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Analysis of A Tall Twin Tower Considering Lateral Load as Per I.S. 1893 : I : 2016 Using ETABS

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ABSTRACT

In order to better comprehend the structure's dynamic properties and seismic performance, high-rise linked structures have recently gained popularity as a structural type. Earthquakes have historically resulted in extensive instability and structure devastation. Modern buildings are gradually subjected to more seismic force as their height and volume rise. Seismic design has grown to be a vital component of the structure's analysis and design in order to prevent severe damage and guarantee safety. In traditional seismic design, increasing stiffness of the building is usually adopted to reduce the structural response during an earthquake. This approach is usually costly, and the effect of practical application is not obvious, which could not fundamentally enhance the bearing capacity of the structure. Utilizing existing research, a theoretical and physical model of a symmetrical, joined twin tower has been created. Meanwhile, a practical design that makes use of damping vibration absorbers with energy-dissipating capabilities also makes use of the movement of additional weight to lower vibration amplitude of the main body structure. The analysis and verification of the model of a symmetrical, linked twin tower's bearing capacity using a shaking table test enhances the building's seismic performance. It supports creative and useful design concepts in the seismic structural design of symmetrical conjoined twin tower.

This study uses the robust finite element programme ETABS to create a finite element model of a connected high-rise structure, calculates seismic response using the dynamic response spectrum analysis approach, and then analyses and explains calculation findings. According to research findings, high-rise connected structures have good seismic behaviour, can satisfy engineering requirements, and can also offer a theoretical foundation for seismic design.

Keywords -High-rise connected structure, Dynamic analysis, Response Spectrum analysis, Finite element method, Seismic performance.

I. INTRODUCTION

High-rise connected structure is a new type of structure that is developed in recent years. Through setting up the connection between buildings towers makes it to be common use of space; at the same time, connected building's distinctive shape can bring strong visual result, and can make building body to be characteristic. Although high-rise connected structures are frequently used in the nation, there is currently no consensus on the seismic behaviour of such structures domestically or abroad. In addition, the design of such structures lacks sufficient theoretical support, test data, and real-world experience in high seismic intensity areas. There is currently less research on the seismic behaviour of high-rise connected structures since they contain two different types of complicated structural systems, an increased base and a twin-tower.

This study uses the compelling finite element programme ETABS to create a finite element model of a high-rise connected structure. It also calculates the seismic response of the connected structure using the dynamic response spectrum analysis method, analyses the results, and explains them. The study's findings can serve as a theoretical foundation for high-rise connected structure seismic design.

1.2 Twin Tower Structure

Twin towers are two tall structures that are nearly equal in height and appearance and are frequently constructed close to one another as a unified complex. Recent days, Twin towers are vastly in demand due to its architectural and structural design, individual plan along with more space with the same foundation support. Conventional practices across the world to combat the seismic forces and wind effects as it is a more important phenomenon nowadays because of increasing construction of skyscraper are obsolete and need new practices and arrangements because the architectural and structural demand is poles apart from earlier construction. To meet the increasing demand of living space along with commercial space various efforts are made to fulfill the need of the hour. Twin towers are the best example to rectify such a problem, which not only complies with the demand but also a mark of social and economic prosperity.

The architectural design of high-rise buildings has become increasingly novel and spectacular in recent decades, leading to the diversity of their exterior and dynamic behaviour. In addition, more and more high-rise buildings are being built in relatively adjacent, due to insufficient land availability in populated areas, particularly in major cities. As a result, there is a growing propensity to construct highrise structures close to one another as a connected building system. That is a system made up of many structures connected by sky gardens and sky bridges, among other structural links. Hence, there are various kinds of connecting, such as fixed, semi-fixed and hinged.

Many high-rise buildings around the world have been designed with a phased evacuation strategy in mind; i.e., evacuating a number of floors at a time and leaving the majority of the building occupants in place. Given the high public profile of the events of the World Trade Center Towers' collapse, it is now doubtful that tall building occupants will feel comfortable to remain in a tall building in an emergency situation, as is required of this phased evacuation approach.The design of tall buildings would be significantly impacted by the alternative simultaneous evacuation strategy, which calls for the evacuation of all building occupants at once. This would result in an increase in the number and width of fire stairs, a corresponding reduction in floor space, and retroactive incorporation in already-existing structures.

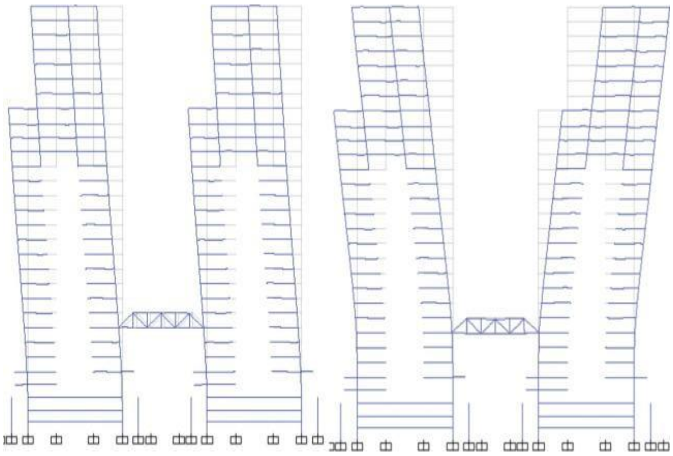


Fig 1 Evacuation of High Rise Connected Structure

Objectives of the research

- To Study load calculation for the connected high rise structure.
- To Analyze the Twin building for earthquake resistance
- To design the Twin Tower Building using ETABS Software for seismic analysis As per IS800
- To determine the strength of the specified framework of the connected floor, using FEM Software ETABS.

II. Literature Survey

Athul Sajeev Manikkoth and Emy Thomas (2021) The purpose of the research paper was to examine the placement of shear walls in a horizontally connected twin high-rise building (G+30) connected by a skybridge, as well as to examine the nature of the earthquake-exposed structure and evaluate the response of connected high-rise buildings in accordance with design-code standards. The effect of sky-bridge location on the induced structural responses was examined using ETABS. The building was analyzed for, base shear, maximum allowable displacement and stiffness.

Results stated that maximum displacement decreases on addition on shear walls. On addition of shear wall on one side displacement reduced both in X and Y direction and further on giving shear walls on both sides each, maximum displacement is further decreased. While moving on to the comparison based on the location of sky bridge, it is expected that providing a skybridge at the one fourth height or at least height will give the best performance. But on the combined effect of shear wall and sky bridge height there has been some variation to the expectation. In the case of displacement along X and Y direction, model with shear wall on both sides of each twin building and sky bridge at three fourth height gives the least displacement.

Jamal Ahmad Alomari (2021) The goal of the research paper was to examine the impact of connecting two nearby reinforced concrete structures with sky bridges made of the same material. Using SAP2000 software, three models of the two buildings connected by a sky bridge are developed and examined in relation to the El Centro seismic excitation and the IBC 2012 response spectrum. Three sky bridges are provided in one model at the levels of the fifth, eighth, and thirteenth floors. Two sky bridges are added at the levels of the 5th and 8th floors in a second model. One sky bridge at the level of the eighth story joins the two buildings in the third model.

The investigated twin buildings show slight decrease in the fundamental period of vibration, and slight increase in the value of base shear as the number of sky bridges increases from 1 to 2 to 3. The length of the first period of vibration of a twin tower connected by sky bridge/bridges is expected to have a value longer than that of the stiffer building and shorter than that of the more flexible one.

Rohit Shinde et.al (2021) objective of the research paper was to design and analyze G+25 steel Skywalk for the Twin Tower Building with using Stadd Pro Software for seismic analysis as per IS800 and determine the strength of the specified framework of the sky walk, using FEM Software ANSYS.

As per design manually staad replace members and give economic sky walk and for the purpose of checking the accuracy as per given analyses from staad pro prepare modeling in Ansys for Cross check for strength of the bridge and the strength and strain capacity of the bridge are economic as per given sizes in staad hence design are safe as given in staad.

Shruti Nagar and Dr. Savita Maru (2021) objective of the research paper was to analyze twin tower structure G+4 podium+25 floor building using linear dynamic earthquake analysis. Four models with different combinations of twin tower with podium were considered to achieve desirable results in terms of story drift, displacement and base shear under seismic forces for seismic zone IV and medium type of soil using Response Spectrum Analysis with the help of ETABS v19 software. Four symmetrical R.C. Frame Structures were subjected to a nonlinear dynamic analysis: a Twin Tower joined by a podium, a Separate Twin Tower without a podium, a Separate Twin Tower with a podium, and a Single Tower with a full podium.

The analysis stated that the displacement and drift ratio of structure have greater value in the case of tower without a podium and the same have lesser value in the case of tower with podium. The value of displacement due to equivalent static lateral force method in X direction increased by 9.26%, 1.57% and decreased by 2.88% for model 2, model 3 and model 4 respectively with respect to model 1.The value of drift ratio due to equivalent static lateral force method in X direction increased by 1.12%, 0.07% and decreased by 0.14% for model 2, model 3 and model 4 respectively with respect to model 1.

III.METHODOLOGY

Steps of Modeling

Step 1- the research papers from different authors were summarized to understand the behaviour of connected towers and the research done till date.

Step 2: In order to initiate the modelling of the case study, firstly their's need to initialize the model on the basis of defining display units on metric SI on region India as ETABS supports the building codes of different nations. The steel code was considered as per IS 800:2007 and concrete design code as per IS 456:2000.

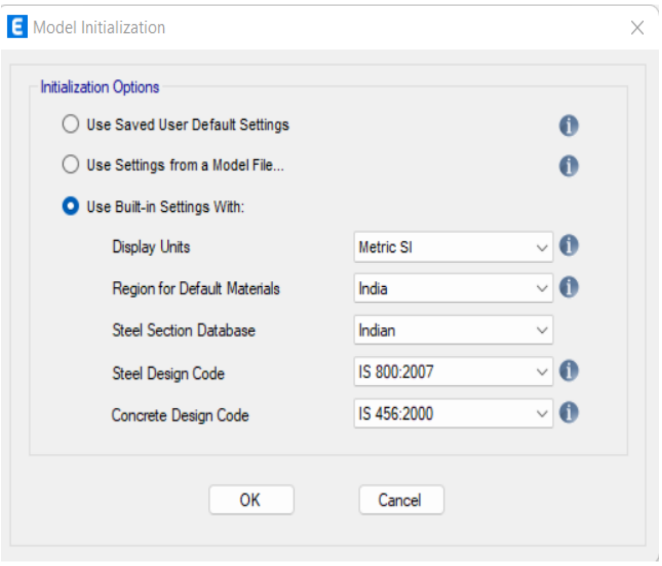


Fig 2 Model Initialization

Step 3: ETABS provides the option of modelling the structure with an easy option of Quick Template where the grids can be defined in X, Y and Z direction. Here in this case, 5 bays in considered in both X and Y direction with a constant spacing of 4m making the model symmetrical in nature. G+ 14 storey structure is considered with typical storey height of 3.2 m and Dome height of 5 m. Two cases were considered unconnected and connected with 10m distance.

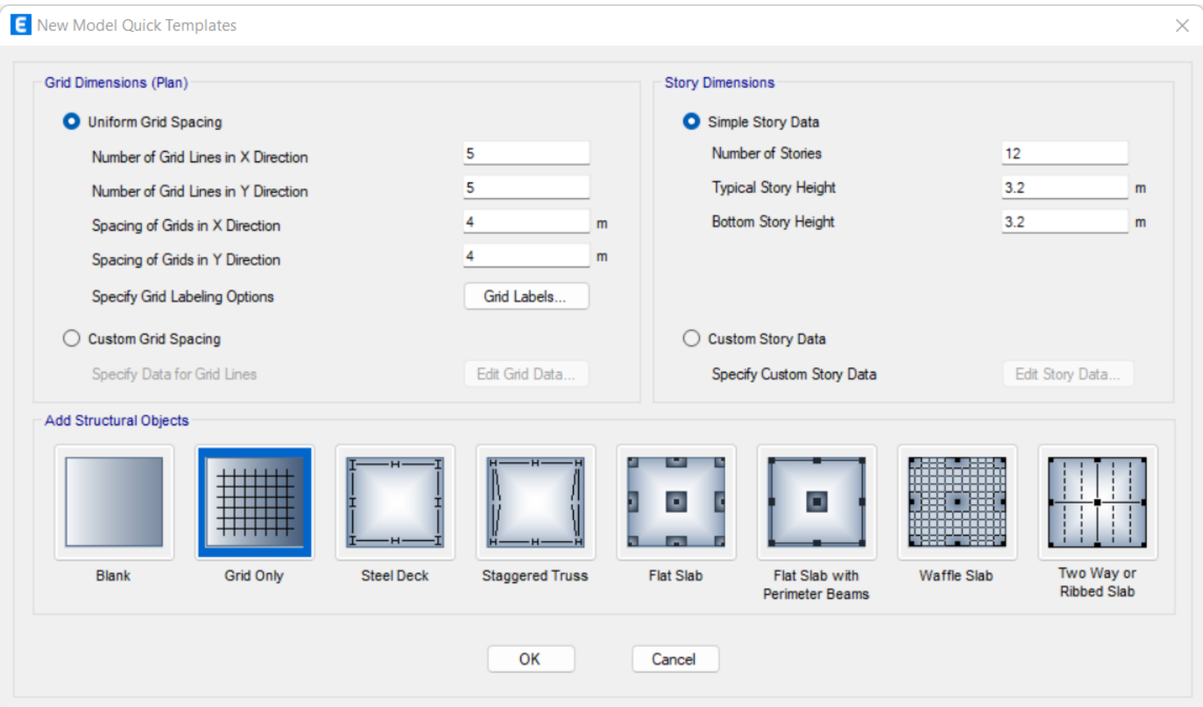


Fig 3 New Model Quick Template

Step 4: Next step is to define material properties for concrete and steel. Here in this case study, M30 concrete and rebar HYSD 415 is considered and its predefined properties are available in the ETABS application.

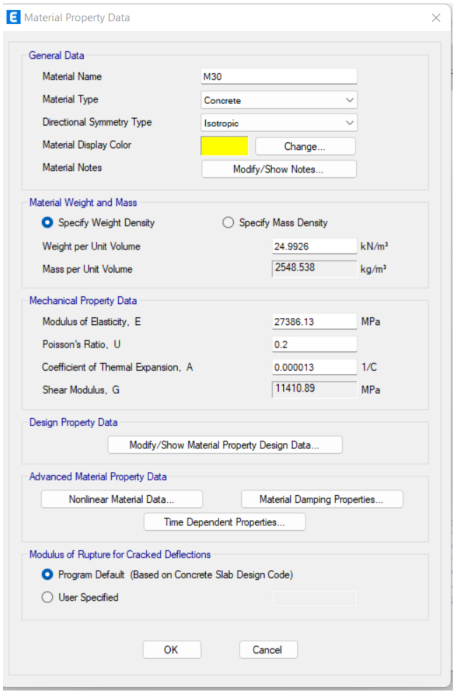


Fig 4 Defining Properties of Concrete M30.

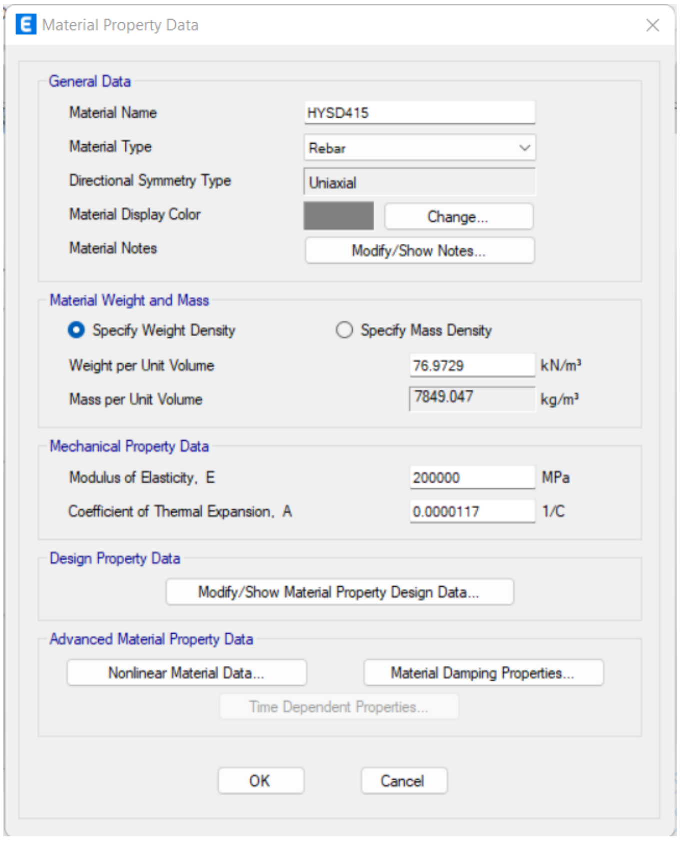


Fig 5 Defining Properties of Rebar HYSD 415

Step 5: Defining section properties for Beam, Column. Beam size of 400x300mm, Column size of 500x300mm and Slab size of 150 mm is considered in the study.

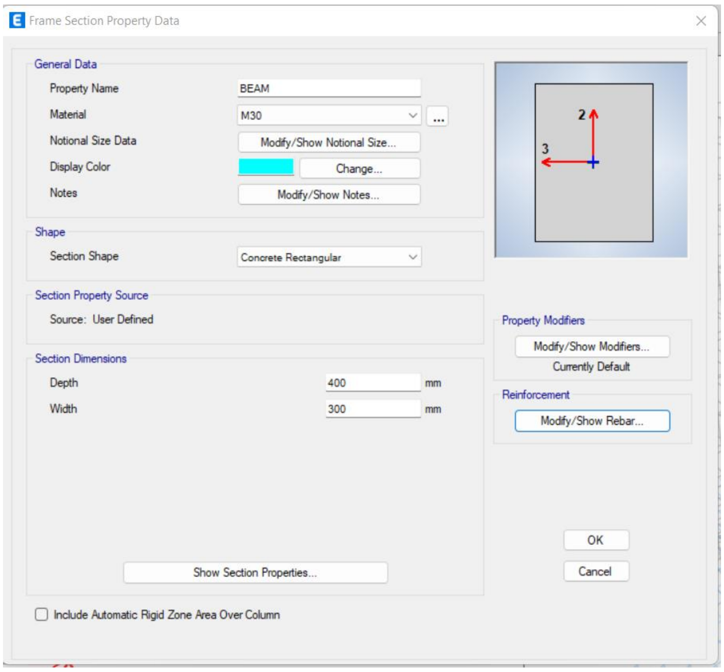


Fig 6 Defining the section properties of Beam

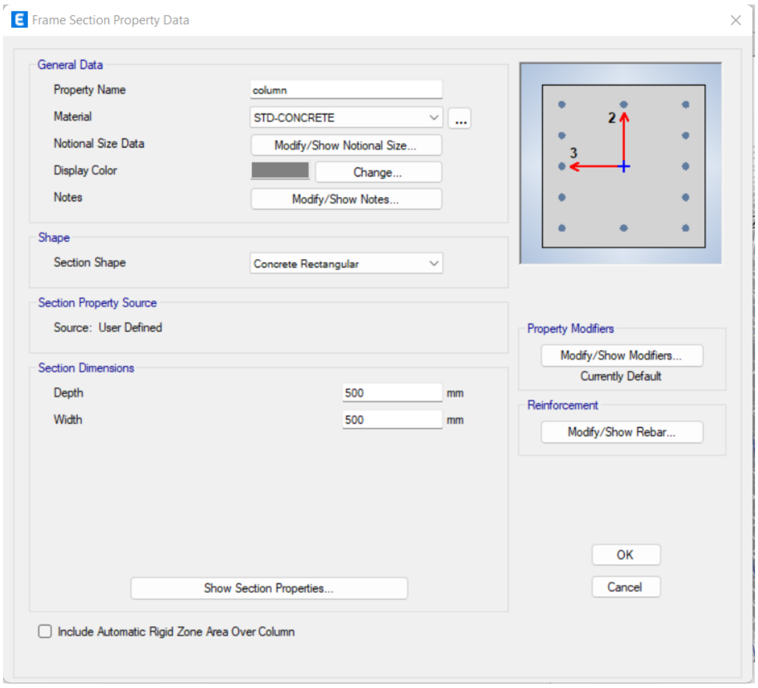


Fig 7 Defining Properties of Column

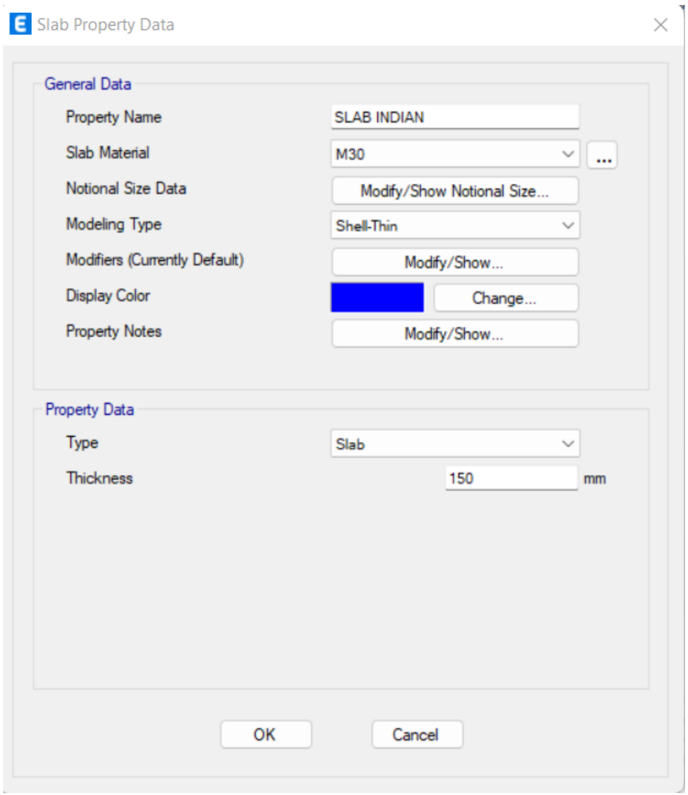


Fig 8 Defining the Properties of Shell-thin slab

Step 6: Assigning Fixed Support at bottom of the structure in X, Y and Z direction in both the considered cases.

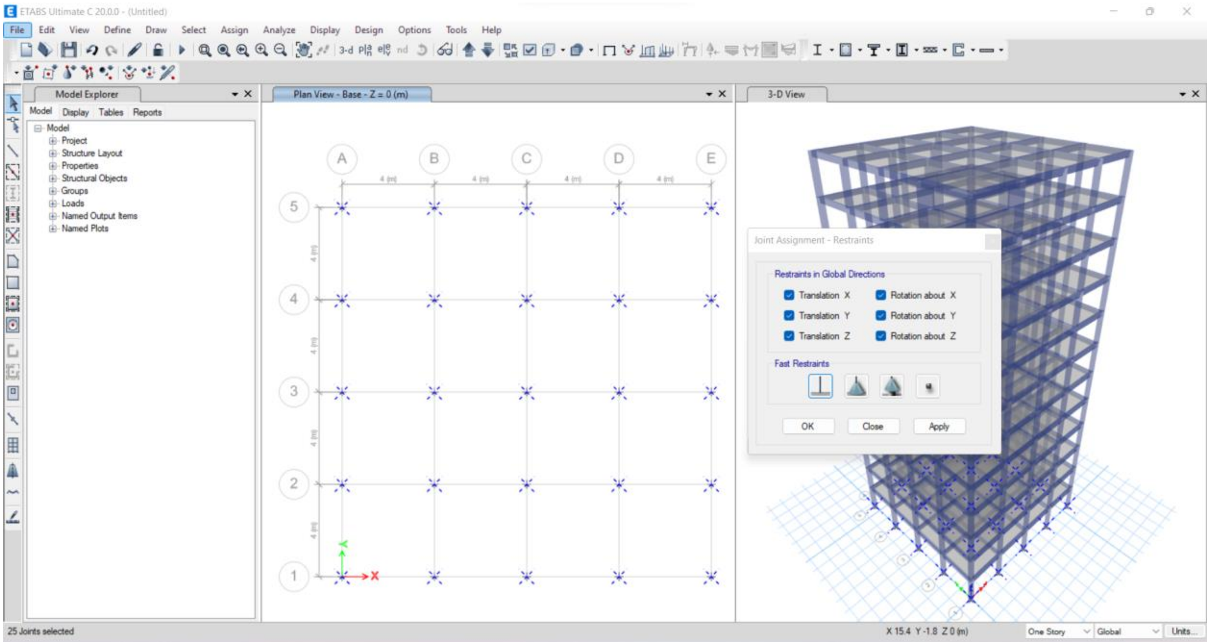


Fig 9 Assigning Fixed Support

Step 7: Defining Load cases for dead load, live load and seismic analysis for X and Y Direction.

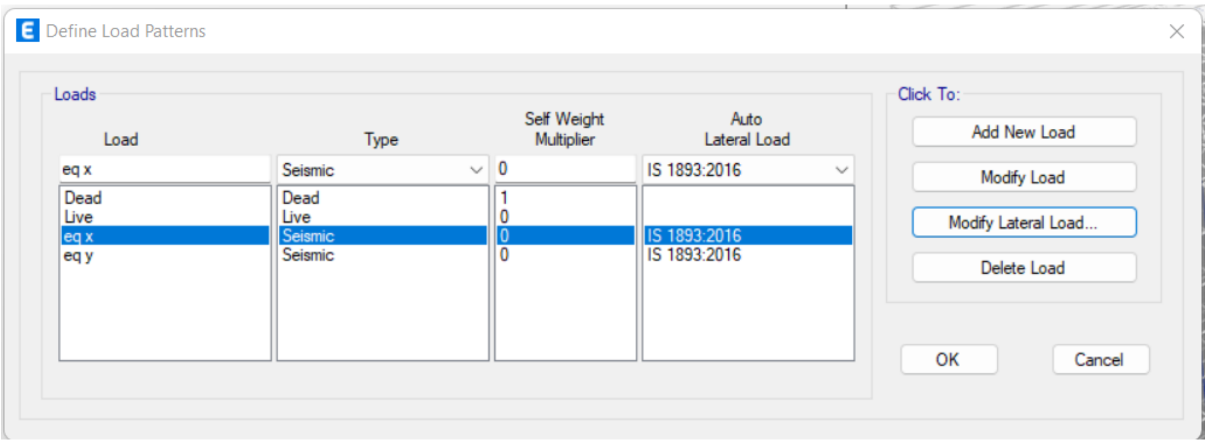


Fig 10 Defining Load Pattern

Step 8 Defining Seismic Loading as per IS 1893: 2016 Part I.

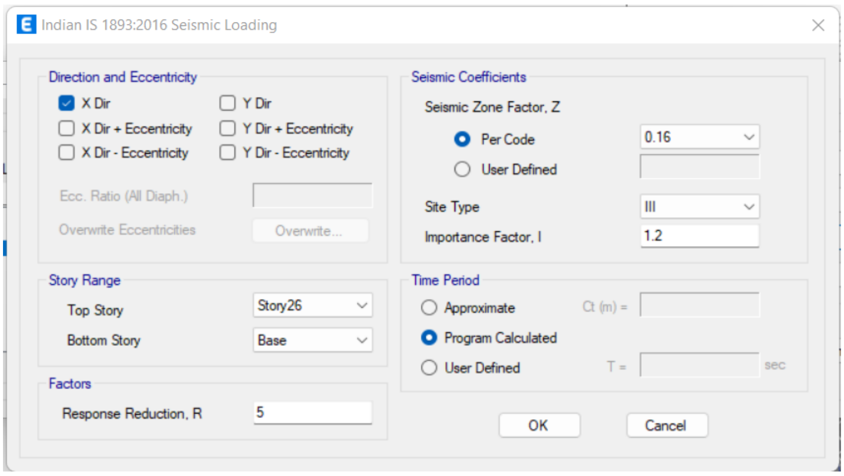


Fig 11 Seismic Loading for the Case Jabalpur for Soil Type II

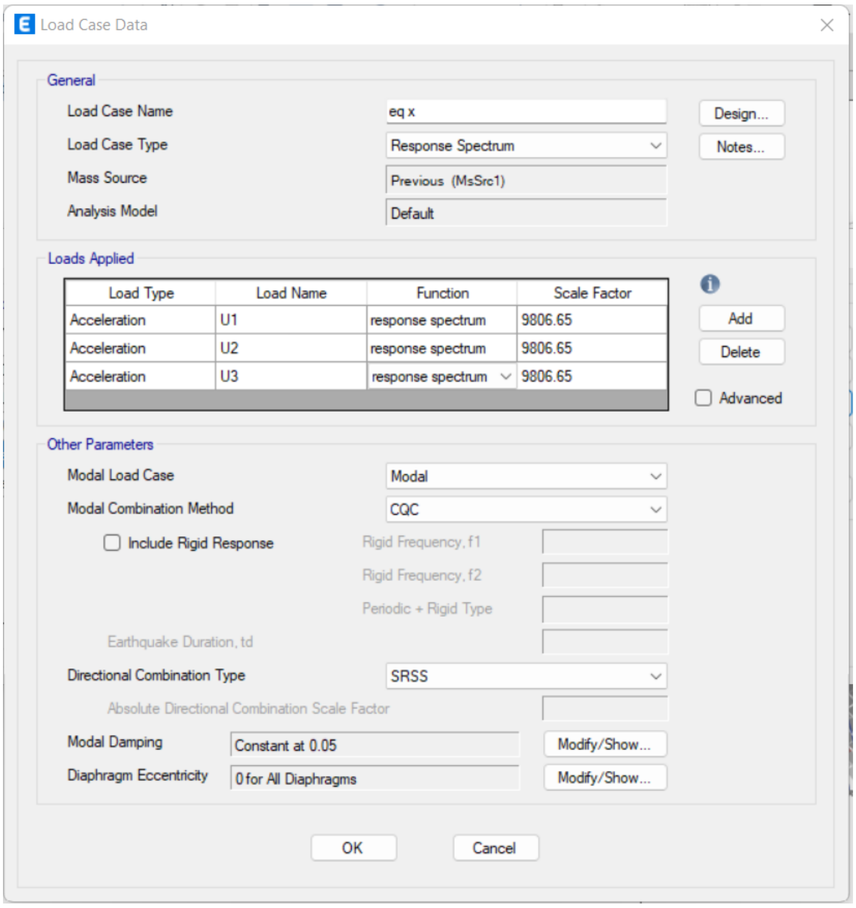


Fig 12 Load Case Data

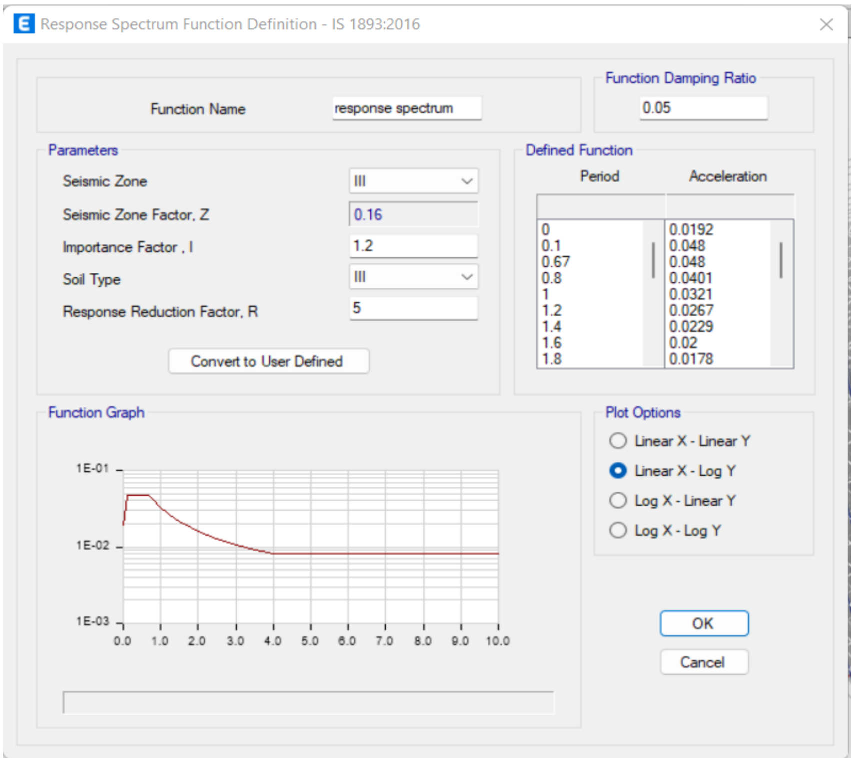


Fig 13 Defining Response Spectrum Analysis as per IS 1893-2016.

Step 9: Conducting the model check for both the cases in ETABS

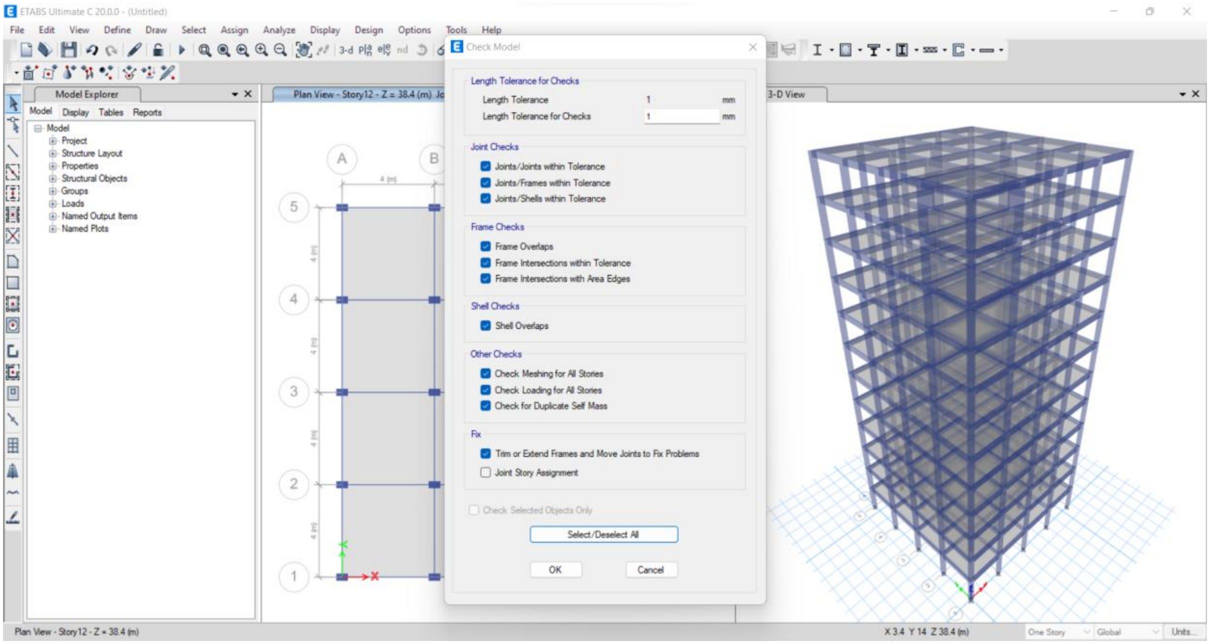


Fig 14 Model Check

Step 10: Analyzing the structure for dead load, stress analysis and displacement.

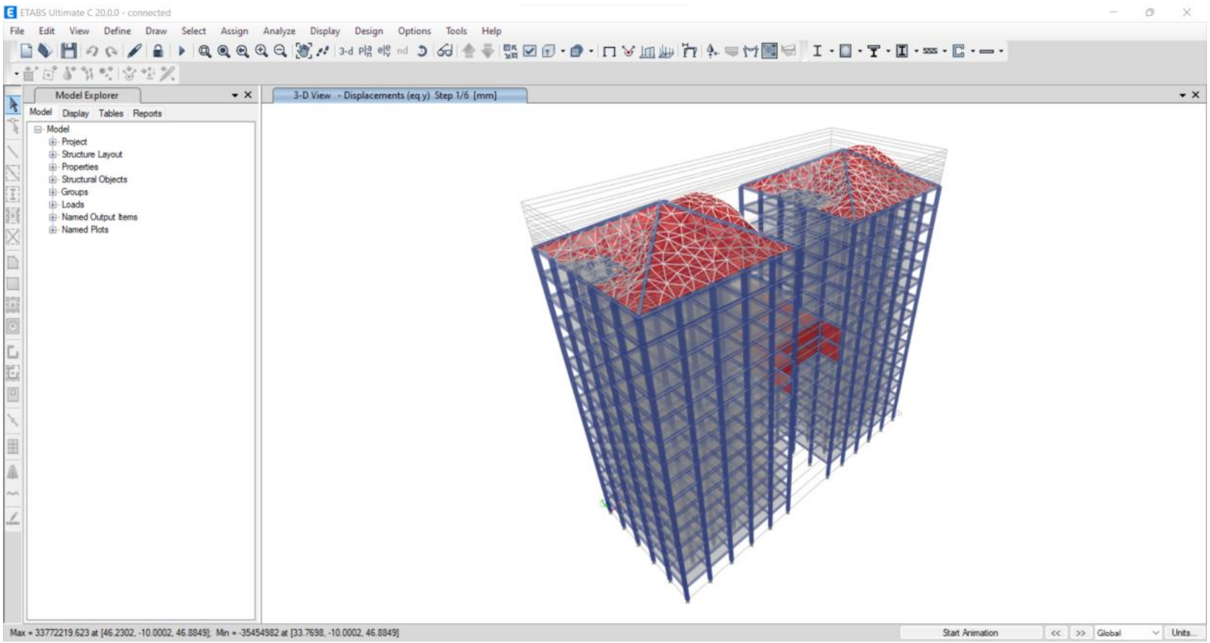


Fig 15 Stress Analysis for Dead Load

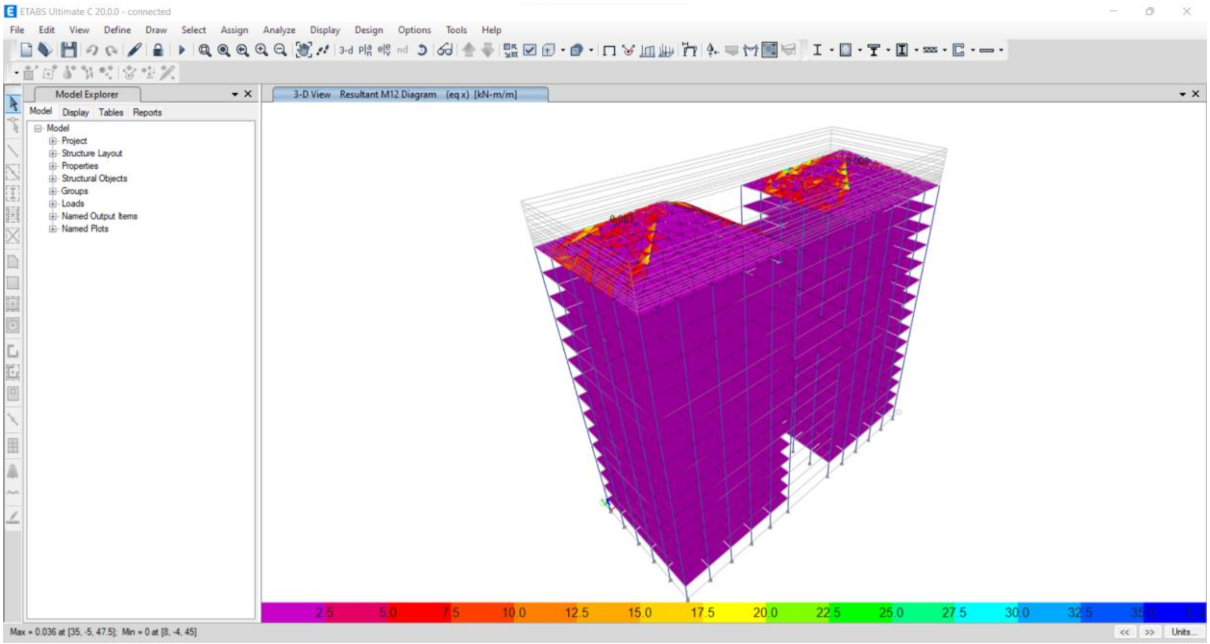
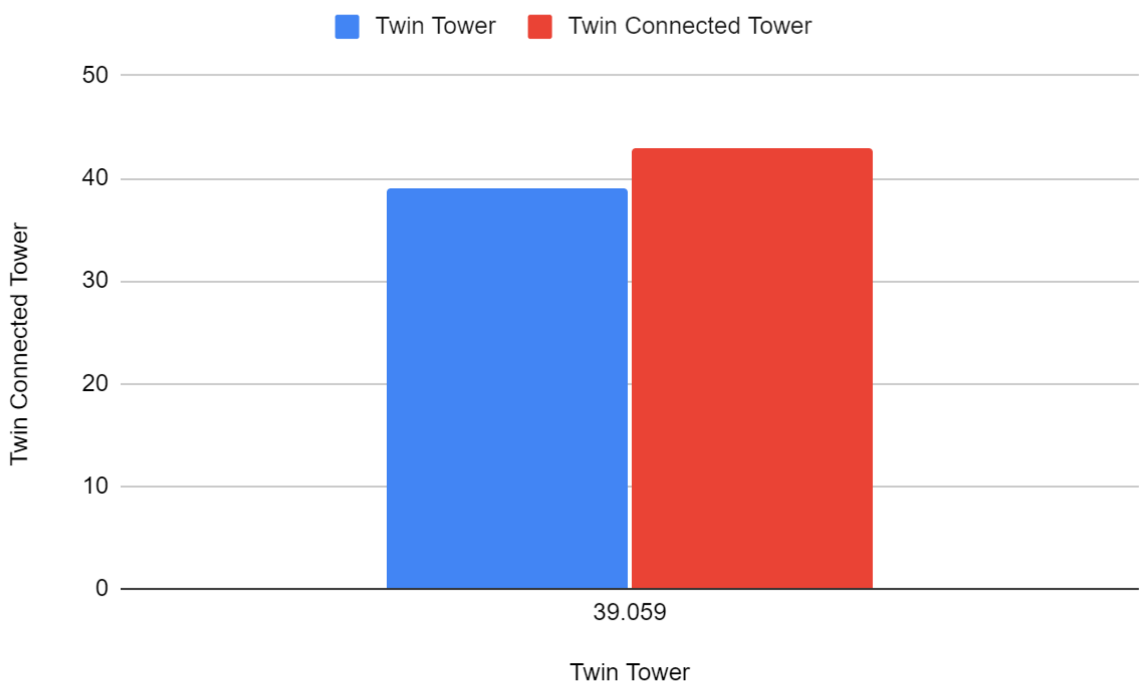
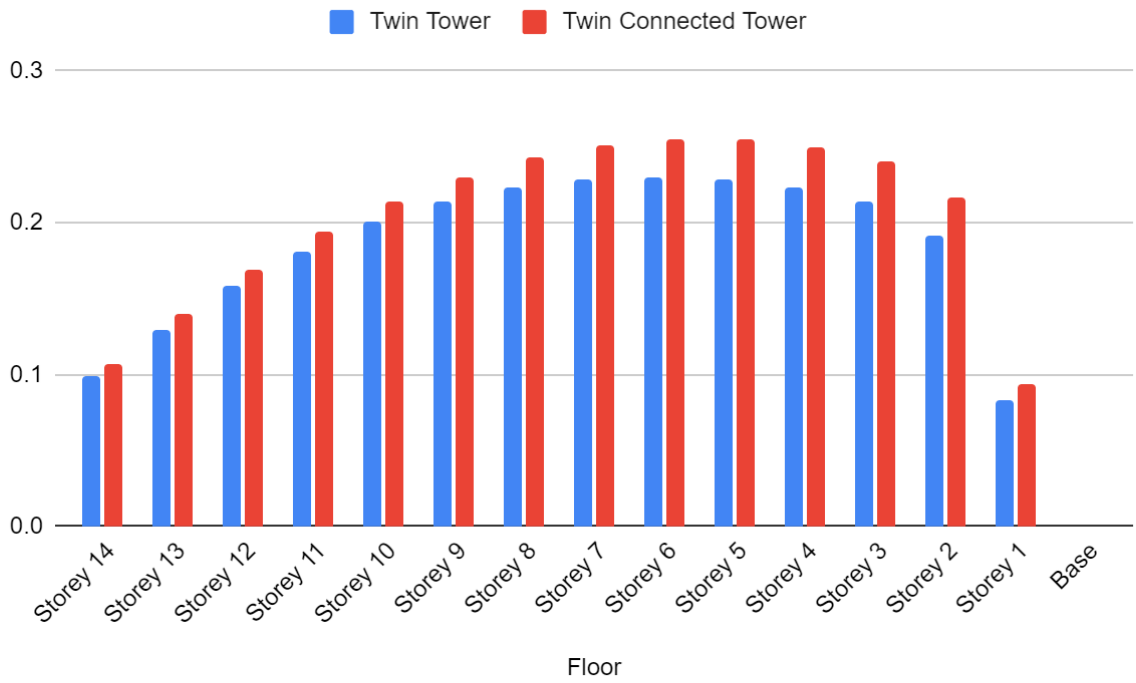
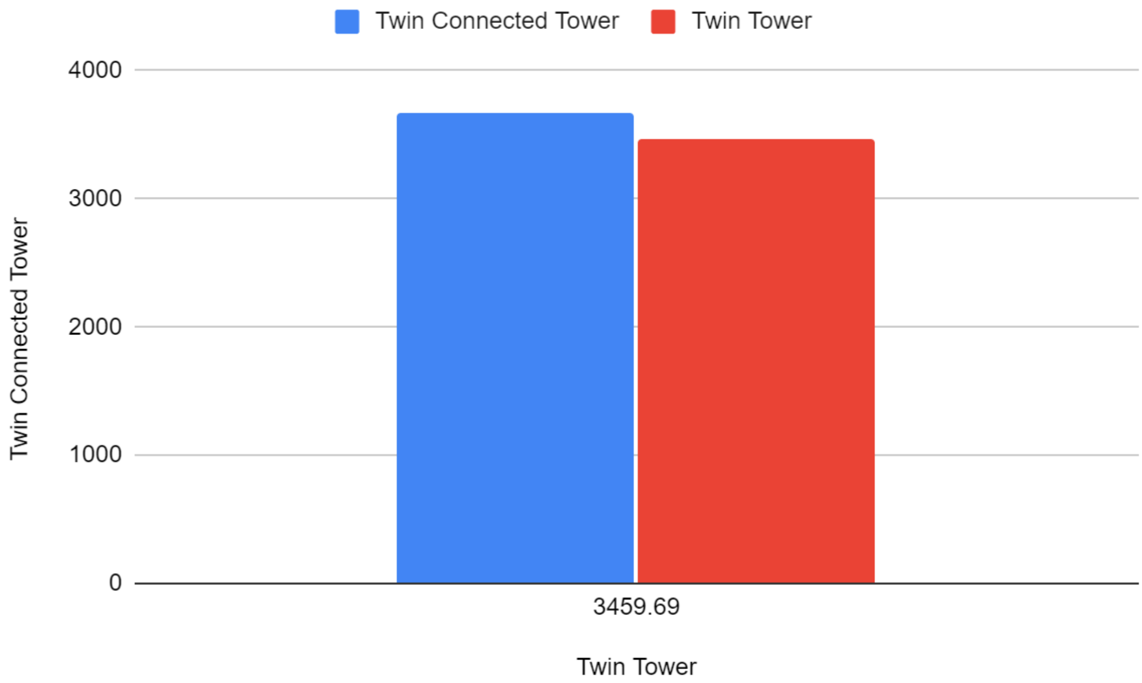


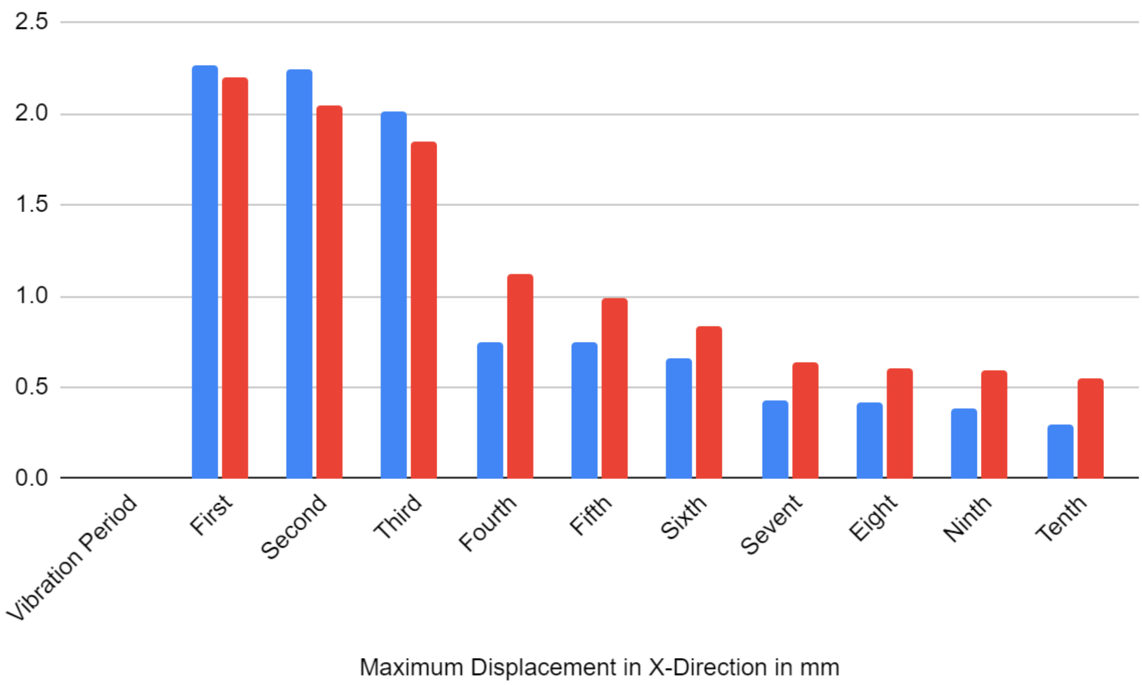
Fig 16 Storey Displacement

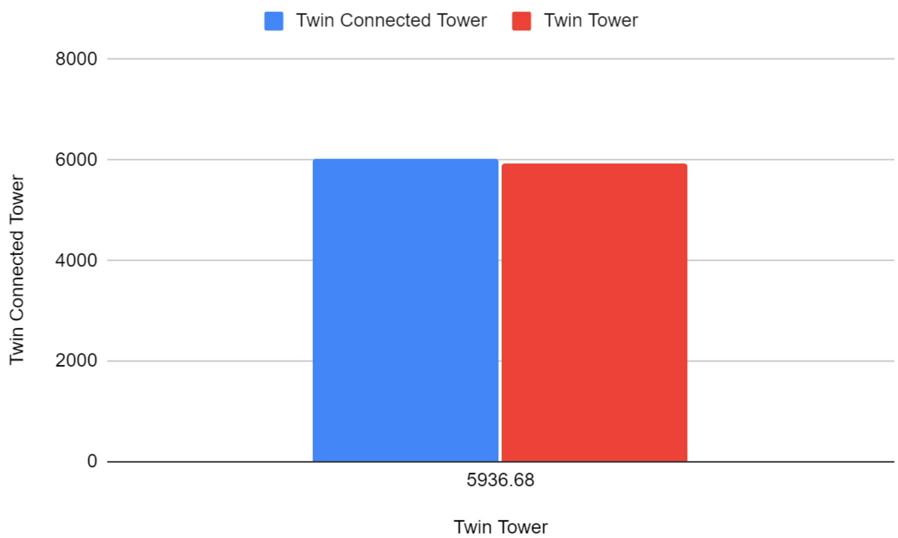
IV.ANALYSIS RESULT




Twin Tower
Twin Connected Tower
0.3
0.2
0.1
0.0
Storey 14
Storey 13
Storey 12
Storey 11
Storey 10
Storey 9
Storey 8
Storey 7
Storey 6
Storey 5
Storey 4
Storey 3
Storey 2
Storey 1
Base
Floor


Twin Connected Tower
Twin Tower
4000
3000
2000
1000
0
Twin Connected Tower
3459.69
Twin Tower





V. CONCLUSION

The design of twin towers building subjected to seismic effects cannot be based on analytical results obtained from general multistoried structure. As seen in results, the displacement values for twin tower cases for X direction gradually decrease.

Maximum Displacement

The pre-peak displacement equal to 75% of peak load and the post-peak displacement equal to 80% of peak load are used to determine the yield displacement and maximum displacement, respectively. When compared to other twin tower cases, the displacement was 8.2% higher for twin connected towers.

Storey Drift

The distance between two consecutive storeys divided by the height of that level is known as "storey drift." Additionally, story displacement is the magnitude of the storey's movement as a result of lateral forces. When designing partitions and curtain walls, story drift is crucial. Storey drift was higher at the centre where storey drift was 1.9% higher in case of Twin connected structure in comparison to Twin structure.

Storey Stiffness

The ability of structure to resist lateral deflection when a lateral force is applied. This is also called as Storey Stiffness, wherein the lateral deflection is storey drift and lateral force is storey shear. Storey stiffness was 4.9% less in case of connected twin tower in comparison to twin tower.

Base Shear

Base shear is a measurement of the maximum lateral stress that seismic activity is anticipated to have on the base of the structure. The seismic zone, soil type, and building code lateral force formulae are used to calculate it. Base shear was 7.1% higher in case of connected twin tower in comparison to twin tower.

Time Period

A building's natural period is simply how long it takes for an oscillation to complete. One of a building's characteristics that is governed by mass and stiffness is its natural period. The TIme period was determined for the fundamental period from stage one to stage tenth. Time period was found maximum in both the cases in the first stage and reduced drastically from the fourth stage in both the cases and a gap of 2.1% was seen in comparison of both the cases.

Storey Shear

The ratio of the story shear force at the time of story collapse to the story shear force at the time of entire collapse is known as the storey shear factor. Simple formulae are tentatively provided to calculate the necessary story shear safety factor that can be utilised to prevent story collapse through a series of dynamic assessments. Minor gap of 1.29% was seen in both the cases of comparison.

Axial Force

Axial force refers to a load whose line of action runs along the length of a structure or perpendicular to the structure's cross-section. Axial force was found maximum in case of twin connected tower by 3.9% in comparison to twin tower.

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