# DYNAMIC ANALYSIS OF TALL BUILDING LOCATED IN DIFFERENT SEISMIC ZONES WITH CENTRAL SHEAR WALL AND DIAGONAL BRACINGS BY 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.*

## 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.

### 1.1 Tube Structure

The tube system is one of the frequently used lateral stability systems in tall building designs. It is intended to function as a hollow cylinder with a vertical cantilever. This enables the construction of an endless stiff "shell" around the outside of the building

### 1.2 Types of Tubular Systems

**Framed Tube Structures:** Closely spaced columns with 2 to 4 m between their centres make up frames, which are joined by deep girders. The idea is to create a tube-like structure that functions as a continuous perforated stack or chimney. Stiff moment resisting frames that form a tube around the building's perimeter provide the lateral resistance for this structure.

**Braced Tube Structures:** By cross-bracing the frame with X-bracings throughout the entire building, the tubular structure is further strengthened. Shear lag effects in flange and web frames combined are essentially eliminated by the braced tube diagonals because they are connected to the column at every intersection. Because of the reduced bending in the frame members, the structure responds to lateral loads like a braced frame.

**Tube- in -Tube Structures:** Another type of framed tube, this one featuring an inner elevator and service core in addition to an outer-framed tube. The braced frames that make up the inner tube. In steel-framed buildings, the outer and inner tubes work together to resist lateral loads as well as gravity. However, because of its deeper structural depth, the outer tube always has a significant impact. Hull and core structures are other names for this class of buildings. The typical Tube-in-Tube structure consists of an inner tube to support vertical transportation demand and an outer tube made up of substantial columns and beams.

**Bundled Tube:** A bundled tube system can be thought of as an amalgamation of separate tubes that produces a multiple cell tube. Large floor areas and great heights are possible with this system. If internal webs are added to this system, the shear lag in the flange beams will be significantly reduced.

## 2.LITERATURE SURVEY

**S Bhavanishankar, Vinod** are carried out work on 'Comparative Analysis of Tubular Structures with Conventional Tall RC Structure' ETABS V17 program is used to model and analyse the data in the study. To analyse the time period, base shear, lateral storey displacement, and storey drift, a tall RC building with a 21-story 3D model is taken into consideration, together with simulations of a tube framed structure in earthquake zones II and V. As comparison to a Tall RC Moment - resistant Structural Frame, the Period Of time of Tube Structure was significantly lowered. As comparison to High RC Moment - resistant Structural Frame, High Tubular Buildings' base shear improved under earthquake loads. When contrasted to High RC Braced Frames Structures, Tubular Structures' stories displacement and top storey have decreased, and their top story displacement and storey drift values are well inside acceptable ranges. When compared to the Tall RC Moment - resistant Structure, storey amplitudes for tubular constructions increased.

**Mrunal P Kawade1, Vivek S Bangde, G H Sawai** are carried out work on 'Seismic Analysis of Tall Building with Central Core as Tube Structure' With in study, a seismic load comparison between a 25-story high rise building with such a core shear as well as a similarly sized Framed structure was made. The identical building plan's 8 configurations—rigid frame, flexible framework with core shear wall, tubes in tube structure, tube mega frame structure, suspending structure, trussed tube, tube in tube with outriggers & frame with central core, and outriggers & belt truss—are compared to one another. Shear walls have long been recognised as being helpful in the structural design of multi-story buildings. Shear walls must now be included in multi-story buildings in order to withstand lateral stresses. ETABS software was used to simulate the structures for India's seismic zones V. The study looks at lateral storey displacement, story drift, base shear, story shear, and time periods for rigid frames, frame shear walls, braced frames, suspending structures, tube-in-tube structures, and tubed mega framed structures in order to estimate the impact of seismic stresses. Dynamic behavior to zone V earthquakes were tested according to IS 1893 (part 1): 2016. Frequency Response technique is employed in nonlinear dynamic.

**Sindhu Nachiar S, Anandh S, Sai Pavithra S, Lakhan Kumar Saini, Elina Thomas, Boojith C S** are carried out 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' wherein they learned This problem is successfully solved by the tube in tube framed structure, also called as hulls and core, which comprises of an external framed tube and a centre core tube that are connected by floor slabs. In order to achieve higher resilience to earthquake loading, an RCC polygonal and hexagon tube in tube construction is contrasted with a traditional polygonal and hexagon structure. STAAD.Pro is used to do the analysis methodically. The analysis is done for several earthquake zones (Zone II to Zone V). The analysis's findings determine how traditional structures and tube-in-tube interactions react to earthquakes. From in this analysis, we can also determine which tube in a tube configuration is more susceptible to its traditional complement.

**Gurudath C, Ganesh Bahadur Khadka, Hafiz Faiz Karim** are carried out work on 'Analysis of Multi-Storey Building with and without Diagrid System Using ETABS' As a result of its effectiveness and higher standards, the diagrid structural system that they researched has been widely used for modern tall structures. This is because of the system's distinctive geometric configuration. For the purpose of estimating the initial component sizes of R.C.C. diagrid structures for a G+14 story building using ETABS 2015, this project proposes a stiffness-based design technique. To establish the best grid configuration for the diagrid structure and to further compare it to a traditional R.C.C. structure, the technique is used to the diagrid. By using the equivalent static method, a G+14-story building with a 630,660,690-square-foot perimeter is analysed. In terms of top story displacement, story drift, story stiffness, and tale overturning moment, a comparison of results analysis is offered.

## 3. OBJECTIVES

1. To ascertain how lateral loads affect symmetrical tall buildings with rigid frames, tube in tube frames, and trussed tube frame structures.
2. To examine how seismic loads affect structures with rigid frames, tube-in-tube frames, and trussed tube frames in relation to RC special moment resisting frame structures throughout all seismic zones.
3. Using ETABS, compare tall RC special moment resisting frame constructions with rigid frame, tube in tube frame, and trussed tube frame buildings.
4. To investigate the horizontal as well as vertical storey displacement, storey drift, and base shear for rigid frame, tube in tube frame, and trussed tube frame structures.
5. To fix the building that is most susceptible to lateral load among the models that were taken into consideration.

## 4. METHODOLOGY

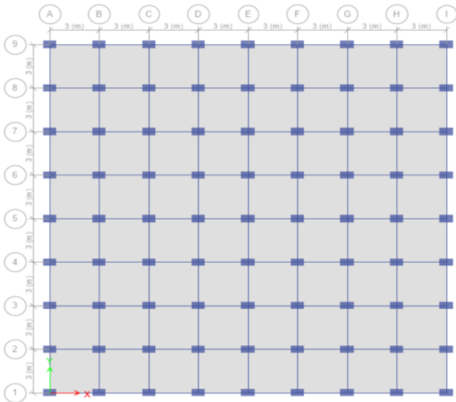
**Table -1:** Material Properties

| | |
|---|---|
| Density of RCC | 25 KN/m$^3$ |
| Density of Masonry | 18 KN/m$^3$ |
| Compressive Strength, $f_{ck}$ | 40 N/mm$^2$(Beam)<br>40 N/mm$^2$(Column) |
| Steel, $f_y$ | 500 N/mm$^2$&<br>415 N/mm$^2$ |
| Modulus of Elasticity, $E_c$ | 5000*( $f_{ck}$)$^{0.5}$ |

**Table -2:** Data / Parameters 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% |

### 4.1 Layout of Buildings



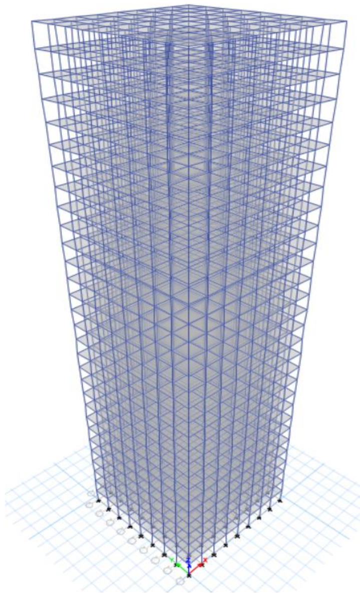
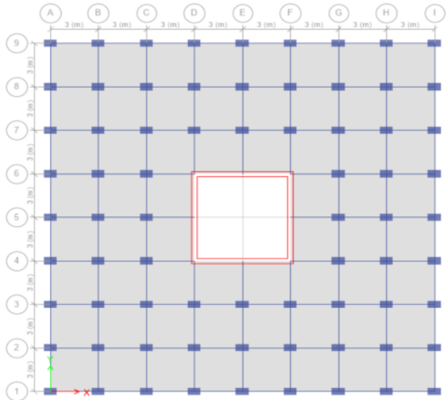


**Fig -1**: Plan and 3D Model of Rigid Frame Building



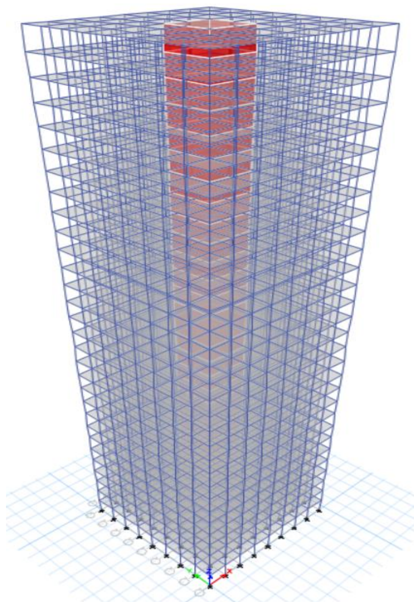


**Fig -2**: Plan and 3D Model of Tube in Tube Frame Building

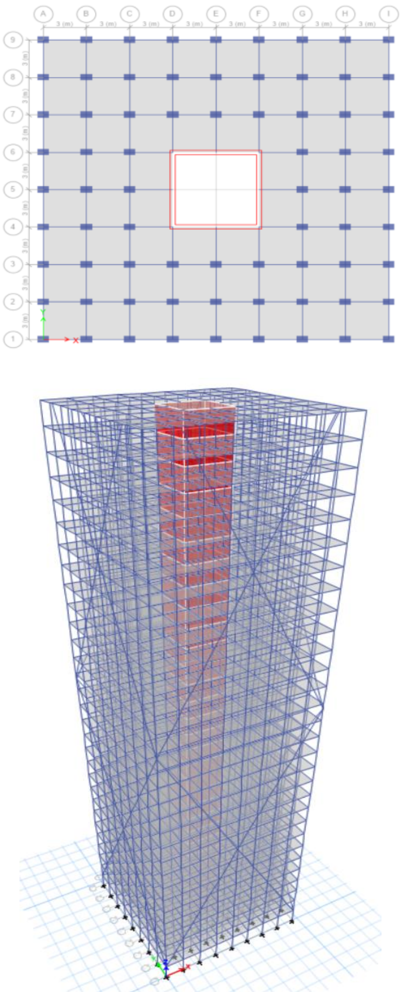


**Fig -3**: Plan and 3D Model of Trussed Tube Frame Building (Bracing-63$^0$)

## 5. RESULTS AND DISCUSSIONS

### 5.1 Comparison of Rigid Frame, Tube in Tube Frame and Trussed Tube Frame Buildings in Different Seismic Zones of India

### 5.1.1 Rigid Frame Building

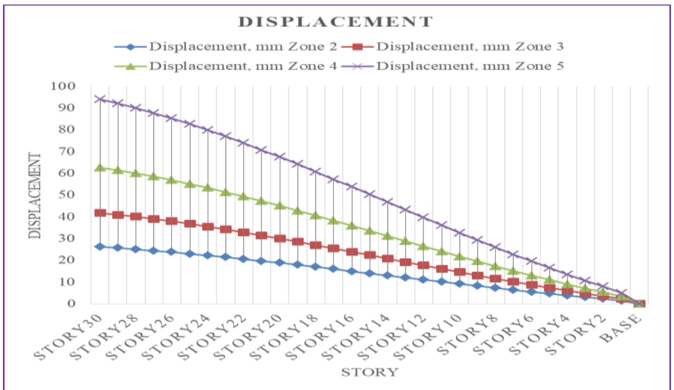



**Chart -1**: Displacement for EQX

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.

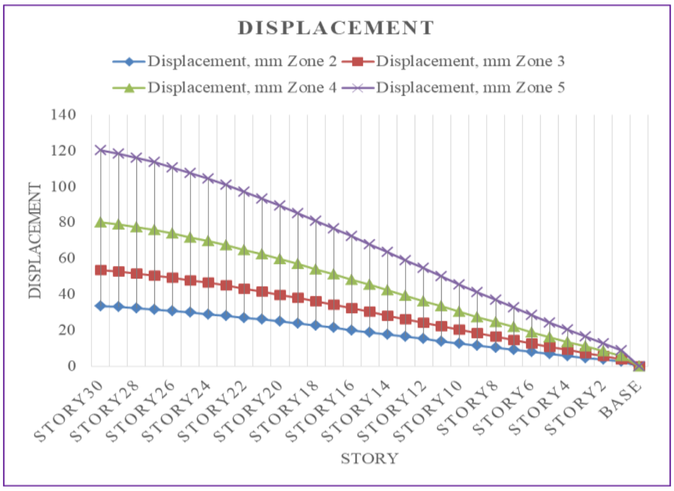



**Chart -2**: Displacement for EQY

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.

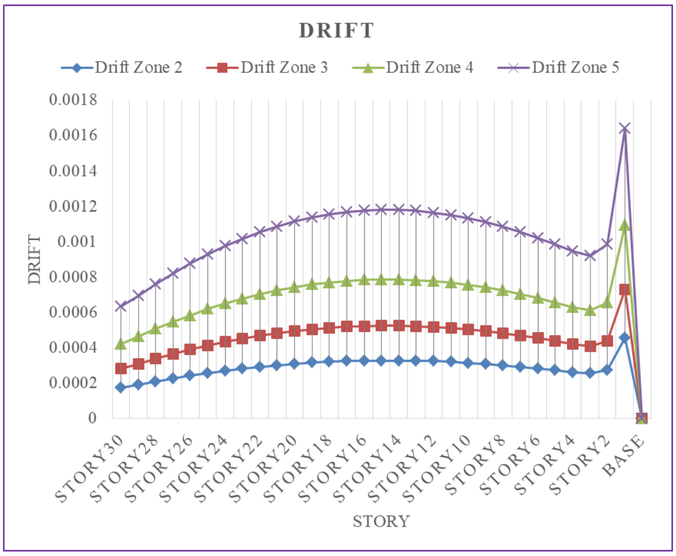



**Chart -3**: Drift for EQX

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.

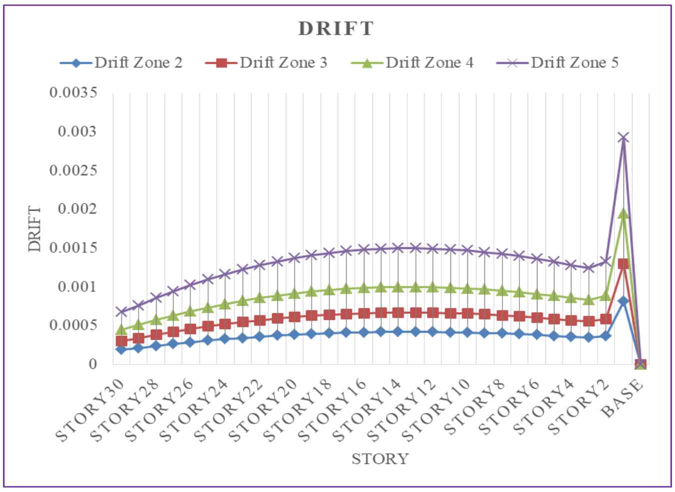



**Chart -4**: Drift for EQY

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.

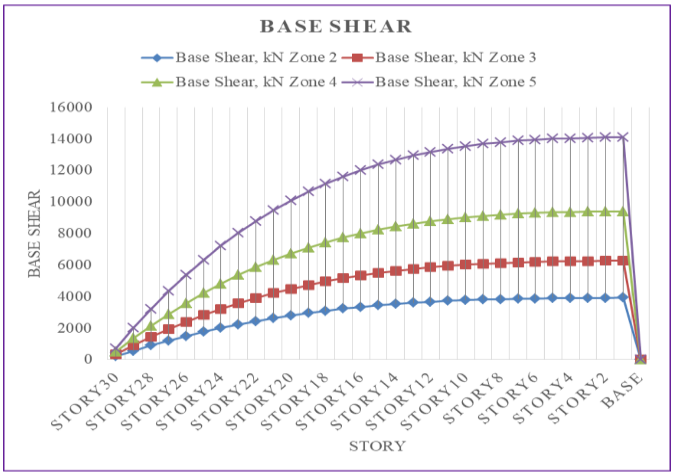



**Chart -5**: Base Shear for EQX

As can be observed from the above chart, base shear increases along with the seismic 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 37.59%, 58.39%, and 72.26%. For narrative 1, the base shear is taken into account.

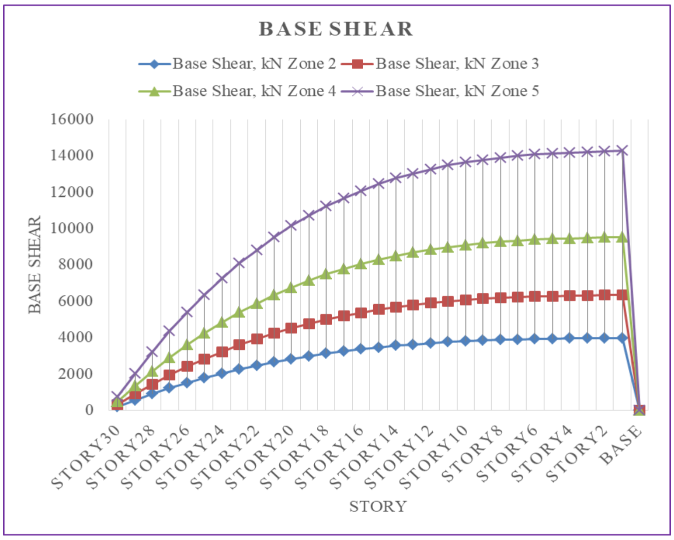



**Chart -6**: Base Shear for EQY

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.

### 5.1.2 Tube in Tube Frame Building

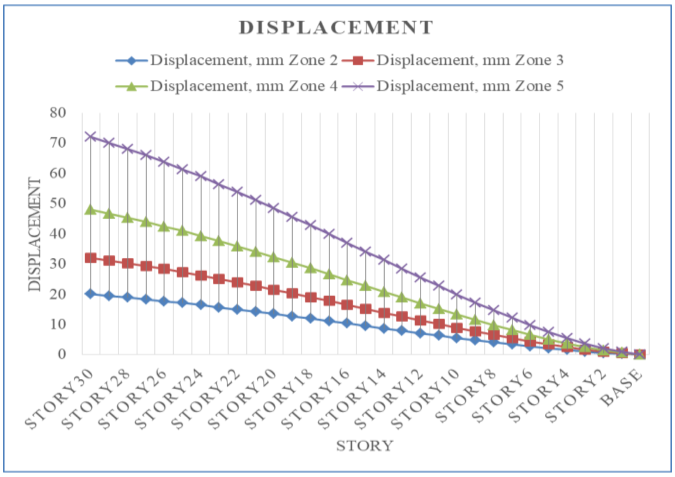



**Chart -7**: Displacement for EQX

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.

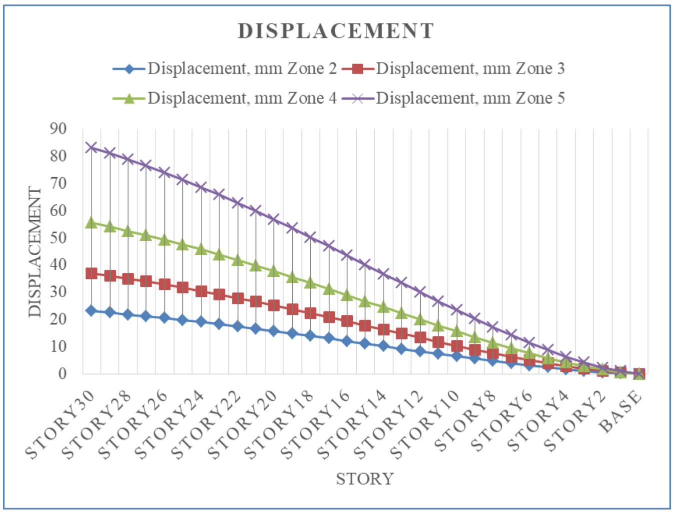



**Chart -8**: Displacement for EQY

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.

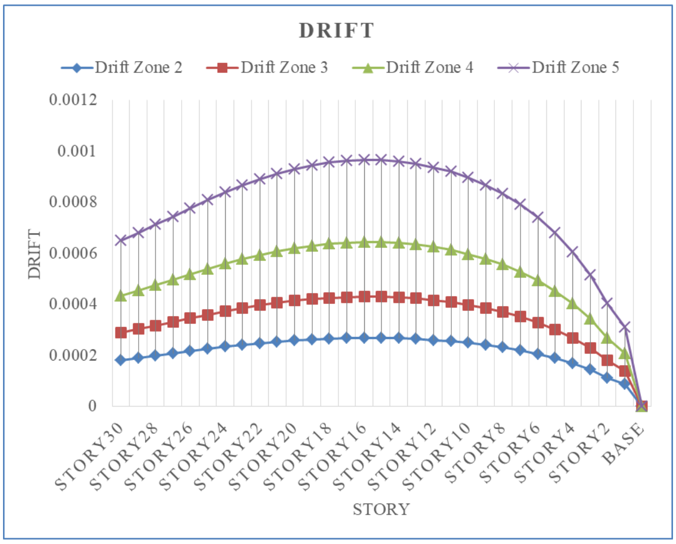



**Chart -9**: Drift for EQX

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. When compared to the other stories of the tall tube-in-tube construction, story 15 experiences the greatest tale drift.

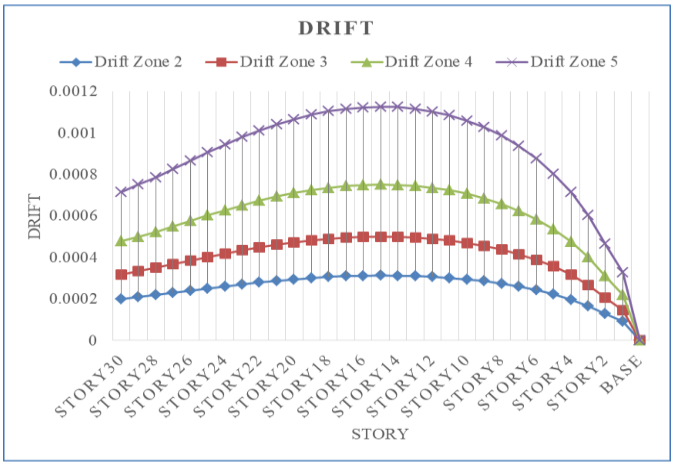



**Chart -10**: Drift for EQY

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.

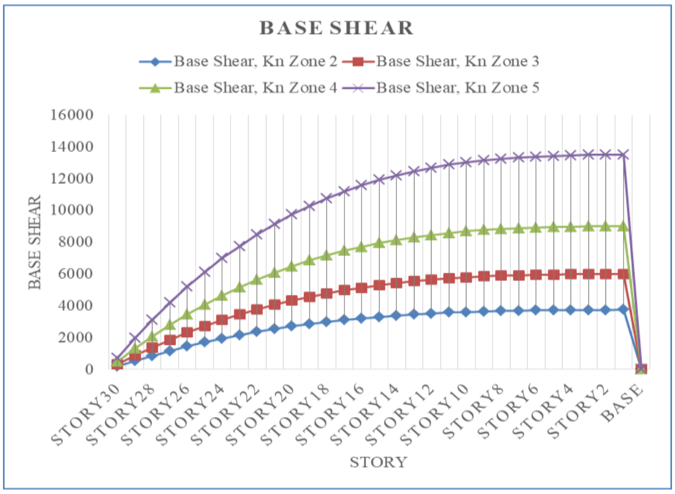



**Chart -11**: Base Shear for EQX

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.

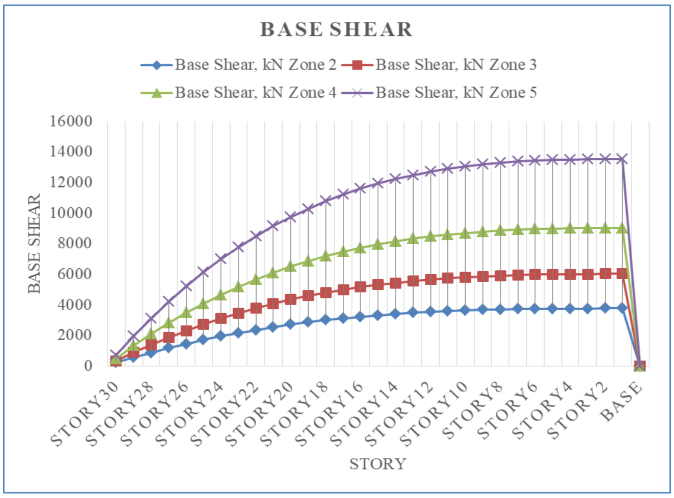



**Chart -12**: Base Shear for EQY

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.

### 5.1.3 Trussed Tube Frame Building

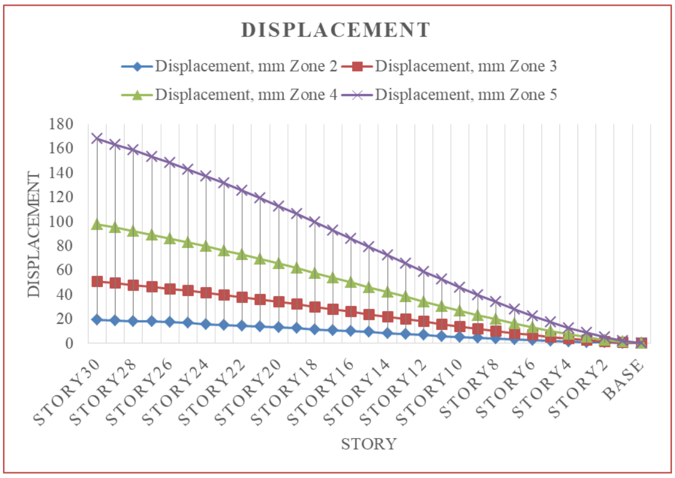



**Chart -13**: Displacement for EQX

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.

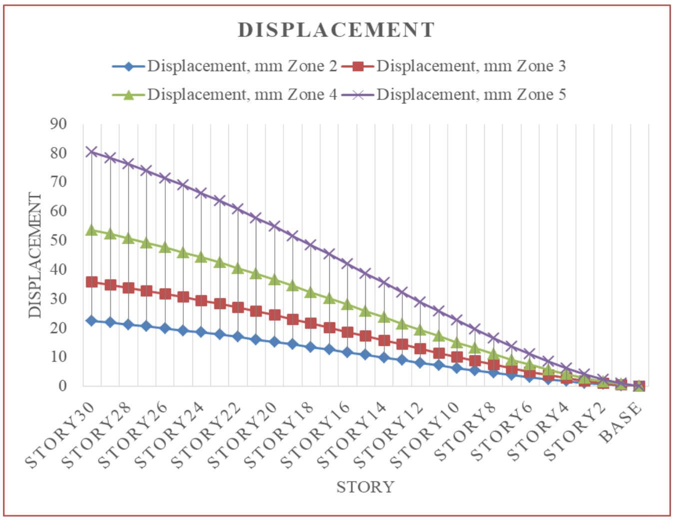



**Chart -14**: Displacement for EQY

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.

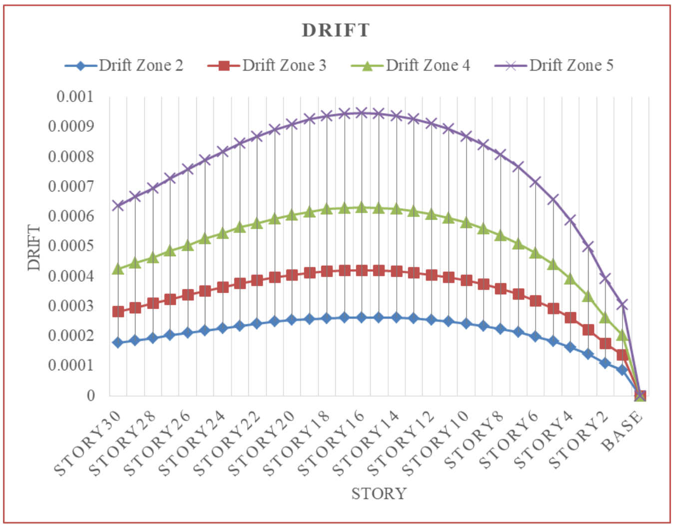



**Chart -15**: Drift for EQX

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.

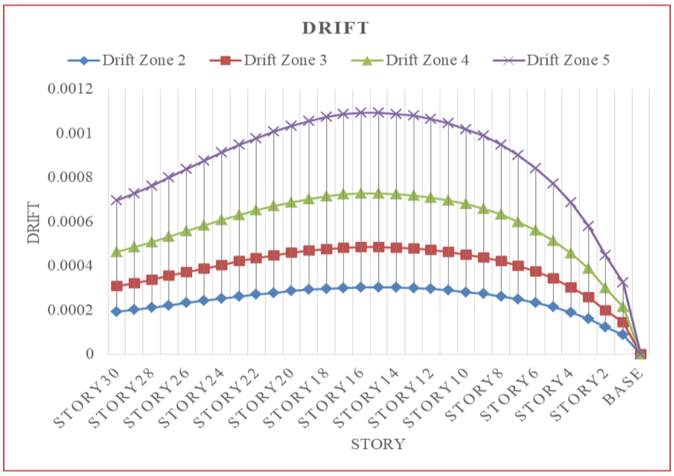



**Chart -16**: Drift for EQY

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.

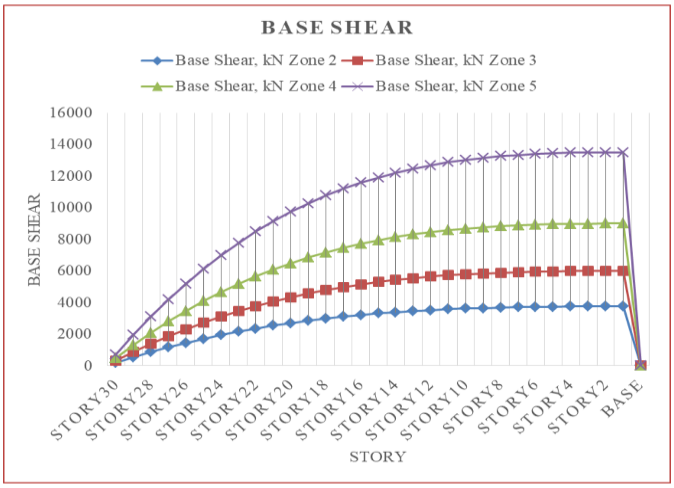



**Chart -17**: Base Shear for EQX

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.

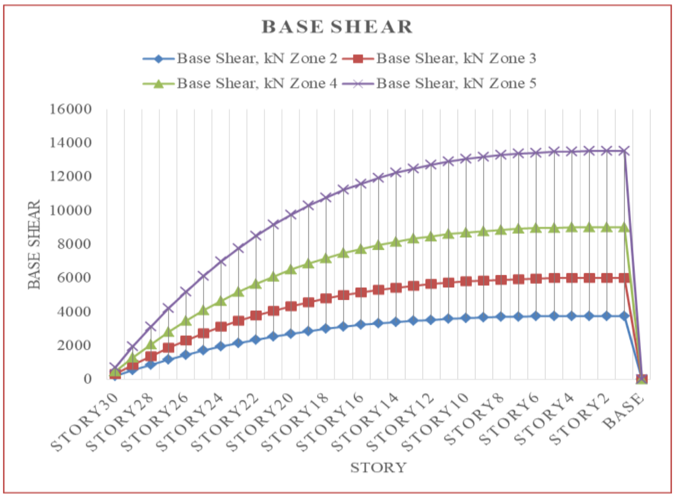


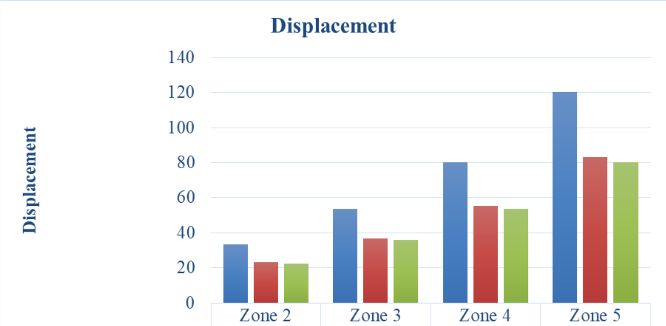

**Chart -18**: Base Shear for EQY

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.

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

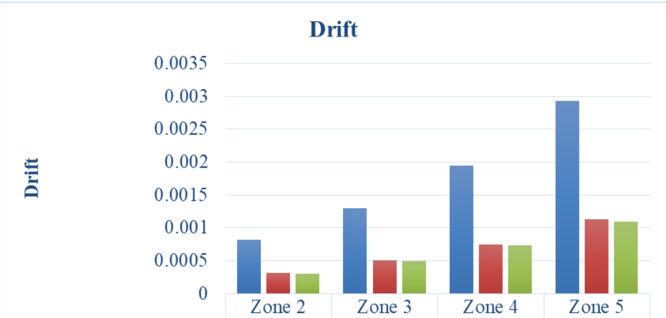
The EQY load values have been used in this comparison because, as shown in clauses 5.1.1 to 5.1.3, the EQY load produces the highest levels of displacement, drift, and base shear when compared to the EQX load. As a result, the comparison below is conducted for EQY load.




| | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|---|---|---|---|---|
| Rigid Frame Building | 33.426 | 53.481 | 80.222 | 120.33 |
| Tube in Tube Frame Building | 23.081 | 36.93 | 55.395 | 83.092 |
| Trussed Tube Framed Building | 22.333 | 35.733 | 53.599 | 80.398 |

**Chart -19**: Displacement

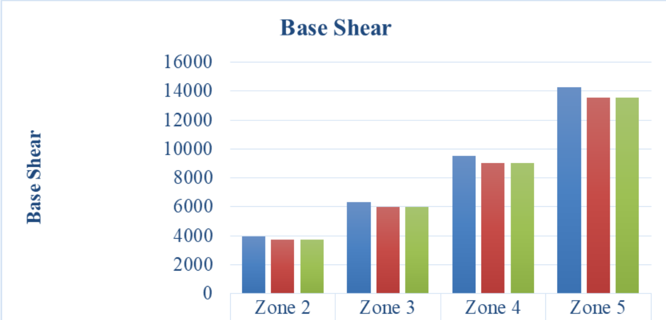
According to chart 19, the trussed frame building experiences the greatest reduction in displacement across the whole seismic zone when compared to rigid and tube-in-tube frame buildings. For all seismic zones, the reduction from a rigid frame building to a trussed frame building is consistent at 33.18%. 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.




| | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|---|---|---|---|---|
| Rigid Frame Building | 0.000812 | 0.0013 | 0.001949 | 0.002924 |
| Tube in Tube Frame Building | 0.000313 | 0.000501 | 0.000751 | 0.001127 |
| Trussed Tube Framed Building | 0.000304 | 0.000487 | 0.00073 | 0.001095 |

**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.




| | Zone 2 | Zone 3 | Zone 4 | Zone 5 |
|---|---|---|---|---|
| Rigid Frame Building | 3967.4074 | 6347.8519 | 9521.7778 | 14282.6667 |
| Tube in Tube Frame Building | 3759.5764 | 6015.3223 | 9022.9835 | 13534.4752 |
| Trussed Tube Framed Building | 3760.871 | 6017.3936 | 9026.0904 | 13539.1356 |

**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.

## 6. 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 5

    - 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.

6. Taking into account the aforementioned details, the trussed tube frame buildings experienced the greatest reduction relative to the others. But as compared to the tube in tube frame buildings, there is a minor increase in the base shear of 0.034%.

7. 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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