DYNAMIC ANALYSIS OF TALL BUILDINGS IN VARIOUS SEISMIC ZONES WITH CENTRAL SHEAR WALLS AND DIAGONAL BRACINGS USING E-TABS SOFTWARE

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Abstract

Since land prices are rising quickly and there is a shortage of available land, tall buildings are preferred in order to preserve agricultural land in rural areas. The main factors influencing tall building design are wind and seismic loads. In the current study, tall buildings were examined in all seismic zones using ETABS 2017 software under the influence of seismic loads with a central shear wall and diagonal bracings, and the results were analysed using the response spectrum method. In addition, the configurations' story displacement, story drift, and base shear at foundations were compared to the seismic parameters derived from the analysis.

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1. Introduction

Tall buildings vary depending on the environment in question. It will be simple to say that a four story building in a neighborhood of bungalows is a tall building, and this claim will be uncontested. It's comparable to a one-eyed man ruling a land of the blind.

The construction boom in metro areas over the past 20 years has significantly altered the skyline of Indian cities. The fanciest skyscrapers, home to some of the wealthiest people in the nation, are now dotted throughout areas that were previously dominated by low-rise residential compounds. An approximate count places Kolkata second with 12 skyscrapers, followed by Mumbai with over 50. The tallest buildings in India that are currently operational and livable are listed below, despite the fact that many skyscrapers are still being built.

Tube Structure

One of the often-used lateral stability solutions in tall structure designs is the tube system. It is meant to have a vertical cantilever and operate as a hollow cylinder. This makes it possible to construct a never-ending, rigid "shell" surrounding the building's exterior.

Types of Tubular Systems

Framed tube structures are made up of frames that are connected by deep girders and have columns that are 2 to 4 m apart from one another in close proximity. The goal is to build a structure that resembles a tube and serves as a continuous perforated stack or chimney. Rigid moment-resisting frames that form a tube around the building's exterior are responsible for this structure's lateral resistance.

Braced Tube Structures: The tubular construction is reinforced even further by X-bracings placed throughout the whole structure to cross-brace the frame. Because the braced tube diagonals are connected to the column at each intersection, shear lag effects in flange and web frames are eliminated. The structure reacts to lateral loads like a braced frame because there is less bending in the frame components.

Structures made of a framed tube that also has an interior elevator and service core are known as **tube-in-tube structures.** frameworks braced around the inner tube. Together, the outer and inner tubes of steel-framed structures can withstand lateral stresses and gravity. The outer tube always has a considerable influence, nevertheless, due to its greater structural depth. They might also be referred to as core structures or hull structures. An inner tube to sustain vertical transit needs and an outside tube comprised of large columns and beams make up the standard Tube-in-Tube construction.

Bundled Tube: An merger of individual tubes that results in a multiple cell tube is what is known as a bundled tube system. With this technique, large floor spaces and lofty heights are feasible. The shear lag in the flange beams in this system will be considerably decreased if internal webs are included.

Literature Survey

S Bhavanishankar, Vinod on "Comparative Analysis of Tubular Structures with Conventional Tall RC Structure" are being done. The study's data are modelled and analysed using the ETABS V17 application. A tall RC building with a 21-story 3D model is taken into account, as well as simulations of a tube framed structure in earthquake zones II and V, to analyse Foundation shear, lateral storey displacement, and storey drift are all factors. The duration of the tube structure was much less than that of a tall RC moment-resistant structural frame. Base shear under earthquake loads has improved for High Tubular Buildings in compared to High RC Moment-resistant Structural Frame. The top story displacement and storey drift values of tubular structures are well within acceptable limits and have lowered when compared to High RC Braced Frames Structures. Storey amplitudes for tubular structures increased as compared to the Tall RC Moment - resistant Structure. Work is being done on "Seismic Analysis of Tall Building with Central Core as Tube Structure" by **Mrunal P. Kawade1, Vivek S. Bangde, and G. H. Sawai.** A seismic load comparison between a 25-story high rise structure with such a core shear and a similarly sized Framed structure was done as part of the research. Eight variations of the same building design are compared against one another: rigid frame, flexible framework with core shear wall, tubes in tubes, tubes mega frames, suspending frames, trussed tubes, tubes in tubes a belt truss, outriggers, and a frame with a central core. Shear walls have long been known to improve the structural design of multi-story buildings. Multi-story structures must now have shear walls in order to resist lateral loads. India's seismic zone V structures were simulated using ETABS software. The study investigates lateral storey displacement, story drift, base shear, story shear, and time periods for rigid frames, frame shear walls, braced frames, suspended structures, tube-in-tube structures, and tubed mega framed buildings to ascertain the impact of seismic loads. According to IS 1893 (part 1), tests on dynamic behavior to zone V earthquakes were conducted in 2016. In nonlinear dynamics, frequency response approach is used.

During the course of their work on "Comparative Seismic Analysis of Conventional and RCC Tube in Tube Structure with Pentagonal and Hexagonal Geometry Subjected To Lateral Loads in Different Zones," **Sindhu Nachiar S, Anandh S, Sai Pavithra S, Lakhan Kumar Saini, Elina Thomas, and Boojith C S** discovered that the tube in tube framed structure, also known as hulls and core, which To acquire enhanced resistance to seismic stress, a traditional polygonal and hexagonal structure is compared to an RCC polygonal and hexagonal tube in tube construction. STAAD is used to methodically complete the analysis. Pro. The examination includes a lot of seismic zones (Zone II to Zone V). The study's findings characterise the tube-in-tube interactions and conventional structures' seismic reaction. This study may also help us determine which tube in a tube configuration is more susceptible to its traditional equivalent.

Gurudath C, Ganesh Bahadur Khadka, and Hafiz Faiz Karim are working on "Analysis of Multi-Storey Building with and without Diagrid System Using ETABS." Due to its effectiveness and more demanding criteria, the diagrid structural system that they devised has been widely utilised for modern tall projects. This is due to the system's distinctive geometric layout. For a G+14 story building, this project offers utilising ETABS 2015 to estimate the initial component sizes of R.C.C. diagrid structures using a stiffness-based design technique. In order to identify the best grid configuration for the diagrid construction and to further compare it to a traditional R.C.C. structure, the technique is used to it. The corresponding static technique is used to analyse a G+14-story building with a perimeter of 630,660,690 square feet. In terms of top story displacement, narrative drift, story rigidity, and tale overturning moment, a comparison of results analysis is given.

Objectives

1. To determine the effects of lateral stresses on tube-in-tube, rigid frame and trussed tube-frame constructions used in symmetrical tall buildings.
2. To compare the effects of seismic loads on RC special moment resistant frame structures throughout all seismic zones to structures with rigid frames, trussed tube frames and tube-in-tube frames.
3. Compare tall RC special moment resistant frame designs with rigid frame, tube-in-tube, and trussed tube frame structures using ETABS.
4. 4. To examine the base shear, storey drift, and vertical and horizontal storey displacement of tube-in-tube, rigid frame, and trussed tube frame structures.
5. To correct the building that among the models taken into account is most vulnerable to lateral loads.

2. Methodology

Table -1: Properties of Materials

RCC - Density	25 KN/m^3
Masonry - Density	18 KN/m^3
Compressive Strength, f_{ck} **Table -2:** Data / Parameters for the Analysis	40 N/mm^2(Beam) 40 N/mm^2(Column)
Steel, f_y	500 N/mm^2& 415 N/mm^2
Modulus of Elasticity, E_c	5000*(f_{ck})$^{0.5}$

Table -2: Data/Paremeters for the Analysis

Storey Height	3m
Wall &Shear wall Thickness	300mm and 400mm
Slab	150mm
Beam	300 x 750mm
Column	500 x 800mm
Frame System	Special RC Moment Resisting Frame

Parapet	750mm
Support	Fixed
Buildings	24m x 24m
Spacings	3m
Number of Storey	30
Bracings	ISMC 350
Damping	5%

Layout of Buildings

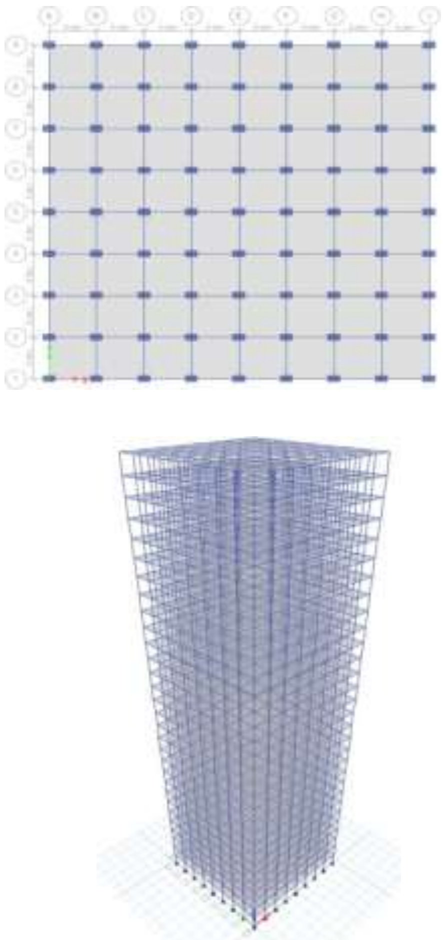
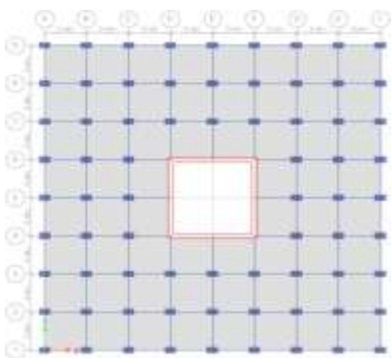


Figure 1 shows a rigid frame building's plan and 3D model.



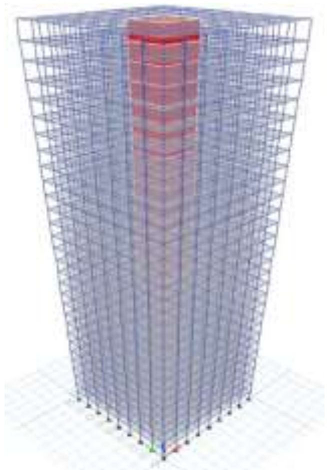


Figure 2 shows the design and 3D model of a tube-in-tube building.

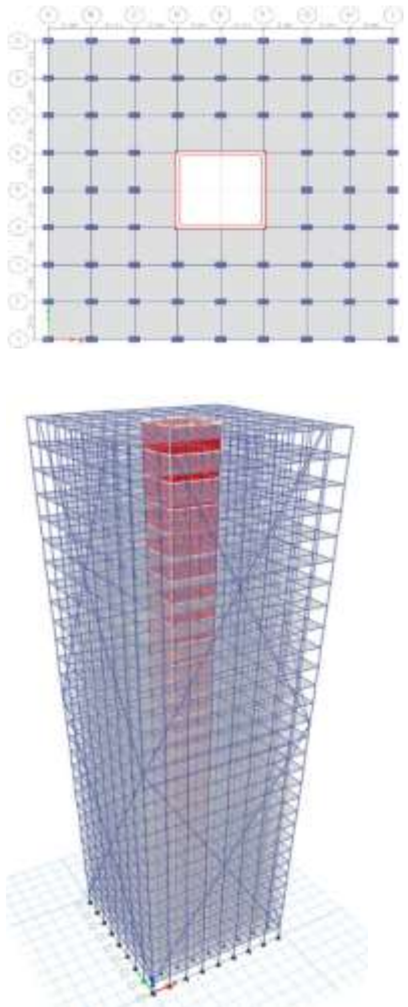


Figure 3 Plan and 3D Model of Trussed Tube Frame Building (Bracing-630)

3. Results and Discussions

Buildings in various seismic zones in India are compared using rigid frame, tube in tube frame, and trussed tube frame construction.

Rigid Frame Building

Chart -1: Displacement for EQX

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. In comparison to seismic zone 2, displacement has increased by 37.5%, 58.33%, and 72.22% in seismic zones 3, 4, and 5. The top story's displacement is taken into account.

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Chart -2: Displacement for EQY

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. In comparison to seismic zone 2, displacement has increased by 37.5%, 58.33%, and 72.22% in seismic zones 3, 4, and 5. The top story's displacement is taken into account.

Chart 1 and 2 above show that there is a 21.9% increase in displacements for all zones when compared to the EQX and EQY loads. The top story's displacement is taken into account.

Chart -3: Drift for EQX

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 59.86%, 33.36%, and 33.33%, respectively. The drift is taken into account for tale

1. When compared to the other stories of the rigid frame tall building, story 1 is experiencing the greatest tale drift.

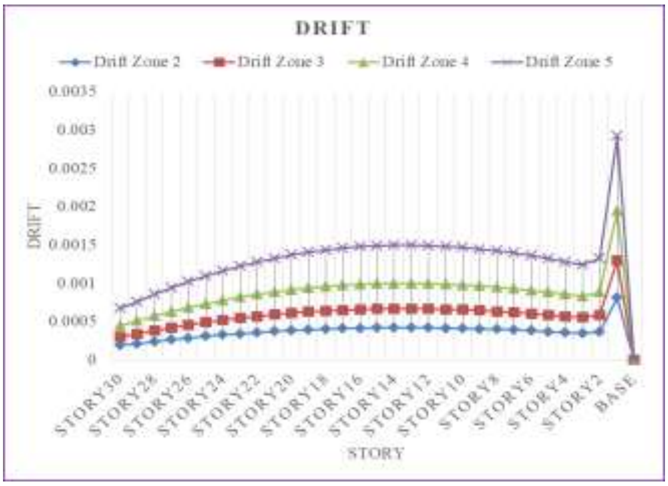


Chart -4: Drift for EQY

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 37.53 percent,
58.33 percent, and 72.22 percent, respectively. The drift is taken into account for tale 1. When compared to the other stories of the rigid frame tall building, story 1 is experiencing the greatest tale drift Chart 3 and 4 above show that there is a 43.84% increase in drift for all zones when compared to the EQX and EQY loads. For tale 1, the displacement is taken into account.

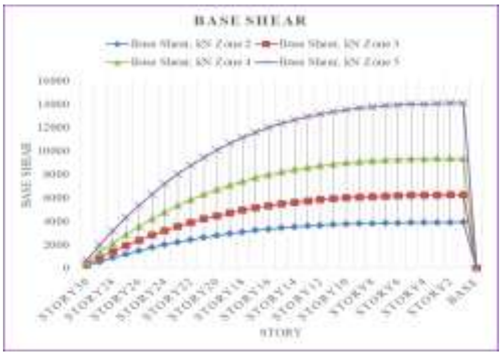
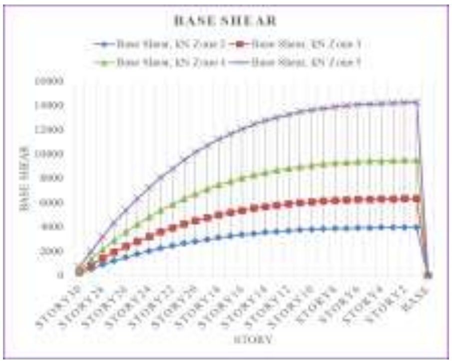


Chart -5: Base Shear for EQX

As can be observed from the above chart, base shear increases along with the seismic one intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.59%, 58.39%, and 72.26%. For narrative 1, the base shear is taken into account



. Chart -6: Base Shear for EQY

As can be observed from the above chart, base shear increases along with the seismic zone intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.5%, 58.33%, and 72.22%. For narrative 1, the base shear is taken into account.

According to the chart 5 and 6 above, the base shear has increased by 1.2% for all zones when compared to the EQX and EQY loads. For tale 1, the displacement is taken into account.

Tube in Tube Frame Building

Chart -7: Displacement for EQX

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. In comparison to seismic zone 2, displacement has increased by 37.5%, 58.33%, and 72.22% in seismic zones 3, 4, and 5. The top story's displacement is taken into account.

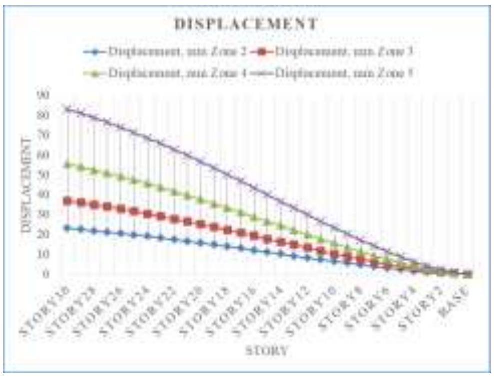


Chart -8: Displacement for EQY

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. In comparison to seismic zone 2, displacement has increased by 37.5%, 58.33%, and 72.22% in seismic zones 3, 4, and 5. The top story's displacement is taken into account.

Chart 7 and 8 above show that there is a 13.32% increase in displacements for all zones when compared to the EQX and EQY loads. The top story's displacement is taken into account.

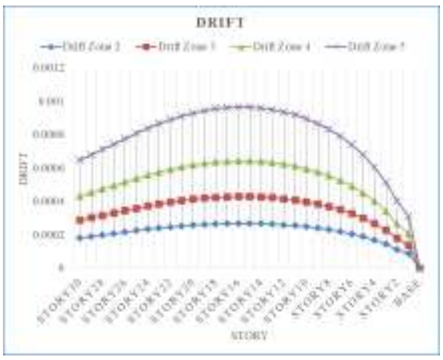


Chart -9: Drift for EQX

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 37.99%, 58.69%, and 72.46%, respectively. The drift is taken into account for narrative 15. Story 15 has the biggest narrative drift when compared to the other stories of the tall tube-in-tube design.

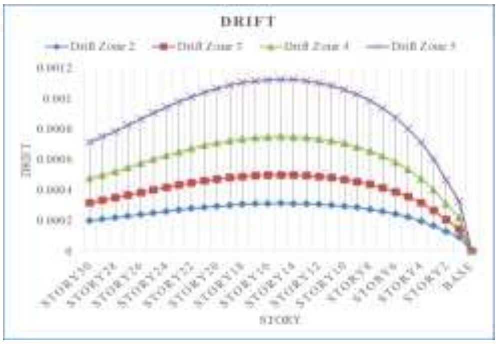


Chart -10: Drift for EQY

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 37.52 percent, 58.32 percent, and 72.22 percent, respectively. The drift is taken into account for narrative 15. When compared to the other stories of the rigid frame tall skyscraper, story 15 will experience the greatest tale drift. Chart 9 and 10 above show that there is a 14.37% increase in drift for all zones when compared to the EQX and EQY loads. For tale 1, the displacement is taken into account.

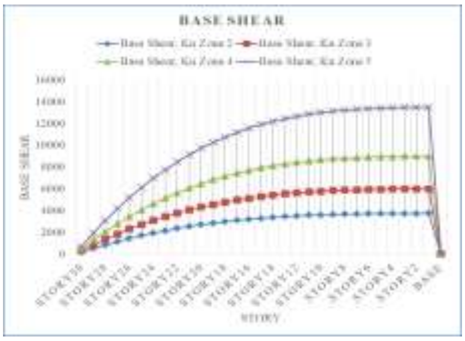


Chart -11: Base Shear for EQX

As can be observed from the above chart, base shear increases along with the seismic zone intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.49%, 58.33%, and 72.22%. For narrative 1, the base shear is taken into account.

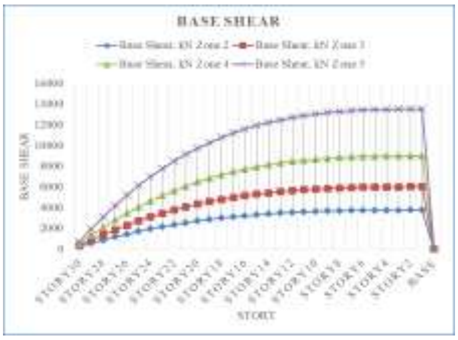


Chart -12: Base Shear for EQY

As can be observed from the above chart, base shear increases along with the seismic zone intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.5%, 58.33%, and 72.22%. For narrative 1, the base shear is taken into account.

Chart 11 and 12 above show that the base shear has increased by 0.31% for all zones when compared to the EQX and EQY loads. For tale 1, the displacement is taken into account.

Trussed Tube Frame Building

Chart -13: Displacement for EQX

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. Seismic zones 3, 4, and 5 show displacement increases of 37.49%, 58.33%, and 72.22% in relation to seismic zone 2. The top story's displacement is taken into account.

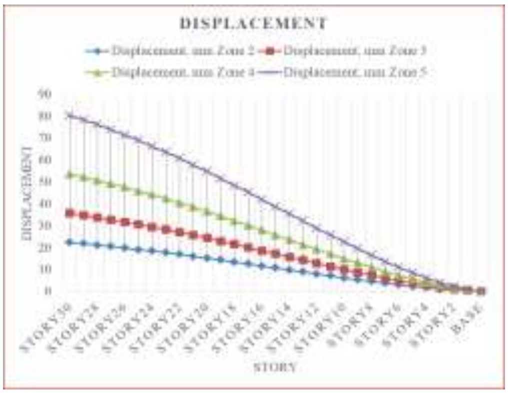


Chart -14: Displacement for EQY

The displacement increases along with the seismic zone intensity, as seen in the above figure, and the highest displacement was recorded in seismic zone 5. In comparison to seismic zone 2, displacement has increased by 37.5%, 58.33%, and 72.22% in seismic zones 3, 4, and 5. The top story's displacement is taken into account.
Chart 13 and 14 above show that there is a 12.6% increase in displacements for all zones when compared to the EQX and EQY loads. The top story's displacement is taken into account.

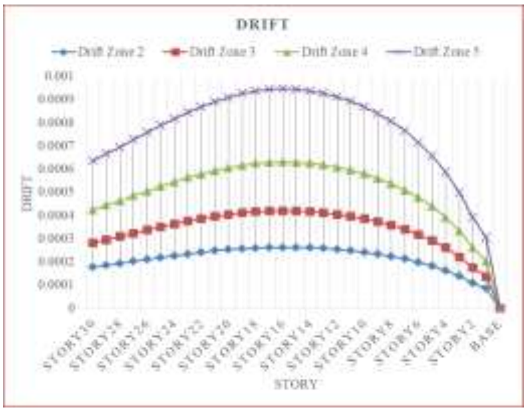


Chart -15: Drift for EQX

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 37.52%, 58.38%, and 72.25%, respectively. The drift is taken into account for narrative 15. When compared to the other stories of the rigid frame tall skyscraper, story 15 will experience the greatest tale drift.

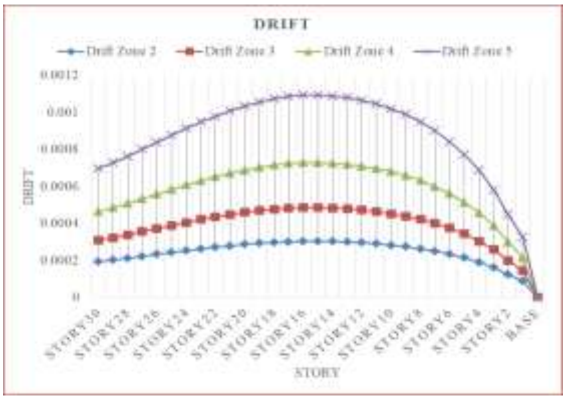


Chart -16: Drift for EQY

As can be observed from the preceding image, drift increases along with seismic zone strength, reaching its peak in seismic zone 5. In comparison to seismic zone 2, the seismic zones 3, 4, and 5 had drift increases of 37.57%, 58.35%, and 72.23%, respectively. The drift is taken into account for narrative 15. When compared to the other stories of the rigid frame tall skyscraper, story 15 will experience the greatest tale drift. Chart 15 and 16 above show that there is a 13.55% increase in drift for all zones when compared to the EQX and EQY loads. For narrative 15, the displacement is taken into account.

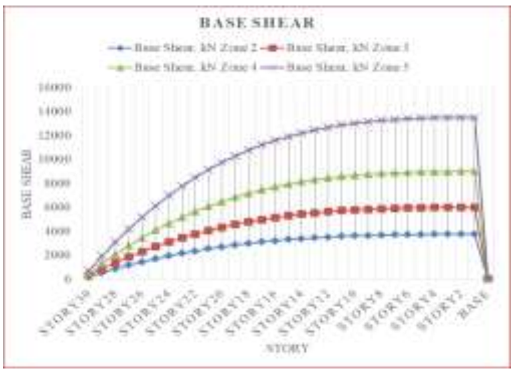


Chart -17: Base Shear for EQX

As can be observed from the above chart, base shear increases along with the seismic zone intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.5%, 58.33%, and 72.22%. For narrative 1, the base shear is taken into account.

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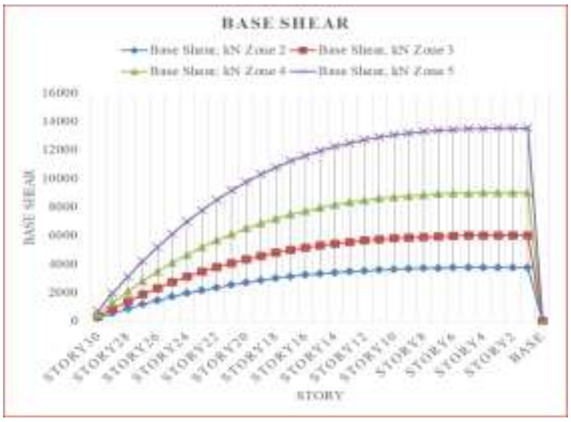

Chart -18: Base Shear for EQY

As can be observed from the above chart, base shear increases along with the seismic zone intensity, with seismic zone 5 experiencing the highest base shear. In comparison to seismic zone 2, seismic zones 3, 4, and 5 see increases in base shear of 37.5%, 58.33%, and 72.22%. For narrative 1, the base shear is taken into account. Chart 17 and 18 above show that the base shear has increased by 0.28% for all zones when compared to the EQX and EQY loads. For tale 1, the displacement is taken into account.

Comparison of Different Seismic Zones for Rigid Frame, Tube in Tube Frame and Trussed Tube Frame Building for EQY Load

The EQY load values have been used in this comparison because, as shown in clauses 5.1.1 to 5.1.3, the EQY load produces the highest levels of displacement, drift, and base shear when compared to the EQX load. As a result, the comparison below is conducted for EQY load.

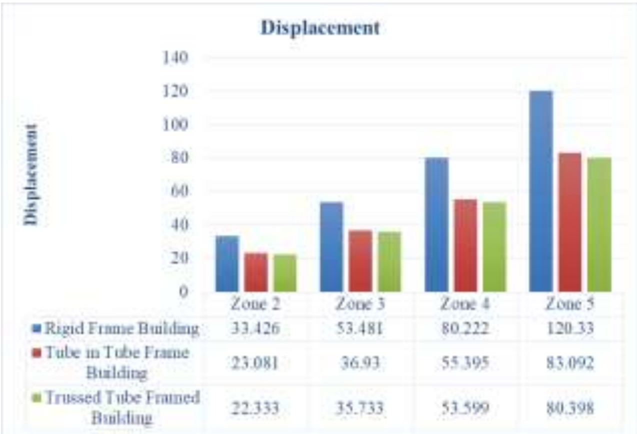

Chart -19: Displacement

According to chart 19, the trussed frame building experiences the greatest reduction in displacement across the whole seismic zone when compared to rigid and tube-in- tube frame buildings. For all seismic zones, the reduction from a rigid frame building to a trussed frame building is consistent at 33.18%. There is a constant decrease of 3.2% for tube in tube framed structures and trussed tube framed buildings, and a constant percentage decrease of 30.94% from rigid frame buildings to tube in tube framed buildings.

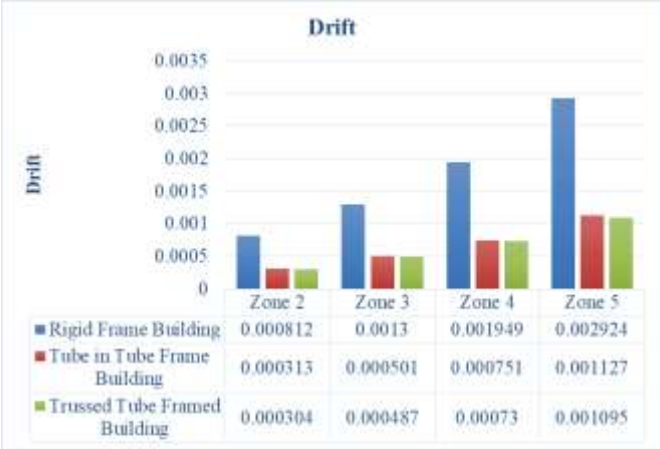

Chart -20: Drift

According to chart 20, the trussed frame building experiences the greatest reduction in drift across the whole seismic zone when compared to rigid and tube-in-tube frame buildings. For all seismic zones, there is a continuous reduction of 62.56% from rigid frame to trussed frame construction. There is a continuous percentage decrease of 62.56% from the rigid frame building to the tube in tube framed building, and there is a constant decrease of 2.87% for tube in tube framed buildings and trussed tube framed structures.

Chart -21: Base Shear

According to chart 21, the trussed frame building experiences the greatest reduction in drift across the whole seismic zone when compared to rigid and tube-in-tube frame buildings. When comparing rigid frame buildings to trussed frame buildings, there is a continuous drop of 5.2% for all seismic zones. There is a constant percentage gain of 0.034% for tube in tube framed buildings and trussed tube framed buildings, and a constant percentage drop of 5.53% for rigid frame buildings to tube in tube framed buildings.

4. Conclusion

Finding the stabilisation system that is most successful is a difficult undertaking because it seems there is no single solution that can satisfy all potential criteria. While certain systems have advantages over others, they are best suited for some criteria. The findings below can be drawn based on the analysis covered in chapter 5.

1. As seismic intensity or zones grow, displacement, drift, and base shear for rigid frame, tube in tube framed, and trussed framed buildings all rise.
2. For all rigid frame, tube in tube framed, and trussed framed buildings, there is a continuous increase in the displacement for both earthquake load in x- direction and y-direction. When compared to the other zones, zone 2 has the least displacement. When compared to zone 2, there is a consistent rise in displacement of 37.5% (zone 3), 58.33% (zone 4), and 72.22% (zone 5).
3. Compared to zone 2, rigid frame buildings' drift for earthquake loads in the x-direction increased by 59.86% (zone 3), 33.36% (zone

4), and 33.33% (zone 5). And when compared to zone 2, the rigid frame building's earthquake load in the y-direction increased by 37.53% (zone 3), 58.33% (zone 4), and 72.22% (zone 5).

The drift for tube in tube framed and trussed framed buildings is continuously increasing for both seismic load in x-direction and y-direction. When compared to the other zones, zone 2 has the least displacement. When compared to zone 2, there is a consistent rise in displacement of 37.5% (zone 3), 58.33% (zone 4), and 72.22% (zone 5).

4. For all rigid frame, tube in tube framed, and trussed framed buildings, there is a continuous increase in the drift for both seismic load in x-direction and y- direction. When compared to the other zones, zone 2 has the least displacement. When compared to zone 2, there is a consistent rise in displacement of 37.5% (zone 3), 58.33% (zone 4), and 72.22% (zone 5).
5. The maximum values obtained for the earthquake load in the y-direction as compared to the x- direction are described in Chapter

- Throughout the seismic zone, the trussed frame building experiences the greatest reduction in displacement as compared to rigid and tube in tube frame buildings. For all seismic zones, the reduction from a rigid frame building to a trussed frame building is consistent at 33.18%. There is a constant decrease of 3.2% for tube in tube framed structures and trussed tube framed buildings, and a constant percentage decrease of 30.94% from rigid frame buildings to tube in tube framed buildings.
- Throughout the seismic zone, the trussed frame building exhibits the greatest reduction in drift when compared to rigid and tube in tube frame buildings. For all seismic zones, there is a continuous reduction of 62.56% from rigid frame to trussed frame construction. There is a continuous percentage decrease of 62.56% from the rigid frame building to the tube in tube framed building, and there is a constant decrease of 2.87% for tube in tube framed buildings and trussed tube framed structures.
- Throughout the seismic zone, the trussed frame building exhibits the greatest reduction in drift when compared to rigid and tube in tube frame buildings. When comparing rigid frame buildings to trussed frame buildings, there is a continuous drop of 5.2% for all seismic zones. There is a constant percentage gain of 0.034% for tube in tube framed buildings and trussed tube framed buildings, and a constant percentage drop of 5.53% for rigid frame buildings to tube in tube framed buildings.
- Taking into account the aforementioned details, the trussed tube frame buildings experienced the greatest reduction relative to the others. But there is a negligible 0.034% increase in the base shear when compared to the tube in tube frame structures.
- The findings show that trussed tube frame buildings are among the most effective lateral load resisting methods employed in tall buildings across all seismic zones.

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