

# The comparative Descriptive Research and Analysis of RCC Twisted and Traditional Buildings using Software for Indian and American Codes

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**Abstract:** The goal of this project is to use Response spectrum analysis to investigate how a twisted building responds to earthquake and wind loads. ETABS 2018 is used to carry out the analysis. In the study, a building model with G+25, G+30, and G+35 storeys and a constant storey height of 3.1m was used. For this study, analysis and design are done in accordance with Indian Standard Code. A tall building's stiffness can be viewed as an indirect indicator of how vulnerable it is to dynamic forces. This effect is influenced by the wind speed and the building's aerodynamic characteristics. As a building's height grows, the wind load value rises. High spatial stiffness raises the natural vibration frequency, which for low values might be hazardous for construction, while reducing the acceleration linked to a structure's horizontal displacements. At certain wind speeds, the structure can enter a resonance that results in severe stresses and vertical displacement. The aerodynamic twisted design has the benefit of disrupting the direction of the wind's impact around the building, which helps to significantly lessen wind excitation. While designing all the forces that induce on the building were considered and in Post analysis of the structure, maximum shear forces, bending moments, maximum storey displacement, behaviour of building to seismic force, storey stiffness, storey drift and other reactions are computed.

**Keywords:** RCC Frame Structure, Twisted Building, ETAB, Storey Drift, Storey Acceleration, Base Shear etc.

## 1. INTRODUCTION

An earthquake is a natural tragedy that has claimed millions of lives throughout known and unwritten history [1], [2]. An earthquake is a disruptive disturbance that generates surface shaking owing to subsurface movement along a fault line or volcanic activity [3]. The produced forces are irresponsibly and only last a brief time. Humans are puzzled by its ambiguity in terms of occurrence time and nature. However, with the advancement of knowledge throughout the years, a degree of probabilistic predictability has been reached [3]. The ability to predict the recurrence and strength of earthquakes for a certain region has improved, but this only solves one half of the problem: knowing what's coming! The second phase is structural seismic design – to resist the storm! This component of the problem has evolved throughout the previous century, with advancements in design philosophy and methodology continually investigated, proposed, and implemented [4], [6]. This chapter introduces the notion of foundation isolation for earthquake-resistant structure design. The usefulness of seismic isolation is proved by modeling and analysis of multi-storey buildings, bridges, and pools [6], [8], [9]. The trend of RCC high-rise structures has increased nowadays in India [14], [16]. Many different amenities, gardens, etc., have been provided in high-story buildings which are very attractive from an aesthetic point of view, but they can be dangerous from a structural point of view [15], [16]. If they break for some reason and all the water rushes out, it would destroy some interior and possibly some

windows. In most cases, the extra water mass will help the building resist earthquakes by acting as a liquid mass dampener [7], [9], [10]. Tall buildings carry very large gravity and lateral loads [4], [5]. Twisted tall buildings of various heights, height-to-width aspect ratios, and rates of twist are designed and their structural efficiency is investigated [14], [16], [35], [38]. Due to the unique geometric configurations of twisted forms, structural buildings are quite different from those employed for tall buildings of rectangular box forms. Twisted forms involve not only structural but also architectural and constructional challenges [1], [4], [14].

- This project investigates the optimum twist angle of the RCC building [14].
- To increase value in certain buildings there are associated risks that we take [14].
- The amenities provided in high-storey buildings are attractive from an aesthetic point of view [15].
- This project represents the structural behaviour of RCC twisted buildings subjected to static load [14].
- In this project, the non-linear static method is being used [14].

In the era of urbanization and vertical growth, the structural performance of high-rise buildings under dynamic loads such as wind and seismic forces has become a critical subject of

study [5], [13], [14]. With the increasing demand for tall structures due to limited land availability in urban regions, engineers are constantly exploring innovative architectural and structural configurations to ensure stability, safety, and efficiency [1], [4]. One such architectural trend is the introduction of twisted or torsional building designs, which not only add aesthetic value but also significantly influence the structural behavior under lateral loads [14], [38]. Traditionally, reinforced cement concrete (RCC) buildings have followed rectangular or square geometries that offer simplicity in design and analysis. However, such conventional buildings often face greater challenges under dynamic loads, especially as height increases [16], [17], [41]. The stiffness, mass distribution, and geometric shape of a building play a major role in determining its response to earthquakes and wind forces. A twisted building, which is geometrically altered along its vertical axis, provides better aerodynamic performance, helping to reduce wind-induced vibrations and structural resonance [38], [39]. This study is a comparative descriptive research and analytical investigation of twisted versus traditional RCC high-rise buildings. The research focuses on understanding the response of these structures when subjected to earthquake and wind forces, using Response Spectrum Analysis (RSA) as the principal methodology [14], [41]. RSA is particularly effective in evaluating the maximum response of structures during seismic events, capturing the modal characteristics and providing insight into potential vulnerabilities [14].

### Research Statement

A twisted RCC building exposed to seismic loads utilizing ETab. The twist rate of RCC twisted buildings will be studied. Each level grows at its own rate. ETab will model. Base shear and storey displacement data will be shown. This project's goal is to find the best angle.

### Research Objectives

The objectives of this study are as the following:

- To design and analysis Symmetrical building and normal RCC frame a building model with G+21, G+30, and G+31 storeys by using ETAB Software using Indian Code
- To design & analysis of twisted building of G+21, G+30, and G+31 storeys using American Code
- To compare the technical parameter like storey drift, storey acceleration, storey stiffness etc.
- Comparatively Study Design and analysis of RCC twisted building with Normal Building for G+21, G+30 & G+31 by using ETab

### 2. Literature Review

A comprehensive review of previous studies was conducted to understand the behavior of structural elements under

various loading conditions and to identify suitable analytical approaches for evaluating structural performance.

**Hemamathi et al.** conducted a numerical analysis of reinforced cement concrete (RCC) beams using ABAQUS finite element software. The study modeled an RCC beam having dimensions of 3 m length, 230 mm width, and 300 mm depth, reinforced with two 12 mm diameter tension bars and 8 mm diameter two-legged stirrups spaced at 150 mm center-to-center. The results demonstrated that finite element analysis can effectively predict the structural behavior of RCC beams under loading conditions. The study highlighted the importance of numerical simulation in evaluating stress distribution, deformation characteristics, and failure mechanisms of reinforced concrete members.

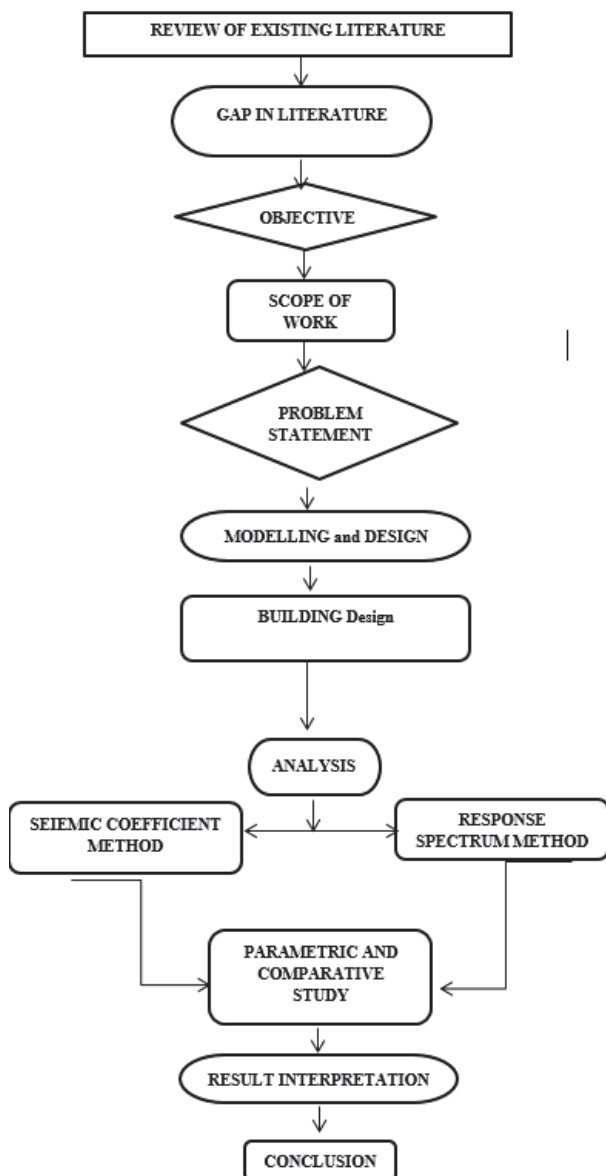
**Kamane, Patil, and Patagundi (2021)** investigated the torsional performance of steel I-beams externally strengthened with Fiber Reinforced Polymer (FRP) sheets using Artificial Neural Network (ANN) techniques. The study considered beam geometry, bonding characteristics, environmental conditions, and loading parameters as input variables. Various ANN model parameters such as network architecture, activation functions, optimization algorithms, and regularization techniques were employed to improve prediction accuracy. The developed model showed high reliability in estimating torsional behavior, indicating that machine learning techniques can serve as effective tools for predicting the performance of strengthened structural members.

A study titled “**Comparative Study on the Design of Pre-Engineered Building with Indian and American Code**” examined the differences between Indian and American design standards for pre-engineered buildings. The results indicated that structures designed according to Indian codes required approximately 38% more steel tonnage compared to those designed using American standards. The authors concluded that revisions in Indian design codes are necessary to achieve better compatibility with international standards while maintaining structural safety and serviceability requirements. The study emphasized the significance of code provisions in influencing structural economy and design efficiency.

**Sheikh and Vyas (2024)** presented a literature review on the comparative analysis of reinforced concrete structures with different aspect ratios subjected to dynamic wind loading considering P- $\Delta$  effects. The review concluded that as building height increases, bending moments and shear forces tend to decrease while lateral displacement and top-story deflection increase significantly. The study emphasized that taller structures are more susceptible to lateral instability and therefore require adequate lateral load-resisting systems such as bracing or shear walls to ensure structural safety and serviceability under wind loading. From the reviewed

literature, it is evident that numerical modeling, advanced analytical techniques, code-based design approaches, and consideration of lateral load effects play a crucial role in assessing the structural performance of buildings and structural components. However, limited studies have focused on the comparative seismic behavior of regular and twisted high-rise buildings designed according to different international codes. Therefore, the present study aims to evaluate and compare the seismic response of regular and twisted high-rise structures designed as per Indian and American standards, considering parameters such as story displacement, story drift, base shear, and overturning moment.

### RESEARCH METHODOLOGY



### RESULT & DISCUSSION

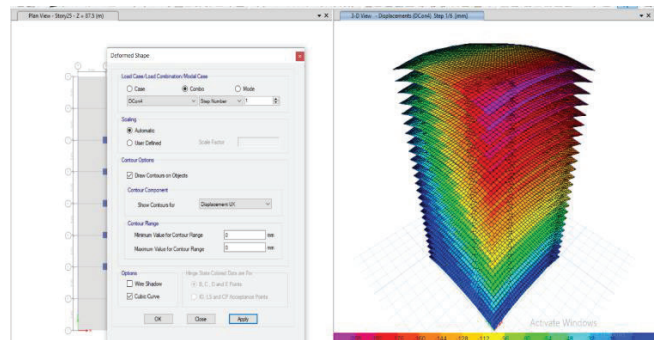


Figure5.1: Deform shape (mode1)

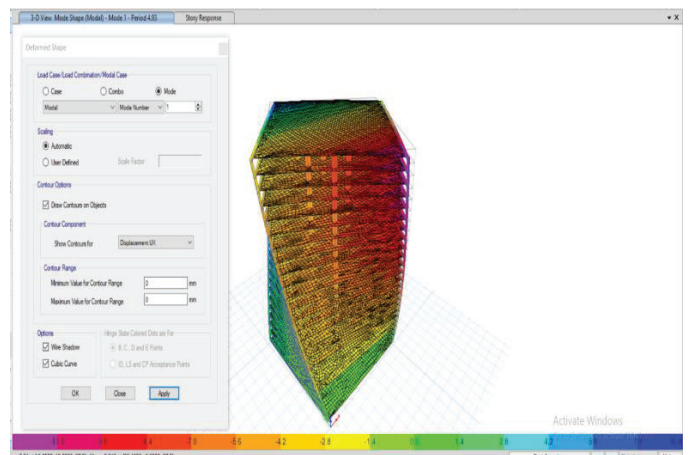


Figure5.2: Deform Shape (Model1)

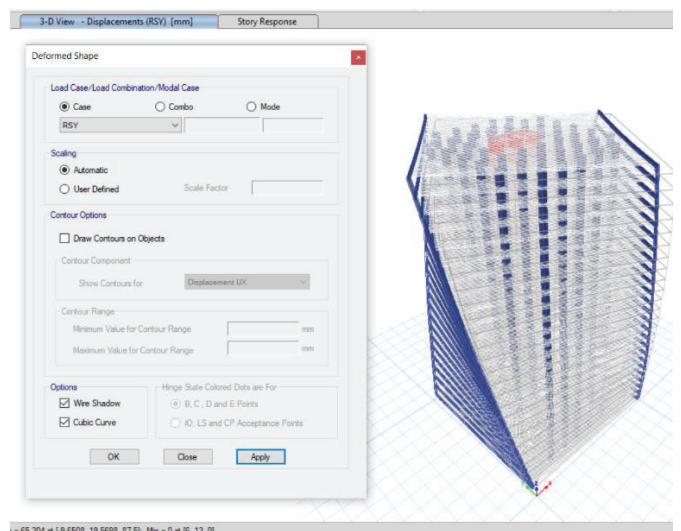


Figure5.3: Max displacement due to loading (Y-Direction)

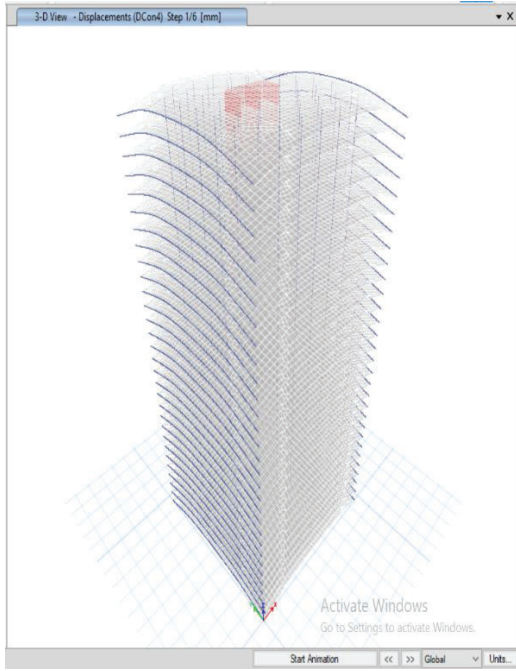


Figure 5.4: Displacement due to loading

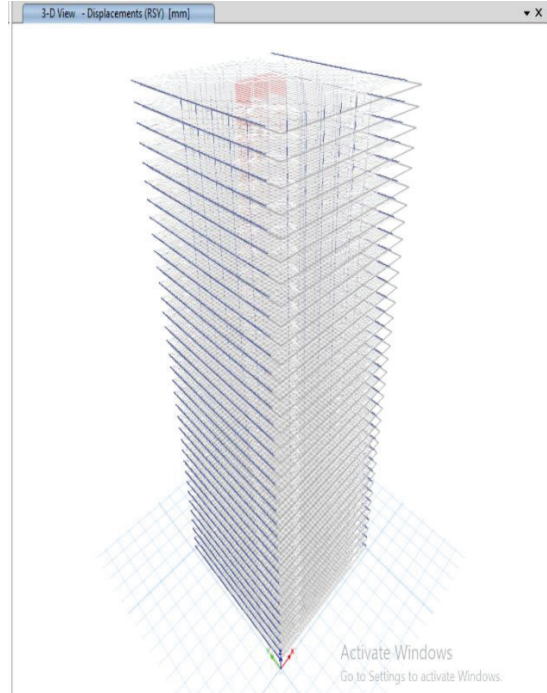


Figure 5.6: Deform Shape (Y-Direction)

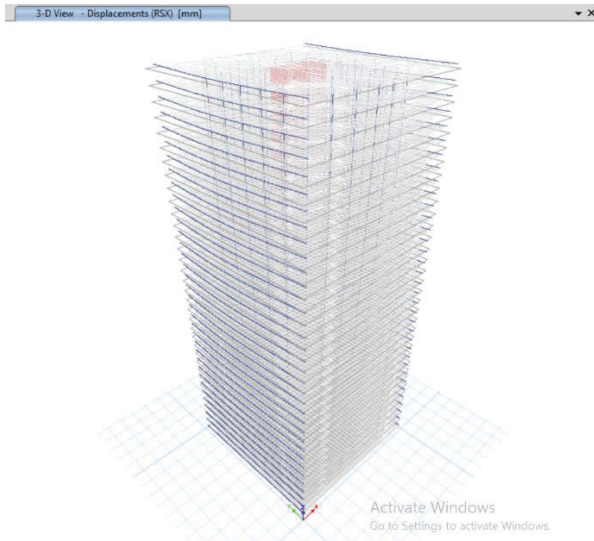


Figure 5.5: Deform Shape (X-Direction)

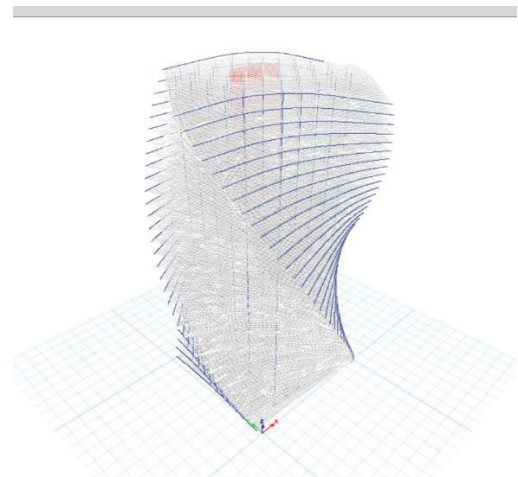


Figure 5.7: Displacement due to loading

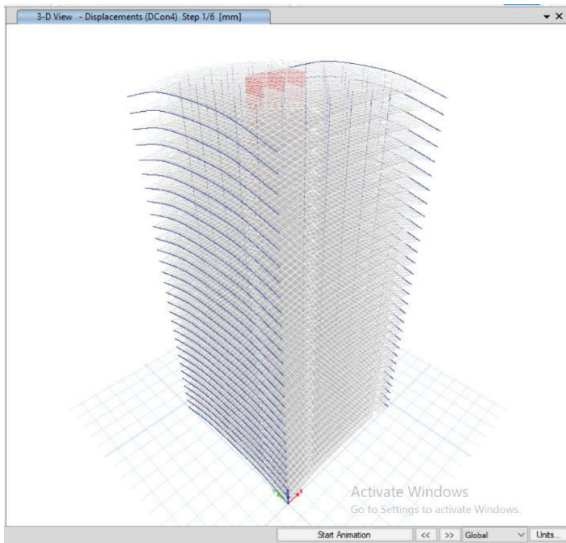


Figure 5.8: Displacement due to loading

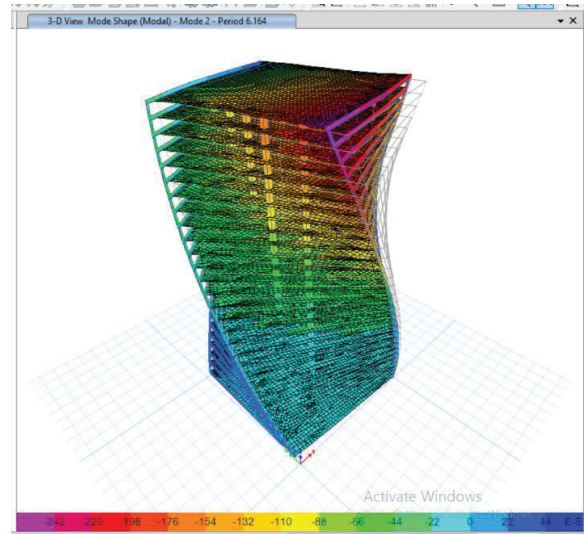


Figure 5.11: Deform Shape (Mode 3)

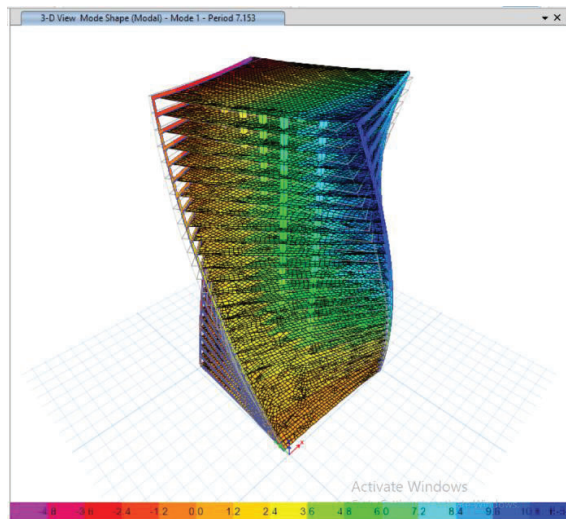


Figure 5.9: Deform Shape (Mode1)

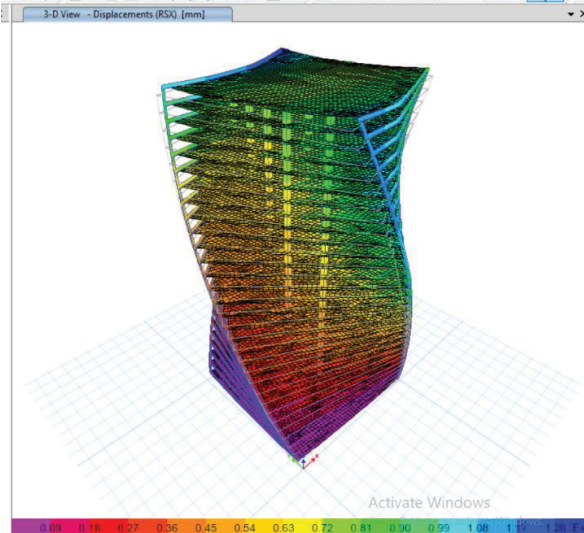


Figure 5.12: Deform Shape (X-Direction)

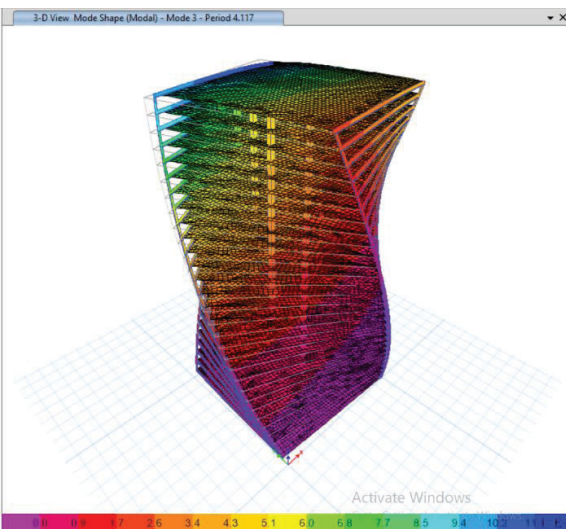


Figure 5.10: Deform Shape (Mode 2)

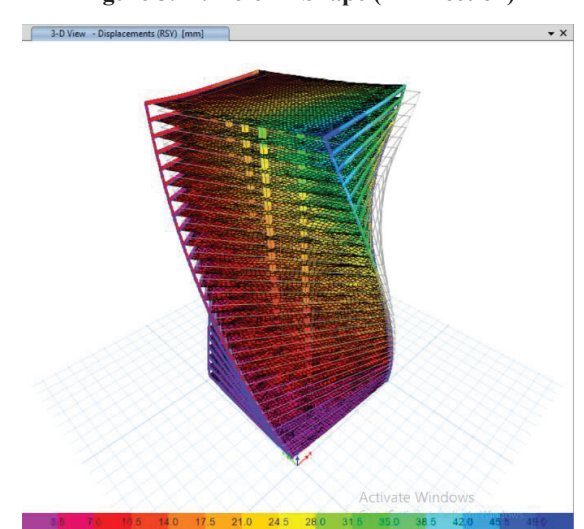


Figure 5.13: Deform Shape (Y-Direction)

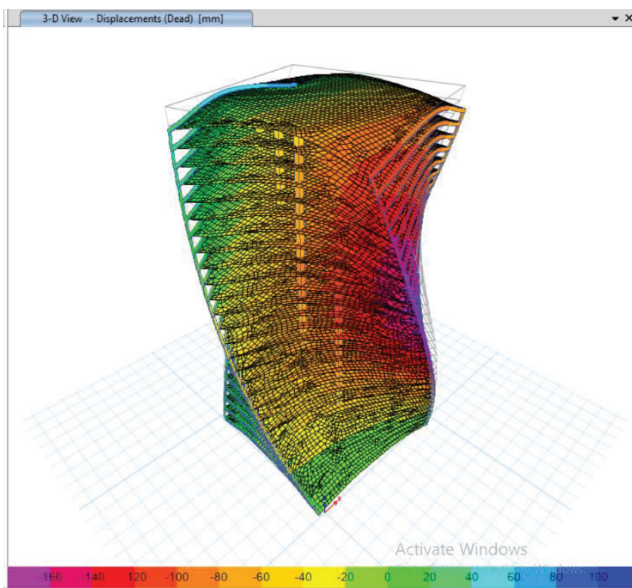


Figure 5.14: Displacement due to loading

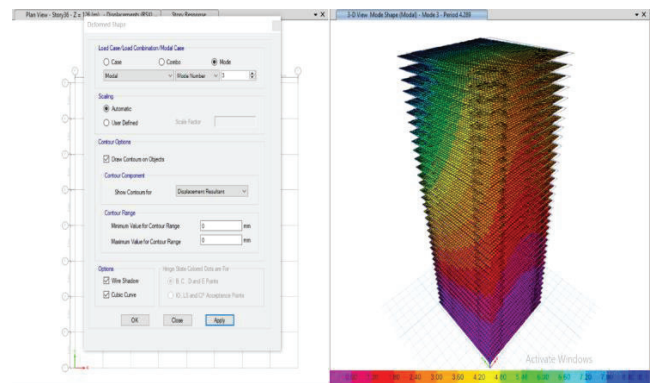


Figure 5.17: Deform Shape (Mode1)

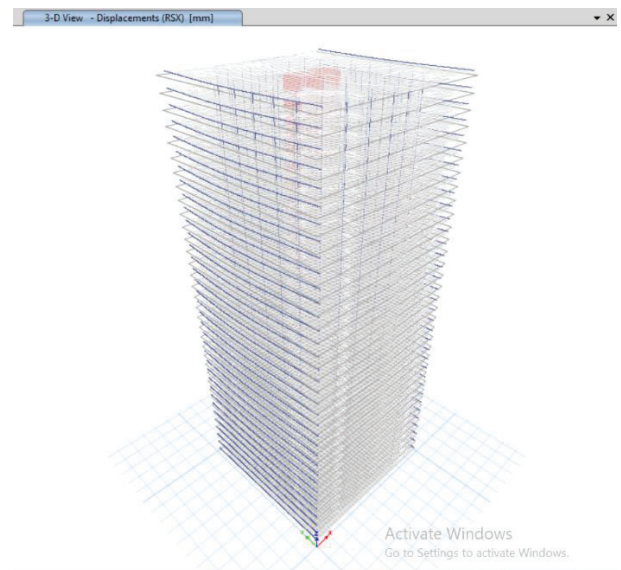


Figure 5.18: Deform Shape (X-Direction)

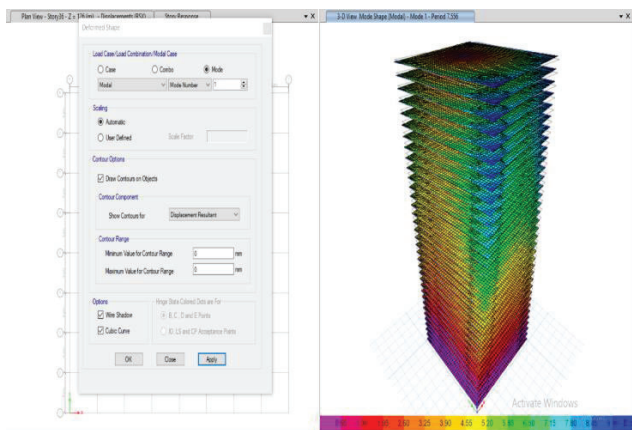


Figure 5.15: Deform Shape (Mode1)

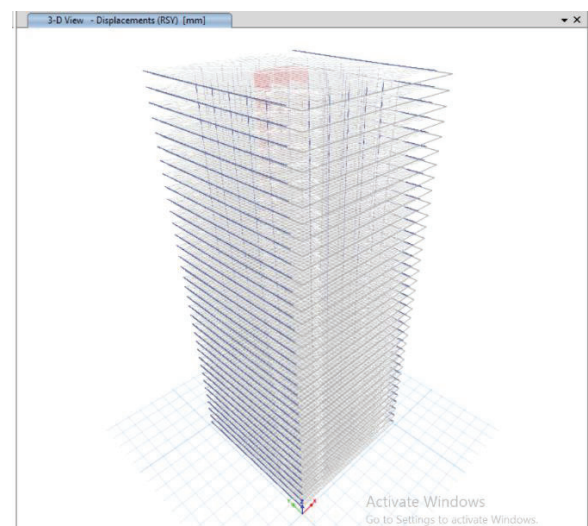


Figure 5.19: Deform Shape (Y-Direction)

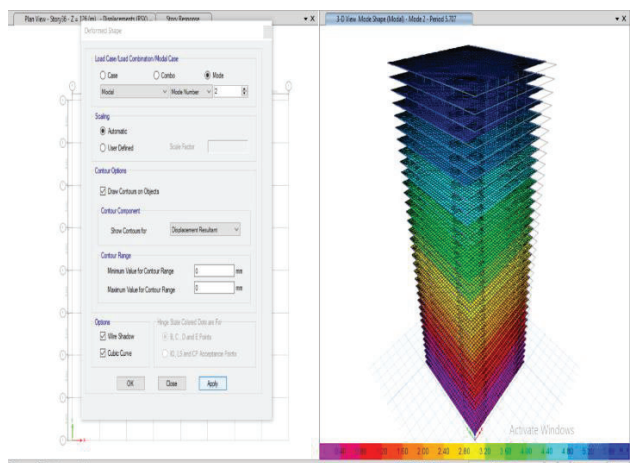


Figure 5.16: Deform Shape (Mode2)

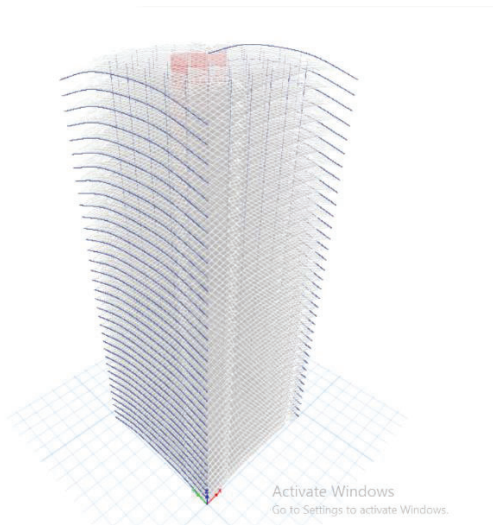


Figure 5.20: Displacement due to loading

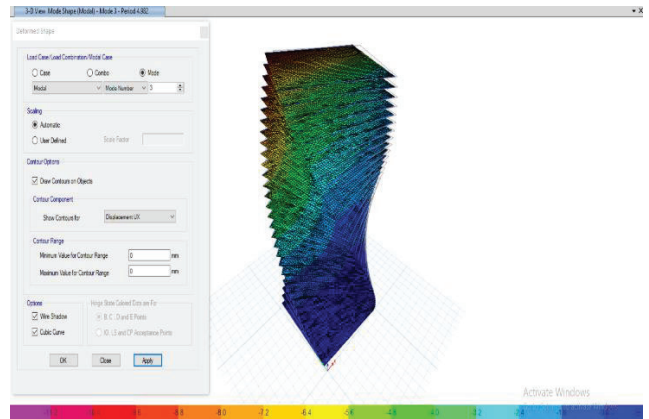


Figure 5.24: Deform Shape (Mode3)

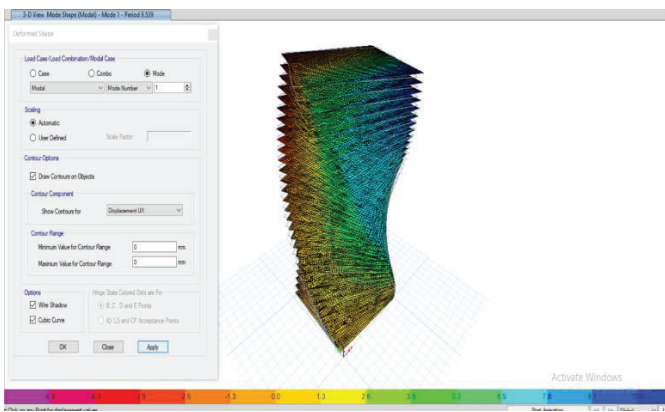


Figure 5.21: Deform Shape (Mode1)

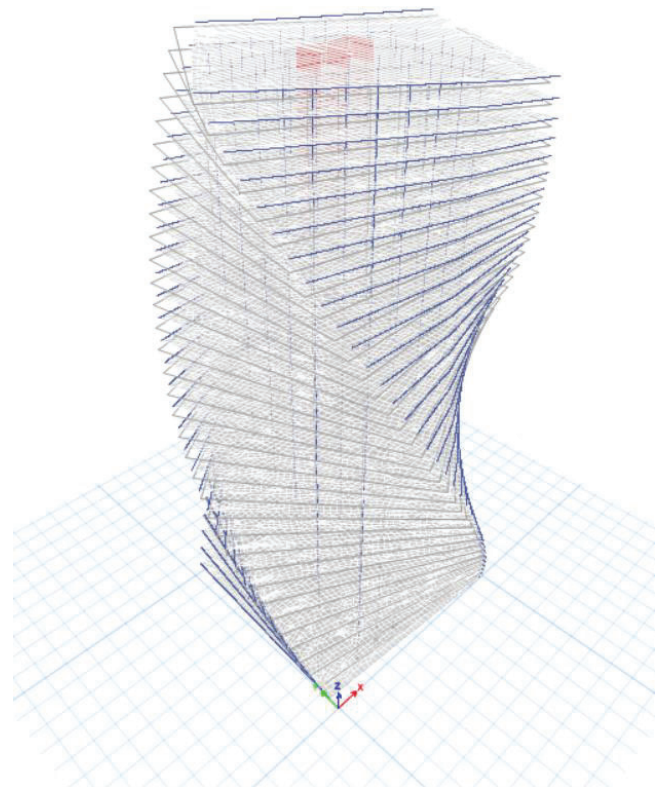


Figure 5.25: Deform Shape (X-Direction)

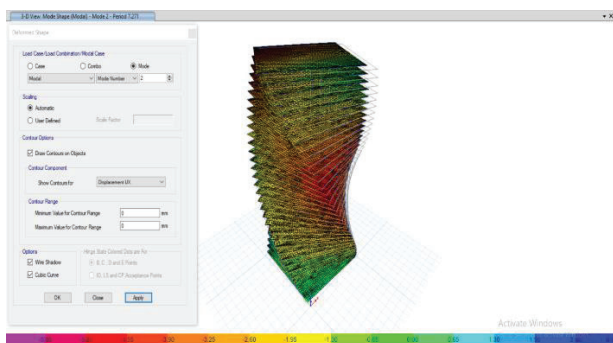


Figure 5.22: Deform Shape (Mode2)

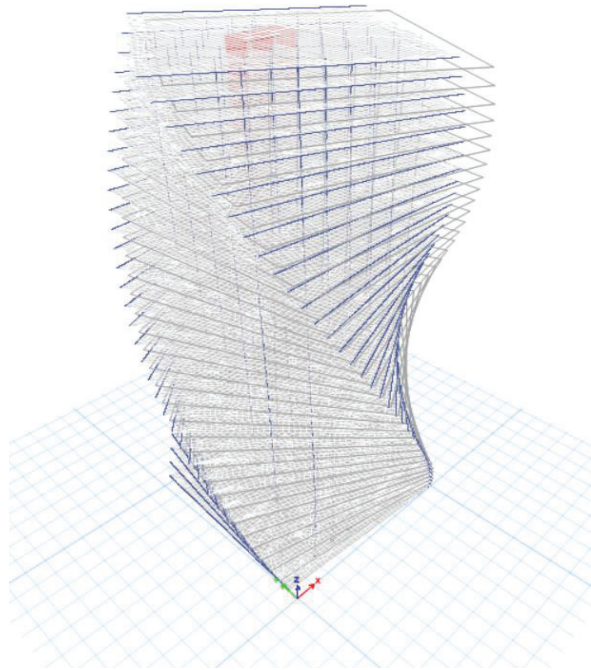


Figure 5.26: Deform Shape (Y-Direction)



Figure 5.27: Displacement due to loading

Table 1.1. Summary of Seismic Response Parameters for Indian Models

Model	Height	Max Displacement (mm)	Max Drift	Base Shear (kN)	Base Overturning Moment (kN-m)
Regular	G+25	53.33	0.000764	12060.09	163.78
Regular	G+30	65.54	0.000803	11828.75	0.0018
Regular	G+35	79.82	0.000862	11302.35	29.03
Twisted	G+25	856.34	0.01299	154297.80	381595.70
Twisted	G+30	76.51	0.001062	10894.44	5743.46
Twisted	G+35	111.97	0.000909	9197.43	1500.33

Table 1.2. Summary of Seismic Response Parameters for American Models

Model	Height	Max Displacement (mm)	Max Drift	Base Shear (kN)	Base Overturning Moment (kN-m)
Normal	G+25	513.14	0.007384	—	4946764.90
Normal	G+30	631.08	0.007679	—	1860.45
Normal	G+35	748.42	0.007853	—	2159.40
Twisted	G+25	856.34	0.01299	154297.80	381595.70

Twisted	G+30	1013.28	0.013575	145219.60	694208.70
Twisted	G+35	2260.46	0.017497	75224.85	2256.66

**Table 1.3. Maximum Story Displacement Comparison**

Model	G+25	G+30	G+35
Indian Regular	53.33	65.54	79.82
Indian Twisted	856.34	76.51	111.97
American Normal	513.14	631.08	748.42
American Twisted	856.34	1013.28	2260.46

**Table 1.4. Maximum Story Drift Comparison**

Model	G+25	G+30	G+35
Indian Regular	0.000764	0.000803	0.000862
Indian Twisted	0.01299	0.001062	0.000909
American Normal	0.007384	0.007679	0.007853
American Twisted	0.01299	0.013575	0.017497

**Table 1.5. Base Shear Comparison**

Model	G+25 (kN)	G+30 (kN)	G+35 (kN)
Indian Regular	12060.09	11828.75	11302.35
Indian Twisted	154297.80	10894.44	9197.43
American Twisted	154297.80	145219.60	75224.85

**Table 1.6. Base Overturning Moment Comparison**

Model	G+25	G+30	G+35
Indian Regular	163.78	0.0018	29.03
Indian Twisted	381595.70	5743.46	1500.33
American Normal	4946764.90	1860.45	2159.40
American Twisted	381595.70	694208.70	2256.66

## CONCLUSION

- 1) When the rotation of the structure is increases then the base shear is also increasing the total 3.1D structure base is higher than the remaining the structure. The base shear is 1% to 11% increases as compare to the other structure.
- 2) The maximum storey acceleration of the structure is 1.1D is increased by 14 %, 14.01%, 8%, and 16% as compared to the 2D, 2.1D, 3D and 3.1D when we decrease the twisted angle then the acceleration increases.
- 3) The Storey Stiffness 2.1D is increases by 6-7% around but 1.1D is decreasing by 66% around means when we increase the twist angle of floor then the Stiffness also increases.
- 4) The overturning moment effect of the all structure all near about the same the only 1-2% slightly increases 2.1D structure. Means no effect of floor rotation on the moment. It was increased when increases the storey height.
- 5) The maximum storey displacement of the structure 2.1D is increase 6% as compared to other type of structure all around displace nearly same means when we twisted the floor displacement is decreases.
- 6) When we increase the rotation of the floor then the modal time period also decreases
- 7) The maximum storey acceleration of the structure is 1.1D is increased by 2 %, 1.1%, 3%, and 1.8% as compared to the 2D, 2.1D, 3D and 3.1D when we decrease the twisted angle then the acceleration increases.
- 8) The overturning moment is for 1.1D is increasing by 41 %, 33.4%, 31.1% and 24.4% as compare to the 2D, 2.1D, 3D and 3.1D model.
- 9) The maximum storey displacement of the structure 2.0D is increase 6% as compared to other type of structure but only 10% 1.1D type of structure. the displacement is varying for floor to floor.
- 10) When the rotation of the structure is increases then the base shear is also increasing the total 3.1D structure base is higher than the remaining the structure. The base shear is 4% to 12% increases as compare to the other structure.
- 11) When we increase the rotation of the floor then the modal time period also decreases

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