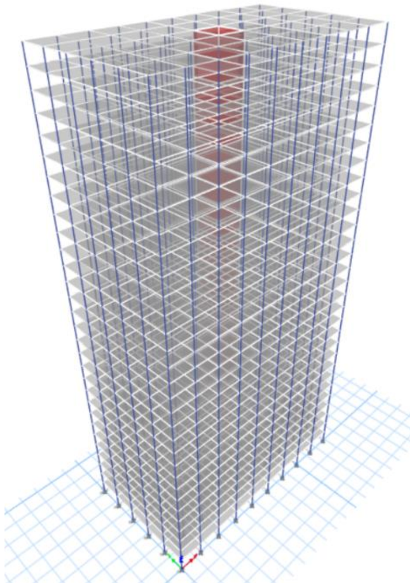


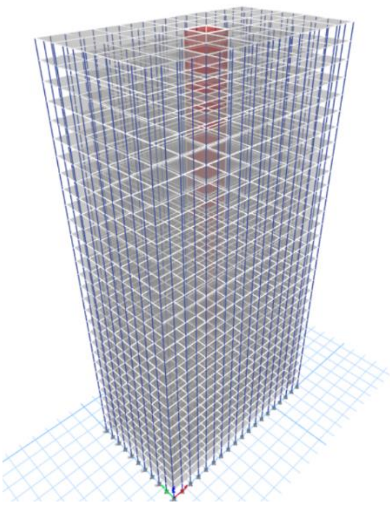
Figure-1 Plan of building for all models



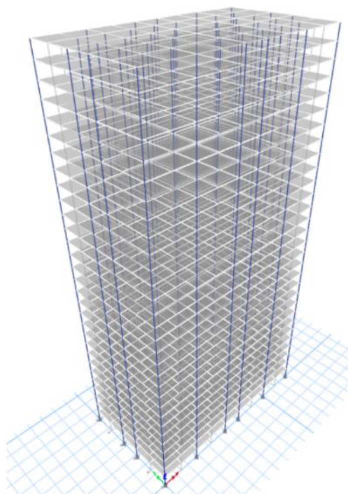
(a) Rigid frame



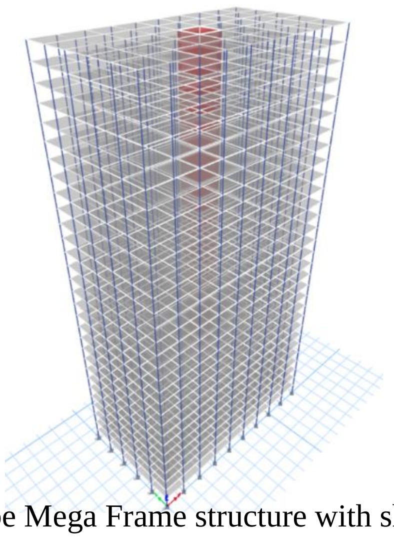
(b) Rigid frame with shear wall core



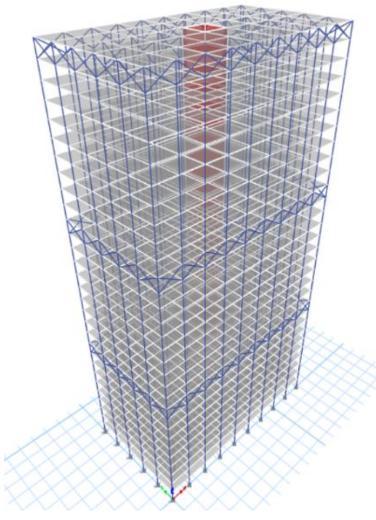
(c) Tube in tube structure



(d) Tube Mega Frame structure



(e) Tube Mega Frame structure with shear wall core



(f) Suspended Frame structure

Fig. 2 3D elevation of all models

6. Results

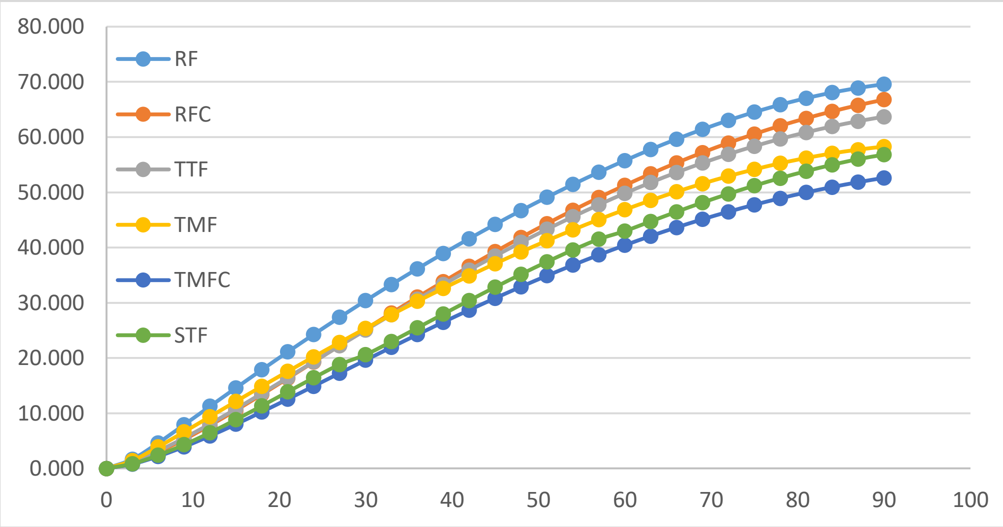


Figure 3 Displacement v/s Storey height for RS-X in X-direction

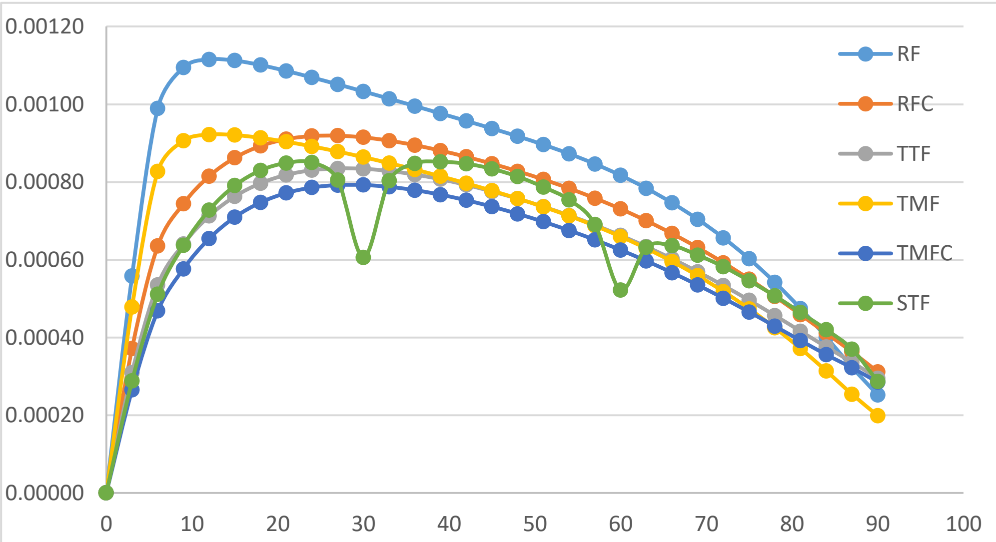


Figure 4 Storey drift v/s Storey height for RS-X in X-direction

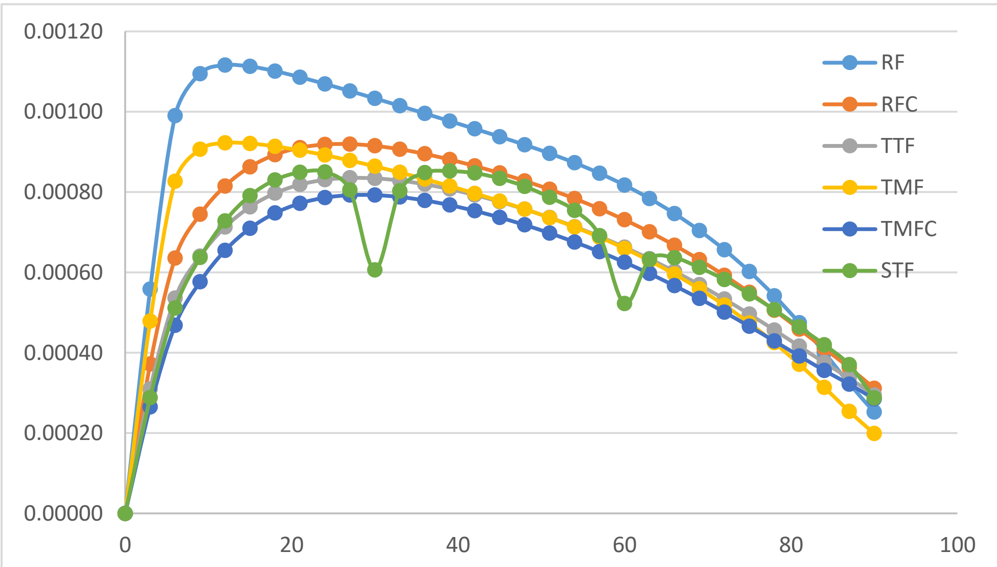


Figure 5 Storey drift v/s Storey height for RS-X in X-direction

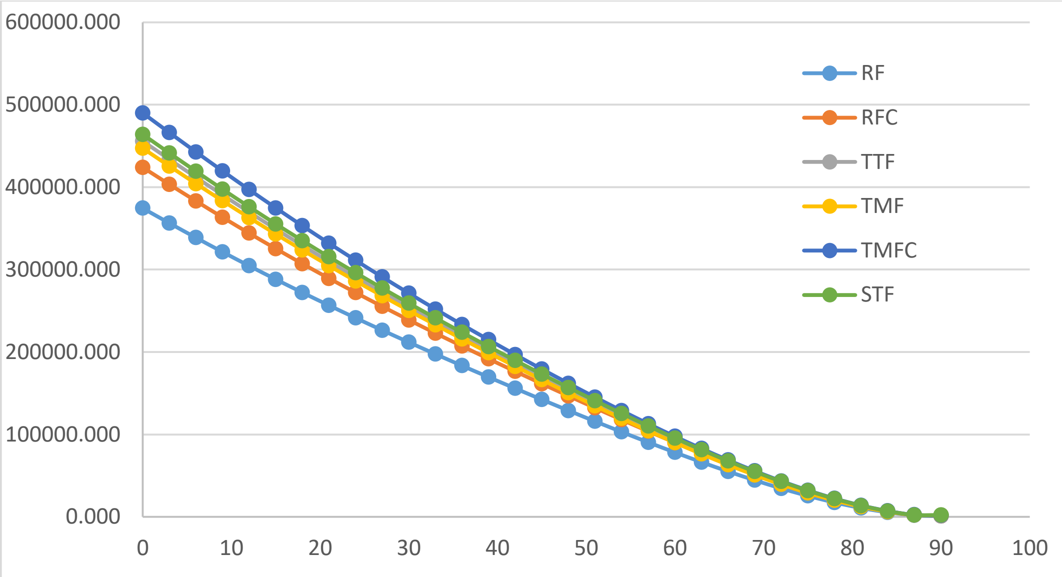


Figure 6 Storey shear v/s Storey height for RS-X in X-direction

7. Conclusion

It was analyzed that Tube Mega Frame with Central Shear Wall Core (TMFC) exhibited the best overall performance, outperforming the other models in terms of lateral displacement, storey drift, and structural stability**.** TMFC demonstrated enhanced lateral stiffness due to the combined effect of the tube system and a central shear wall**,** reducing both displacements and drift significantly. The Suspended Tube Frame (STF)**,** despite offering improved load distribution, showed higher displacements compared to TMFC. The Tube in Tube Frame (TTF) outperformed Rigid Frames in testing however Tube Mega Frame Systems achieved superior results which demonstrates that TMFC represents an advanced version of the Tube in Tube system design. Evidence shows that Tube Mega Frame without Central Shear Wall (TMF) exhibits lower stiffness together with higher drift compared to TMFC which confirms that central shear walls substantially increase structural resistance. The optimized force distribution demonstrated by TMFC proved base shear and moment values thus making it a superior option for high-rise structures built in seismic-prone areas.

7. References

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