MINOR PROJECT REPORT

Submitted in partial fulfillment of the Requirements for the Award of Degree

Bachelor of Technology
in
Civil Engineering

COMPARATIVE RESPONSE SPECTRUM ANALYSIS OF B+G+15 BUILDINGS WITH AND WITHOUT CORE WALL SUBJECTED TO HISTORICAL EARTHQUAKES

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2023-24

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DECLARATION

We hereby declare that this project report entitled **" Comparative Response Spectrum Analysis of B+G+15 Buildings with and without Core Wall Subjected to Historical Earthquakes"** is an authentic record of our own work carried out as a partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering at Maulana Azad National Institute of Technology Bhopal (M.P.)-462003.

The work presented in this report is entirely our own, and we have not copied it from any other source without proper citation. We acknowledge and have duly cited all the references used in this project.

Date: April, 2024

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CERTIFICATE

This is to certify that the work contained in this report entitled **"Comparative Response Spectrum Analysis of B+G+15 Buildings with and without Core Wall Subjected to Historical Earthquakes"** submitted in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, is a bonafide work carried out by **Navneethan Pillai (211111241)**, **Abhishek Shukla (211111249) and Dhananjay Mani Mishra (211111250)** under my supervision. I further certify that this work has not been submitted elsewhere for any other degree or diploma.

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ABSTRACT

This minor project investigates the **seismic behaviour of a B+G+15 building** subjected to historical earthquake ground motions using **ANSYS software**. **Response spectrum analysis (RSA)**, encompassing both single (SRS) and multi response spectrum (MRS) methods, is a valuable tool for assessing the seismic performance of buildings. The analysis compared the structural response of the building **with and without a core wall** under earthquake loads from the **Koyna (1967)** and **Bhuj (2001)** earthquakes, considering both **SRS and MRS** approaches.

AutoCAD software was employed to create a detailed geometric model of the B+G+15 building, including the dimensions and locations of all structural elements. This model, incorporating the presence or absence of a core wall, was then imported into **ANSYS**. Material properties were assigned to the various building components within the ANSYS environment.

The chosen earthquake ground motions from Koyna and Bhuj were applied to the models through **both SRS and MRS** within ANSYS. This allowed for the comparison of structural responses considering a single ground motion direction (SRS) and the influence of considering multiple ground motion directions simultaneously (MRS). The analysis compared the **deflections, stresses, and shear forces** experienced by the building with and without a core wall under both earthquake scenarios and analysis methods (SRS and MRS).

The results revealed that the building with a core wall exhibited **significantly lower** values in all three categories (deflections, stresses, and shear forces) compared to the building without a core wall, for both SRS and MRS analyses. This indicates that the core wall significantly improves the **stiffness and strength** of the building, leading to a more robust response under seismic loads. Additionally, the analysis provided insights into the **differences between SRS and MRS results**, highlighting the potential influence of considering multiple ground motion directions on the overall seismic behaviour of the building.

These findings, obtained through **ANSYS-based RSA** using both SRS and MRS approaches on a model created using **AutoCAD**, highlight the critical role of core walls in enhancing the **earthquake resilience** of B+G+15 buildings. The project also contributes to a better understanding of the **effectiveness of SRS and MRS** for seismic analysis of tall buildings.

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CHAPTER -1

INTRODUCTION

The Earth's crust is constantly in motion, and the resulting movements can trigger earthquakes, sudden and violent shaking of the ground. These events have become a growing concern globally, with increasing frequency and intensity observed in recent decades. This rise in seismic activity necessitates a heightened focus on the vulnerability of structures, particularly high-rise buildings like B+G+15 buildings, to earthquake damage.

1.1 VULNERABILITY OF HIGH-RISE BUILDINGS

B+G+15 buildings, with their significant height and mass, are particularly susceptible to earthquake forces. Several factors contribute to this vulnerability:

1.1.1 Increased Centre of Gravity:

As buildings rise in height, their centre of gravity also moves upwards. Exclamation This higher centre of gravity creates a greater lever arm for earthquake forces to act upon, inducing larger moments (twisting forces) that can cause structural instability.

1.1.2 Amplified Ground Motion Effects:

Higher floors experience a more amplified shaking effect compared to lower floors due to the phenomenon of **seismic wave amplification**. This amplification further intensifies the forces acting on the building structure.

1.1.3 Brittle Material Behaviour:

Concrete and steel, commonly used materials in high-rise buildings, can exhibit brittle behaviour under extreme seismic loads. This means they may crack or fracture suddenly with minimal warning, leading to catastrophic failure.

1.1.4 Pounding Effects:

In densely populated areas, high-rises may be located close together. During an earthquake, swaying of one building can cause it to collide with its neighbour. This "pounding" effect can inflict severe damage on columns, beams, and exterior walls at the point of contact.

1.2 POTENTIAL CONSEQUENCES OF SEISMIC FAILURE

The consequences of seismic failure in high-rise buildings can be devastating and far-reaching. Here are some of the potential impacts:

1.2.1 Loss of Life:

Building collapse or partial failure can tragically lead to loss of life for occupants and emergency responders.

1.2.2 Widespread Property Damage:

The shaking forces can cause significant damage to the building itself, rendering it uninhabitable and requiring extensive repairs or demolition. Surrounding structures and infrastructure can also be damaged by falling debris or cascading failures.

1.2.3 Economic Disruption:

Earthquake damage to buildings disrupts businesses and can lead to significant economic losses. This includes repair costs, lost productivity, and potential long-term economic impacts on the affected area.

1.2.4 Psychological Trauma:

The experience of a major earthquake and witnessing its aftermath can cause lasting psychological trauma for survivors.

1.3 IMPORTANCE OF SEISMIC ANALYSIS

Given the immense potential for destruction, it is crucial to employ robust methods for evaluating the seismic performance of buildings, especially high-rise structures. Seismic analysis helps engineers:

1.3.1 Identify Potential Weaknesses:

By analysing the building's response to simulated earthquake loads, engineers can identify areas susceptible to damage. Engineers utilize simulated earthquake loads to assess a building's vulnerability to seismic events. This process involves subjecting a computer model of the building to controlled earthquake ground motions and analyzing the resulting structural response.

1.3.2 Optimize Design Strategies:

This analysis allows engineers to refine the building design to improve its ability to withstand earthquake forces. This may involve incorporating features like shear walls, base isolation systems, or energy dissipation devices.

1.3.3 Develop Emergency Response Plans:

Understanding the potential failure modes of the building can inform emergency response plans, enabling faster and more effective interventions during and after an earthquake.

In conclusion, the rising frequency and severity of earthquakes necessitate a proactive approach to seismic safety. Seismic analysis of high-rise buildings is a vital tool for mitigating the risks associated with earthquakes and ensuring the safety of occupants, minimizing property damage, and promoting economic resilience in the face of these natural disasters.

1.4 ZONES OF EARTHQUAKE IN INDIA

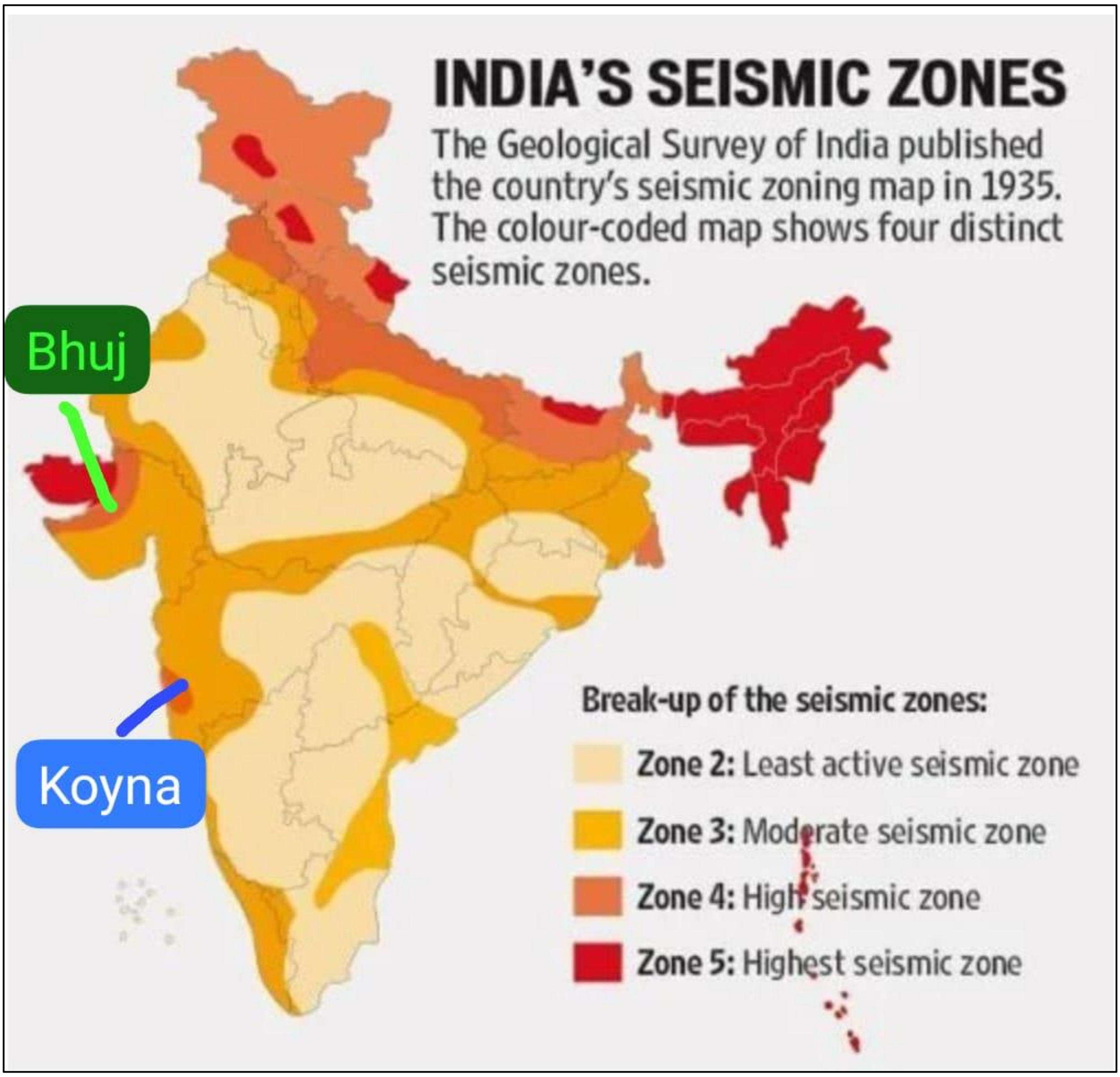


Fig1.4.1 Zones of Earthquake in India

CHAPTER -2

LITERATURE REVIEW

2.1 KOYNA EARTHQUAKE (1967): A RESERVOIR-TRIGGERED TREMOR

The Koyna earthquake, which struck on December 10, 1967, in Koyna Nagar, Maharashtra, offers a unique case study in earthquake science. With a magnitude estimated between Ms 6.3 and 6.5 (moment magnitude), it caused moderate damage in nearby regions. However, its primary significance lies in its suspected cause: reservoir-induced seismicity. Prior to the construction of the Koyna Dam, the region had minimal recorded seismic activity. However, the significant increase in water level behind the dam is believed to have played a critical role in triggering the earthquake.

The construction of the Koyna Dam on the Krishna River significantly increased the water level in the reservoir behind it. This, in turn, is believed to have triggered changes in the underlying rock formations by increasing pore pressure (the pressure of water trapped within cracks and pores). These changes in stress conditions are thought to have ultimately resulted in the earthquake.

The Koyna earthquake serves as a crucial reminder of the potential impact of human infrastructure projects on seismic activity. Analysing the B+G+15 building's response to the Koyna earthquake's ground motions allows us to assess its behaviour under a moderate seismic event with a unique cause.

In stark contrast to the Koyna earthquake, the Bhuj earthquake of January 26, 2001, stands as a tragic illustration of the destructive power of large earthquakes. This event, centred near Bhuj, Gujarat, with a magnitude of Ms 7.6 (estimated moment magnitude 7.7), unleashed immense forces that caused widespread devastation.

2.2 BHUJ EARTHQUAKE (2001): A REMINDER OF SEISMIC VULNERABILITY

The Bhuj earthquake was a shallow crustal event, occurring along a pre-existing fault line in the Earth's crust. The violent shaking caused widespread building collapses, particularly among unreinforced masonry structures. Estimates suggest that over 20,000 people lost their lives, and hundreds of thousands were injured. The Bhuj earthquake serves as a stark reminder of the importance of earthquake-resistant design, especially in densely populated regions.

By analysing the B+G+15 building's response to the Bhuj earthquake's ground motions, we can assess its behaviour under a much more severe seismic event. This comparison will provide valuable insights into the building's capacity to withstand a major earthquake and its overall contribution to earthquake resilience.

2.3 SEISMIC ANALYSIS METHODS FOR BUILDING DESIGN

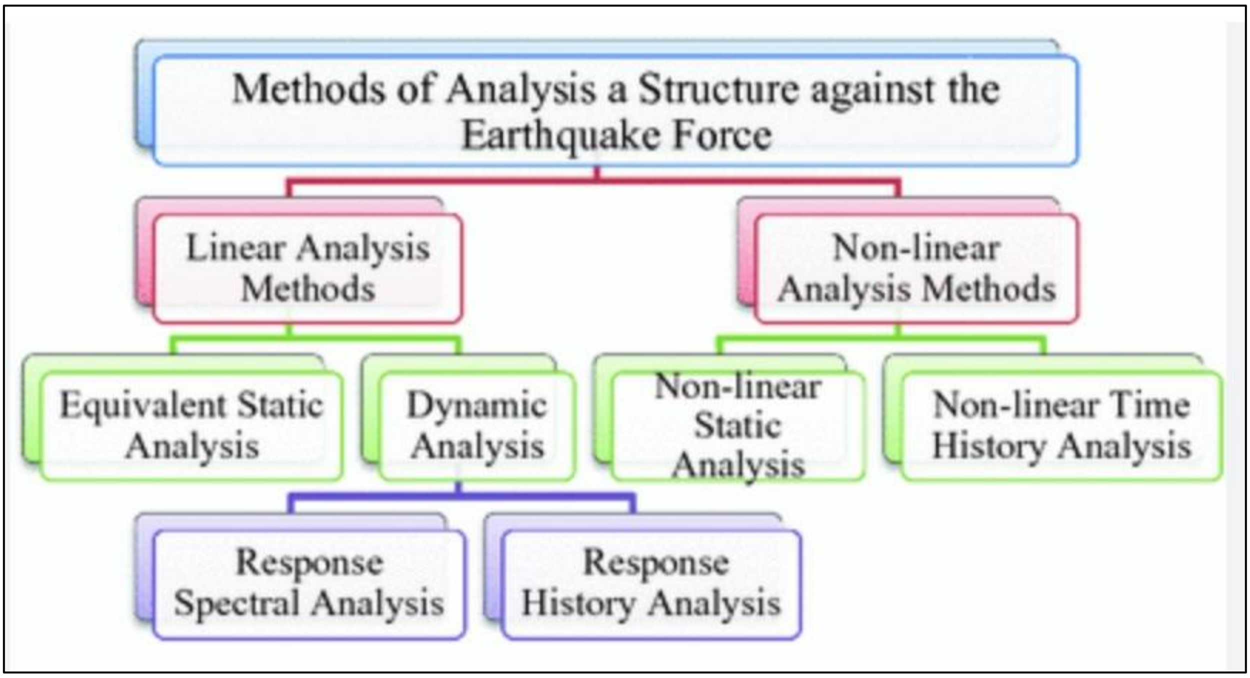


Fig 2.3.1 Method of Seismic Analysis

The safety and stability of buildings in earthquake-prone regions are paramount concerns for engineers. To address these concerns, a diverse toolbox of **seismic analysis methods** exists. These methods fall into two broad categories: **static** and **dynamic**. Each category further encompasses **linear** and **non-linear** approaches, providing a spectrum of analysis techniques.

2.3.1 Static Analysis:

Static analysis theory for seismic load involves assessing the structural response to seismic forces without considering the dynamic effects of the earthquake. It typically includes evaluating the structure's capacity to resist seismic forces using simplified mathematical models, such as equivalent lateral force method or response spectrum analysis, to determine the internal forces and deformations induced by seismic loads.

2.3.1.1 Static Equivalent Lateral Force (ELF) Procedure (Linear):

This widely used method applies a set of static horizontal forces to the building based on its seismic zone and importance. While efficient and leading to conservative designs, it neglects the dynamic nature of earthquakes and may not provide detailed information about building deflections.

2.3.1.2 Non-linear Static Pushover Analysis:

This method applies a gradually increasing lateral load (pushover) to the structure until collapse. It provides insights into the building's capacity under monotonic loading but does not directly represent an earthquake.

2.3.2 Dynamic Analysis:

These methods provide a more comprehensive assessment by considering the building's dynamic properties and the time-varying nature of earthquake ground motion.

2.3.2.1 Response Spectrum Analysis (RSA) (Linear):

This popular method utilizes earthquake ground motion data (response spectra) to predict the building's response (deflections, stresses, shear forces). It offers a balance between efficiency and accuracy but assumes linear material behaviour.

2.3.2.2 Modal Analysis (Linear):

This method decomposes the building's response into its natural vibration modes, combining individual modal responses for overall response. It is more efficient than full dynamic analysis and is good for initial assessment, but may not capture complex behaviour if higher modes contribute significantly.

2.3.2.3 Non-linear Time-History Analysis:

This method applies the complete earthquake ground motion record to the structural model, considering non-linear material behaviour. It provides the most realistic representation of building response but is computationally expensive and requires detailed data and expertise.

2.4 SEISMIC ANALYSIS METHODS: A COMPARISON TABLE

Table 2.4.1 Comparison between Seismic Methods

Category	Method	Description	Advantages	Limitations
Static Analysis	Static Equivalent Lateral Force (ELF) Procedure (Linear)	Applies a set of static horizontal forces to the building based on seismic zone and building importance.	Simple, efficient, conservative design	Neglects dynamic effects, limited insights into deflections
Static Analysis	Non-linear Static Pushover Analysis	Applies a gradually increasing lateral load (pushover) to the structure until collapse (limited non-linearity).	Insights into building capacity under monotonic loading	Less common, doesn't capture full complexity of non-linear behaviour under earthquakes
Dynamic Analysis	Response Spectrum Analysis (RSA) (Linear)	Uses earthquake ground motion data (response spectra) to predict building response (deflections, stresses, shear forces).	Balance between efficiency and accuracy, valuable insights	Assumes linear material behaviour, may not capture complex non-linear behaviour
Dynamic Analysis	Modal Analysis (Linear)	Decomposes building response into natural vibration modes, combines individual modal responses for overall response.	More efficient than full time-history analysis, good for initial assessment	May not capture complex behaviour if higher modes contribute significantly
Dynamic Analysis	Non-linear Time-History Analysis	Applies complete earthquake ground motion record to the structural model, considering non-linear material behaviour.	Most realistic representation of building response	Computationally expensive, requires detailed data and expertise

2.5 RESPONSE SPECTRUM: (SINGLE-POINT Vs. MULTI-POINT)

The concept of a response spectrum is central to Response Spectrum Analysis (RSA), a crucial tool for seismic analysis in engineering software like ANSYS. Imagine a collection of single-degree-of-freedom (SDOF) oscillators, each with a unique natural frequency. A response spectrum represents the **maximum response** (displacement, velocity, or acceleration) of each of these oscillators when subjected to a specific earthquake ground motion. This response is typically plotted as a function of the oscillator's natural frequency. Essentially, it condenses the complex information of the entire ground motion record into a single, informative graph.

2.5.1Types of Response Spectra:

2.5.1.1 Single-Point Response Spectrum:

This type of spectrum focuses on the response at a specific location within a structure. It is generated by analysing a single-degree-of-of-freedom system fixed at that location and subjected to the chosen ground motion.

Advantages:

1. Simple to generate and interpret.
2. Useful for analysing critical points in the structure.

Limitations:

1. May not capture the variations in response across different locations within the structure.
2. This can be a concern for complex buildings or when assessing potential weak points.

2.5.1.2 Multi-Point Response Spectrum:

This spectrum considers the response at multiple locations within the structure. It involves generating individual response spectra for each chosen location, effectively creating a "spectrum of spectra."

Advantages:

1. Provides a more comprehensive understanding of the building's behaviour under earthquake loads by capturing response variations across different locations.

2. Essential for analysing complex structures potential weak points.

Limitations:

1. Requires more computational effort compared to a single-point spectrum.
2. Interpretation can be more complex due to the presence of multiple spectra.

2.6 ANSYS-BASED SEISMIC ANALYSIS: RESPONSE SPECTRUM TECHNIQUES

ANSYS utilizes the FEM, a numerical technique that subdivides a complex structure into smaller, simpler elements. By applying governing equations to each element and considering their interactions, ANSYS can predict the overall structural response under various loading conditions, including earthquake forces. This approach allows for detailed analysis of complex building geometries. Modal analysis is a crucial step in the seismic analysis workflow within ANSYS. It involves determining the **natural frequencies** and **mode shapes** of the building structure. These represent the inherent vibration characteristics of the building when subjected to external forces, such as earthquakes.

2.6.1 Natural Frequencies:

These are the frequencies at which the building tends to vibrate most readily during an earthquake. Resonance between the earthquake ground motion and these natural frequencies can lead to significant structural response.

2.6.2 Mode Shapes:

These represent the deflection patterns of the building at its natural frequencies. Understanding these shapes helps engineers visualize how the building might deform under earthquake loads.

2.7 INTEGRATION WITH AUTOCAD GEOMETRY

AutoCAD is a widely used computer-aided design (CAD) software for creating 2D and 3D models. For seismic analysis in ANSYS, the building geometry is often first created in AutoCAD. ANSYS offers tools to import this geometry directly, eliminating the need for manual recreation within the software. This streamlines the workflow and reduces the potential for errors in geometry definition.

CHAPTER -3

METHODOLOGY OF ANALYSIS

This chapter details the methodology employed to assess the seismic performance of the B+G+15 building under investigation. The core approach revolves around Response Spectrum Analysis (RSA) with two variants: Single Response Spectrum (SRS) and Multi-Response Spectrum (MRS). Both approaches will be implemented within the ANSYS software framework, which utilizes the Finite Element Method (FEM) for complex structural analysis.

3.1 ANSYS AND THE FINITE ELEMENT METHOD (FEM)

This chapter details the methodology employed to assess the seismic performance of the B+G+15 building under investigation. The core approach revolves around Response Spectrum Analysis (RSA) with two variants: Single Response Spectrum (SRS) and Multi-Response Spectrum (MRS). Both approaches will be implemented within the ANSYS software framework, which utilizes the Finite Element Method (FEM) for complex structural analysis.

ANSYS is a powerful engineering simulation software that leverages the Finite Element Method (FEM) to analyse the behaviour of structures under various loading conditions, including earthquake ground motions. FEM works by discretizing the complex geometry of the building into a finite number of smaller elements (beams, columns, walls, etc.). This essentially creates a simplified mesh representation of the actual structure.

3.2 ANSYS FUNCTIONALITY IN THE ANALYSIS PROCESS:

3.2.1 Model Import and Discretization:

The detailed geometric model of the B+G+15 building, incorporating the presence or absence of a core wall (created using AutoCAD software), will be imported into ANSYS. Within ANSYS, the software automatically discretizes the model geometry into the mesh of elements. This mesh allows for a more manageable and computationally efficient analysis.

3.2.2 Material Property Assignment:

Material properties like elasticity, density, and strength characteristics are assigned to each element within the model. This enables ANSYS to accurately represent the behaviour of different materials (concrete, steel, etc.) used in the building's construction.

3.2.3 Modal Analysis:

ANSYS performs a modal analysis to extract the natural frequencies and vibration modes of the discretized structure. These modes represent the inherent dynamic characteristics of the building and how it would vibrate under various excitations. Understanding these modes is crucial for analysing the seismic response.

3.2.4 Response Spectra Integration:

Historical earthquake records from the Koyna (1967) and Bhuj (2001) earthquakes (Acceleration Vs. Frequency) data is used to generate response spectra. These spectra will be integrated into the analysis within ANSYS.

3.2.5 Modal Participation and Response Combination:

The response spectra are then used to determine the modal participation factors for each mode of the structure. These factors quantify how much each mode contributes to the overall response under the specific earthquake ground motion. Finally, the modal responses are combined using appropriate methods (e.g., SRSS) to obtain the total structural response (deflections, stresses, and shear forces) for both SRS and MRS approaches.

3.3 ANSYS APPROACH

3.3.1 Pre-processing:

1.Streamlined Model Setup: Workbench offers dedicated modules for pre-processing tasks, such as:

- **Model Import:** Seamlessly import geometric models from CAD software like AutoCAD, eliminating the need for manual recreation within ANSYS.
- **Mesh Generation:** Utilize Workbench tools to generate a finite element mesh for your model. The software offers options to control mesh density and ensure proper representation of complex geometries.

- **Material Assignment:** Define material properties (elasticity, density, strength) for different elements within your model, accurately reflecting the behaviour of concrete, steel, or other building materials.

3.3.2 Solution:

- **Analysis Definition:** Workbench allows you to define the type of analysis you want to perform. In our case, you would select "Static Structural" analysis for initial calculations, followed by "Response Spectrum Analysis" (RSA) to assess seismic performance.
- **Solver Integration:** Workbench seamlessly integrates with ANSYS solvers to perform the calculations required for the chosen analysis type. You can initiate the solver directly within the Workbench environment.

3.3.3 post-processing:

1. **Visualization and Results Exploration:** Workbench provides powerful tools for visualizing and analysing the results of your structural analysis. These tools include:
    - **Deformed Shapes:** Visually assess the deformation of the structure under applied loads, such as earthquake ground motions.
    - **Stress and Strain Distributions:** Analyse the distribution of stresses and strains throughout the structure, identifying critical areas with high stress concentrations.
    - **Modal Animation:** Animate the vibration modes of the structure extracted through modal analysis, gaining insights into its dynamic behaviour.

CHAPTER -4

FINITE ELEMENT METHOD

4.1 Introduction

Finite element method (FEM) also known as finite element analysis (FEA) is a numerical method for finding approximate solutions of partial differential equations (PDE) and integral equations. The method essentially consists of assuming the piecewise continuous function for the solution and obtaining the parameters of the functions in a manner that reduces the error in the solution. The most used until the development of finite element method was the finite difference method. replacing it with an assemblage of discrete elements. Since these elements can be put together in a variety of ways, they can be used to represent exceedingly complex shapes.

The Finite Element Method (FEM) is a powerful numerical technique widely used for solving complex structural analysis problems, particularly those involving earthquake engineering. Here are its key advantages that make it well-suited for our project:

- **Accurate Approximations:** FEM employs a piecewise approximation of the physical field across individual elements within the structure. This approach allows for achieving good precision even with relatively simple mathematical functions. Additionally, by refining the mesh (increasing the number of elements), the accuracy of the solution can be systematically improved.
- **Efficient Handling of Large Problems:** FEM utilizes a concept called "locality of approximation." This means that the behaviour of each element is primarily influenced by its immediate neighbours. This characteristic leads to sparse systems of equations when discretizing the governing equations, making them computationally efficient to solve. This is a significant advantage for problems with many unknowns (degrees of freedom), such as the analysis of high-rise buildings like the B+G+15 structure in our project.
- **Versatility for Complex Geometries:** Unlike finite difference methods, which struggle with irregular shapes and complex boundary conditions, FEM excels in such scenarios. By dividing the structure into smaller elements, FEM can effectively represent intricate geometries, making it ideal for analysing real-world structures with various architectural features.

The basic assumption of the finite element method is that a solution region can be analytically modeled or approximated by replacing it with an assemblage of discrete elements. Since these elements can be put together in a variety of ways, and unlike the finite difference method the equations for each element are not dependent on the previous element or the subsequent one, this assemblage of elements can be used to represent complex shapes. This factor is a major advantage of the F.E.M. over the finite difference method, which becomes difficult to use in case of very irregular geometry or unusual specification of boundary conditions. The F.E.M. is particularly well suited for problems with complex geometry.

4.2 WHAT IS FINITE ELEMENT ANALYSIS?

In finite element analysis a computational model of an object subjected to a specific boundary conditions and different loading conditions is required for analysis. There are generally two types of analysis that are two-dimensional modelling and three-dimensional modelling. Two-dimensional modelling is simpler than three-dimensional modelling but it leads to less precise results. Due two this reason three-dimensional modelling is preferred for the complex geometry.

4.2.1 How Does Finite Element Analysis Work?

Finite element analysis uses the complex system of points known as NODES which make a network known as MESH. This mesh contains material and structural properties which describe that how the material will react under the applied loads and boundary conditions. The node contains the density throughout the material depending on the probable stress level of a particular area. The area which receives large stresses usually contain higher node density compared to another region which receives less stresses.

4.3 MERITS, DEMERITS AND APPLICATIONS OF FEM

4.3.1 Merits of FEM

Compared to other numerical methods some of the merits of FEM as follows:

1. Modelling of complex geometries and irregular shapes are easier as varieties of finite elements are available for discretization of domain.

2. Boundary conditions can be easily incorporated in FEM.

3. Different types of material properties can be easily accommodated in modelling from element to element or even within an element.

4. Problems with heterogeneity, anisotropy, nonlinearity, and time-dependency can be easily dealt with.

5. The systematic generally of FEM procedure makes it a powerful and versatile tool for a wide range of problems.

6. FEM is a simple, compact, and result-oriented and hence widely popular among engineering community.

7. FEM can be easily coupled with computer-aided design programs in various streams of engineering.

8. In FEM, it is relatively easy to control the accuracy by refining the mesh or using higher order elements.

9. Availability of large number of computer software packages and literature makes FEM a versatile and powerful numerical method.

4.3.2 Demerits of FEM

1. Closed form expressions in terms of problem parameters are not available in FEM. Numerical solutions are obtained at one time for a specific problem case only. Hence, unlike analytical solutions, there is no advantage of flexibility and generalization.

2. Large amount of data is required as input for the mesh used in terms of nodal connectivity and other parameter depending on the problem.

3. Generally, voluminous output data must be analyzed and interpreted.

4. Experience, good engineering judgment and understanding of the physical problems are required in FEM modelling. Poor selection of element type or discretization may lead to faulty results.

4.3.3 Application of FEM

Some application areas of Finite Element Method are following:

1. Structural mechanical, two dimensional analyses: In plane trusses, stretching of plates, gravity dams

2. Three-dimensional analysis: - 3D Trusses, space frames such as cranes, thin-walled structure like machine tools, transmission towers, nuclear reactors, shell roofs, arches, drilling platforms etc.

3. Thermal analysis: Transient and steady state temperature distribution, thermal strains and stresses flow towards wells, seepage through foundations, fluids flow in pipes, canal etc.

4. Hydro Elasticity: Hydrodynamic, Hydrostatic and air bearing, reservoir-dam interactions, flashing or liquids in flexible containers etc.

5. Dynamics: - Natural frequencies and mode shape of structures. Response to arbitrary dynamic loading such as wind, explosions, water waves, earthquake etc.

4.4 Different Approaches in FEM

Most conventional method are cumbersome, uneconomical and time consuming to apply engineering, due to introduction of new materials such as composites, fiber reinforced materials etc. and complicated geometry to be modeled has become one of the most popular numerical methods to deal with complex geometries and material properties with the availability of high-speed digital computers. Generally, FEM can be considered as variant of Rayleigh-Ritz method in combination with the variational principle applied to continuum mechanics. In the Rayleigh-Ritz method, trial functions are used to represent the entire domain. On the other hand, the trial functions used in FEM are approximated over a sub-domain, referred to as an element.

.5 The Basic Concept

The problem involving in complex material properties and boundary conditions, the engineer resorts to numerical methods that provides approximate, but acceptable solutions. In most of the numerical methods, the solutions yield approximate values of the unknown quantities only at discrete points in the body. The process of selecting only certain number of discrete points in the body can be termed as discretization. One of the ways of discrediting body or a structure is to divide it in to an equivalent system of smaller bodies or units. The assemblage of such units then represents the whole body. Although the analysis procedure of going from part to whole is considerably simplified, the amount of data to be handled is dependent upon the number of smaller bodies into which the original body is divided. The number of elements used in a problem depends mainly on the element type and accuracy desired. Problems are usually solved by one of the approaches: the displacement method, the equilibrium method, and the mixed method. Displacements are assumed as primary unknown quantities in the displacement method; stresses are assumed as primary unknowns in equilibrium method, some displacements and some stresses are assumed as unknown quantities in mixed method.

CHAPTER -5

DETAILS OF BUILDING

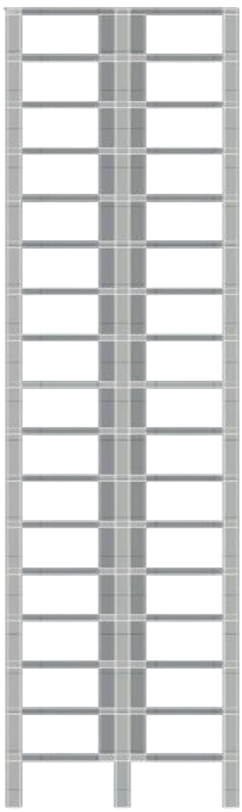
5.1 STRUCTURAL MODAL DESCRIPTION

Building type: Multi-storied residential building (B+G+15)

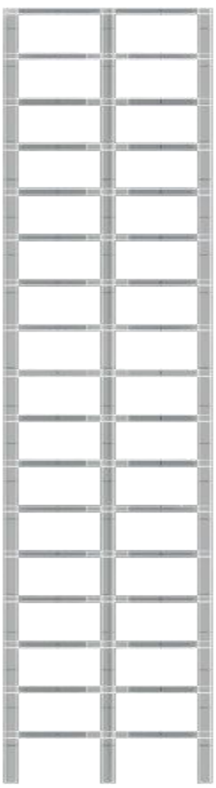
Table 5.1.1 Description of structural data

S.NO.	SECTION	DIMENSION
1	Column Cross Section	600mm* 600mm
2	Slab Thickness	400mm
3	Core Wall Thickness	400mm
4	Basement Wall Thickness	300mm
5	Concrete Density	2300kg/m^3
6	Poisson’s Ratio (Concrete)	0.18
7	Height of Building	5100mm

5.2 CROSS SECTION



With core Wall



Without Core Wall

CHAPTER -6

SOFTWARE EVALUATIONS

FLOWCHART:

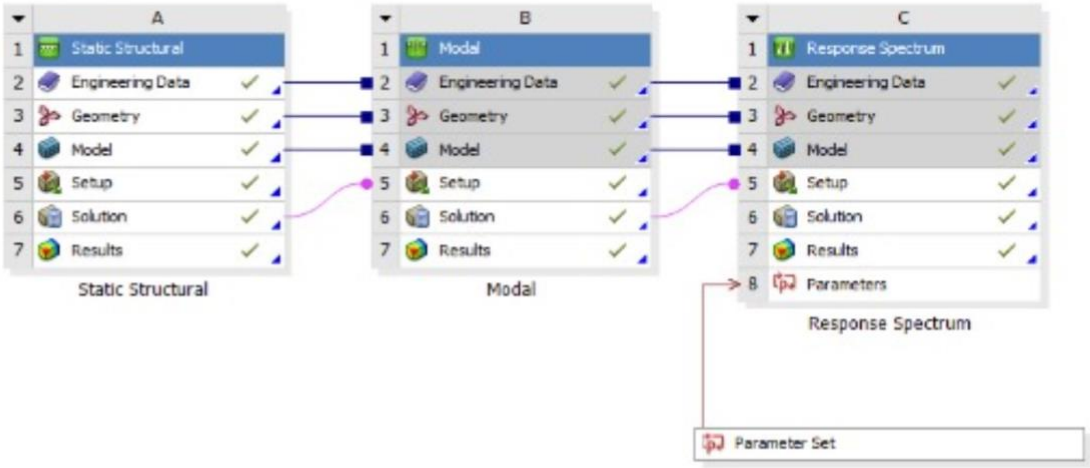


FIG 6.1

IMPORT OF GEOMETRY:

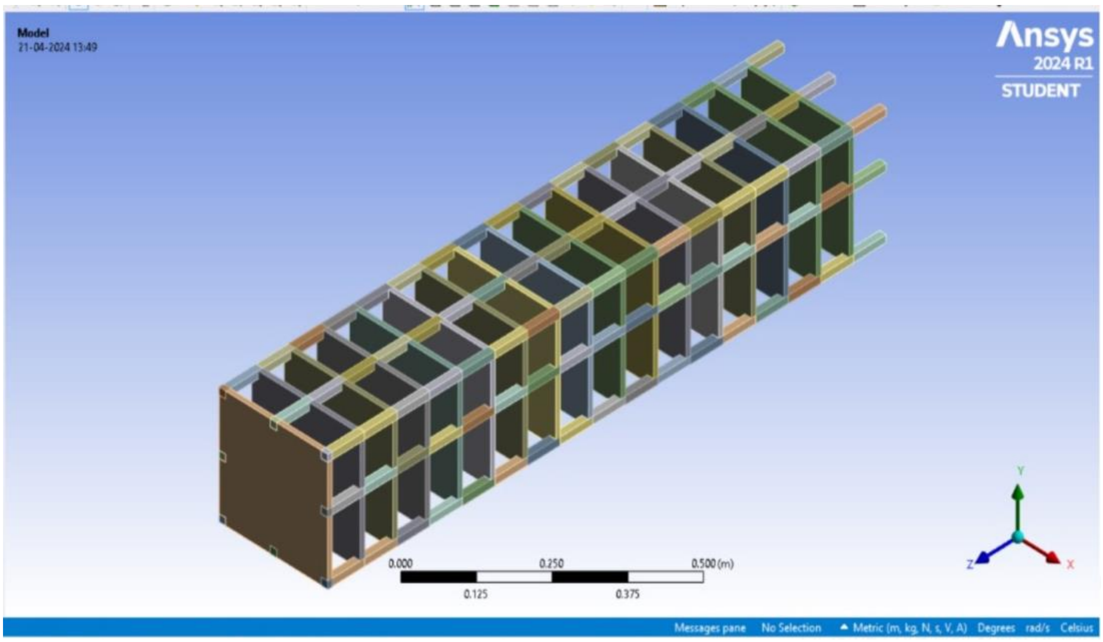


FIG 6.2

MESHING OF BUILDING:

FIG 6.3

FIXING THE SUPPORT:

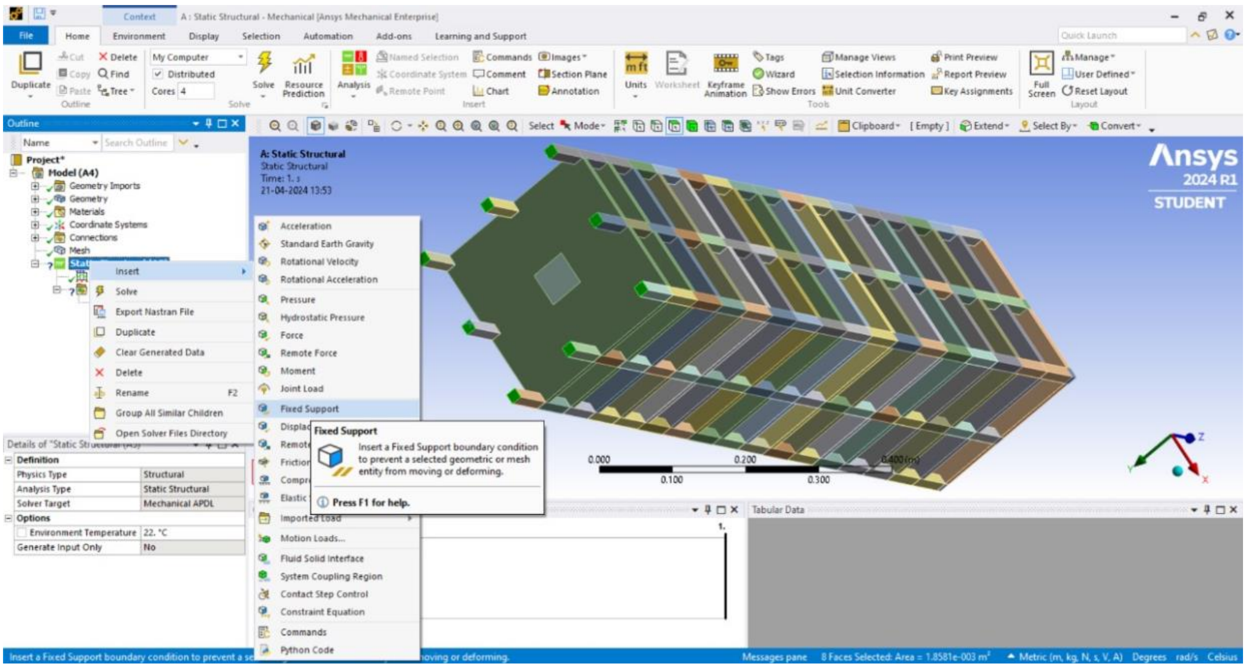


FIG 6.3

MODES OF FAILURE:

WITH CORE WALL

1)

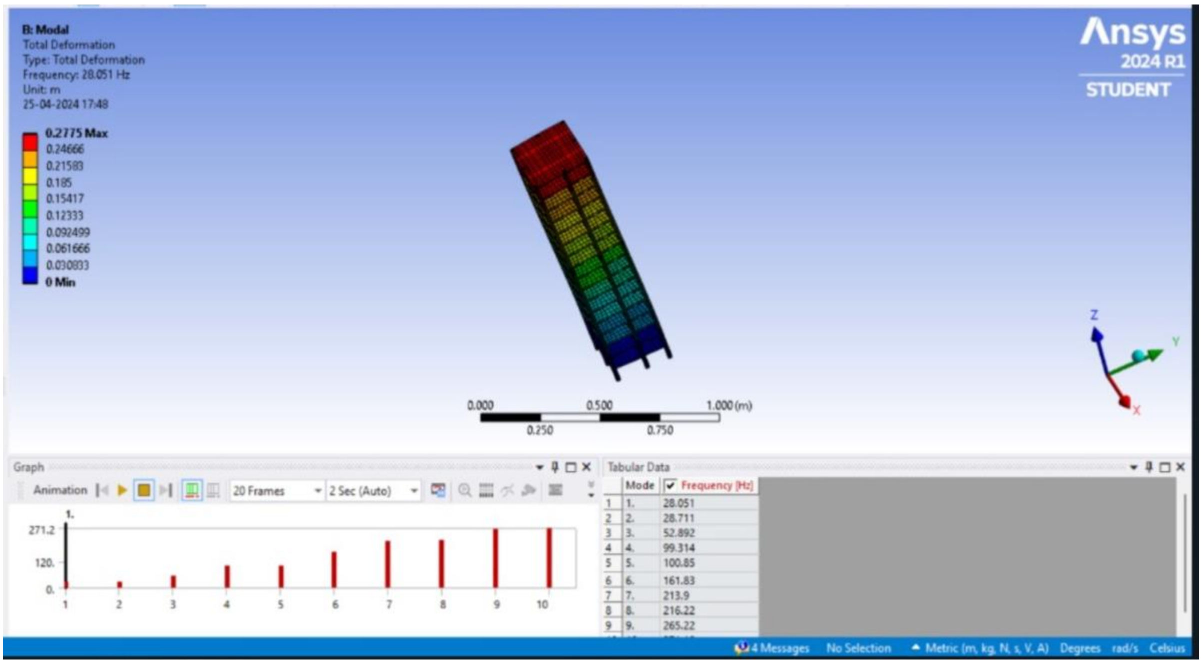


FIG 6.4.1

2)

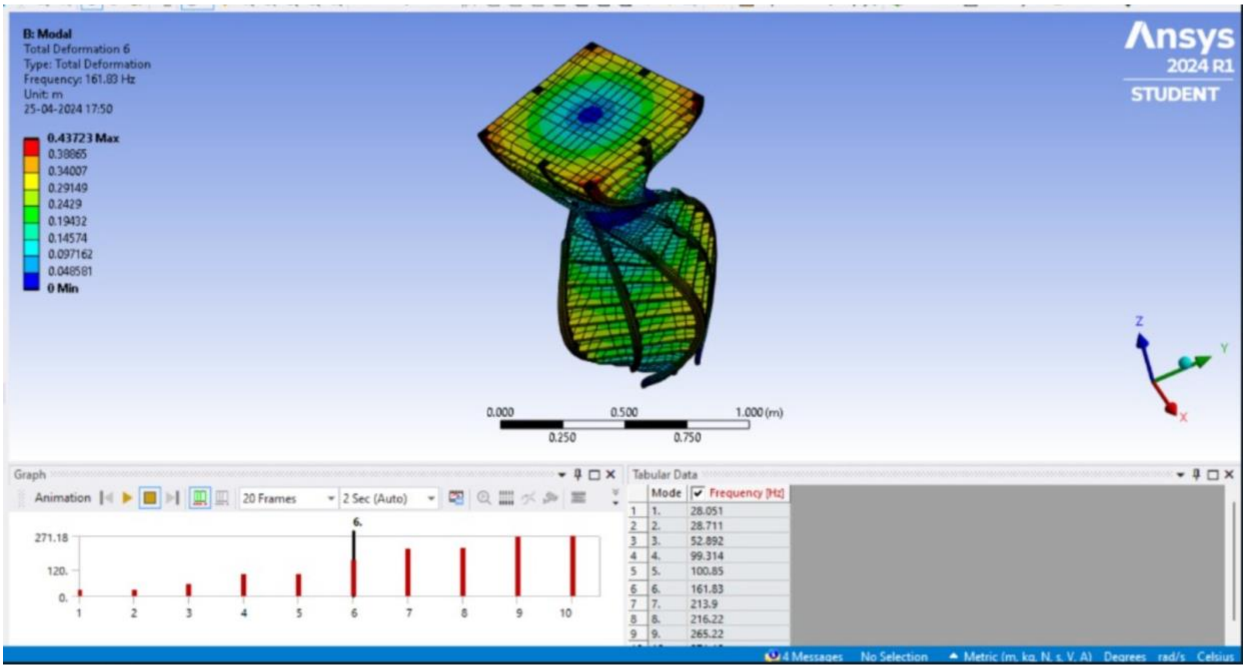


FIG 6.4.2

3)

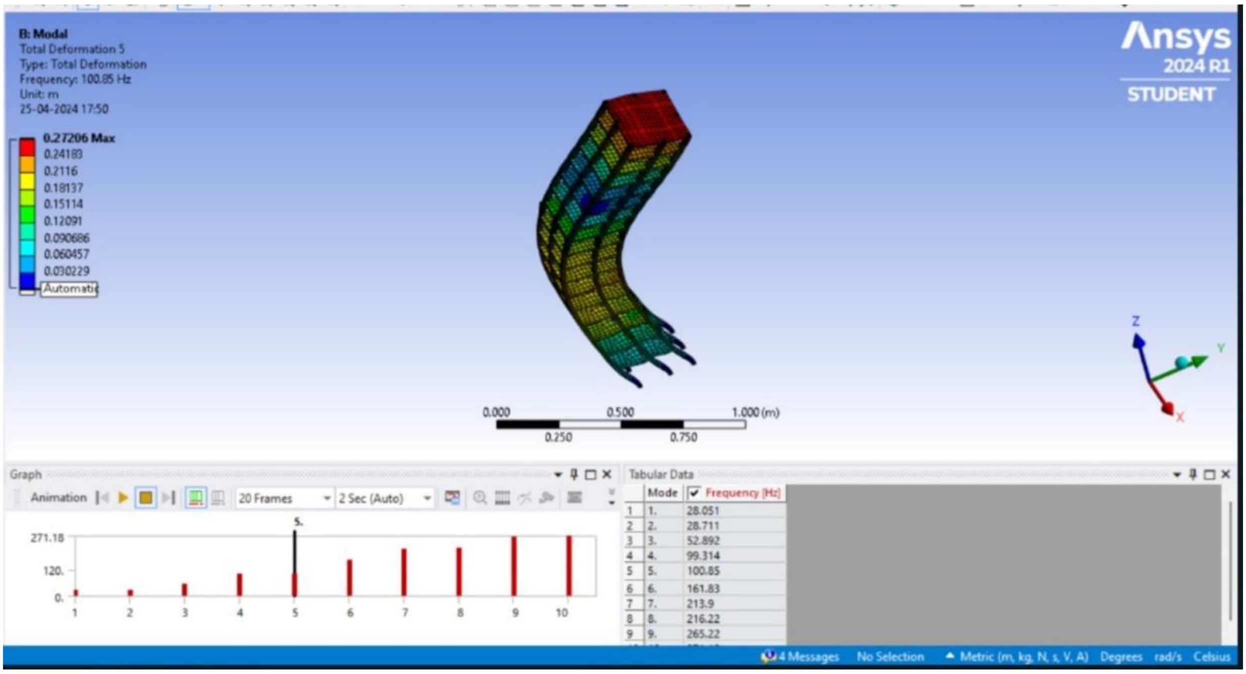


FIG 6.4.3

4)

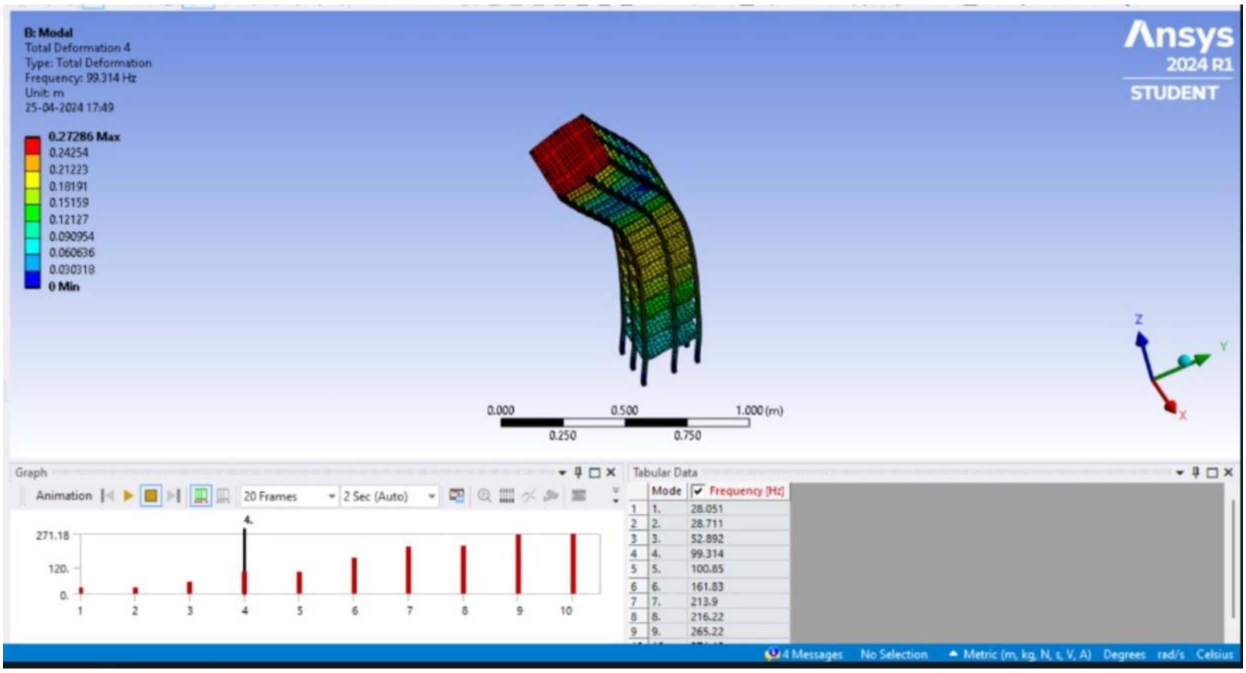


FIG 6.4.4

5)

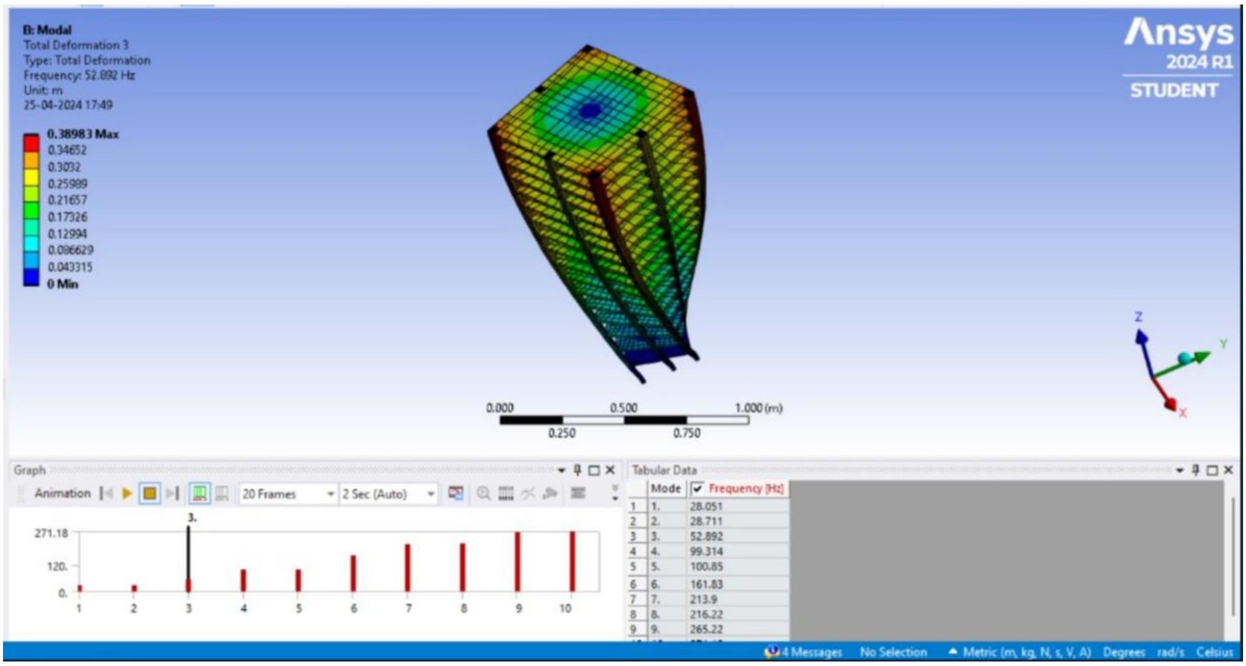


FIG 6.4.5

6)

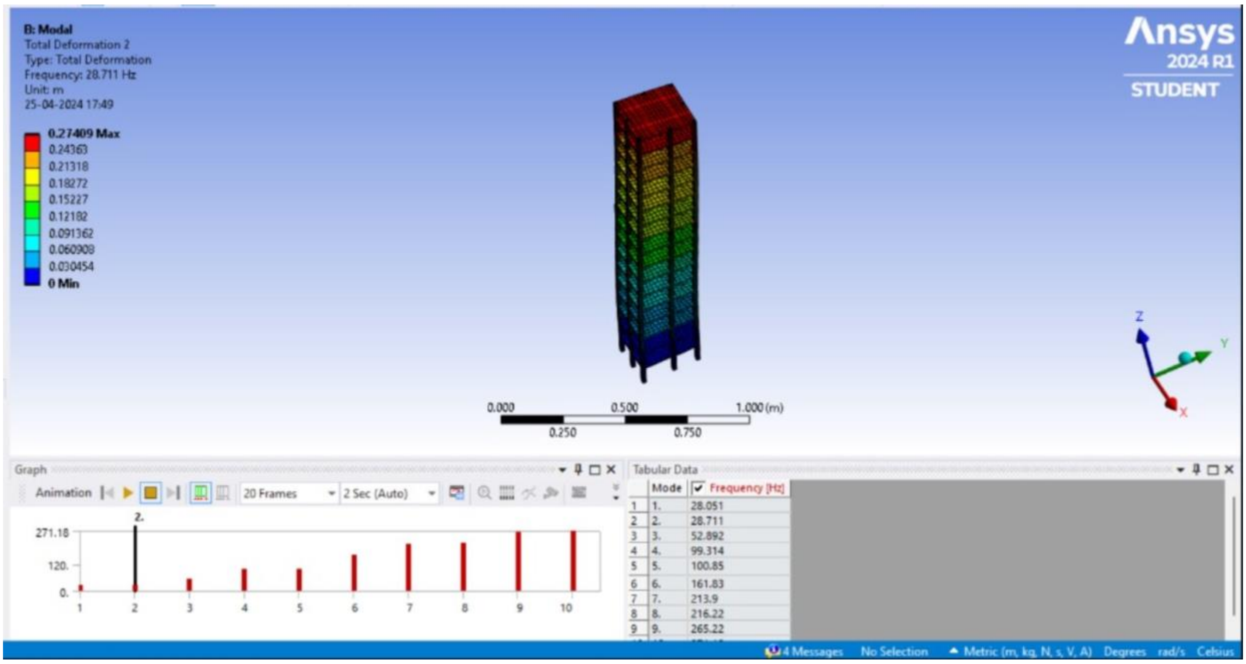


FIG 6.4.6

WITHOUT CORE WALL:

1)

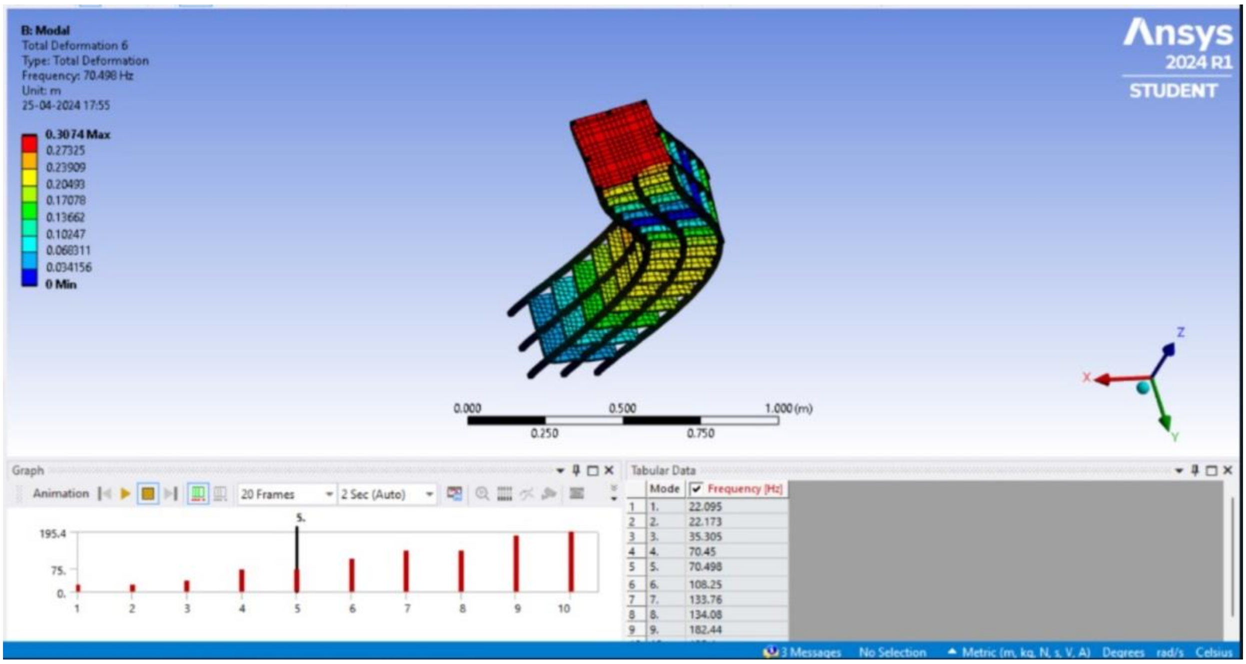


FIG 6.5.1

2)

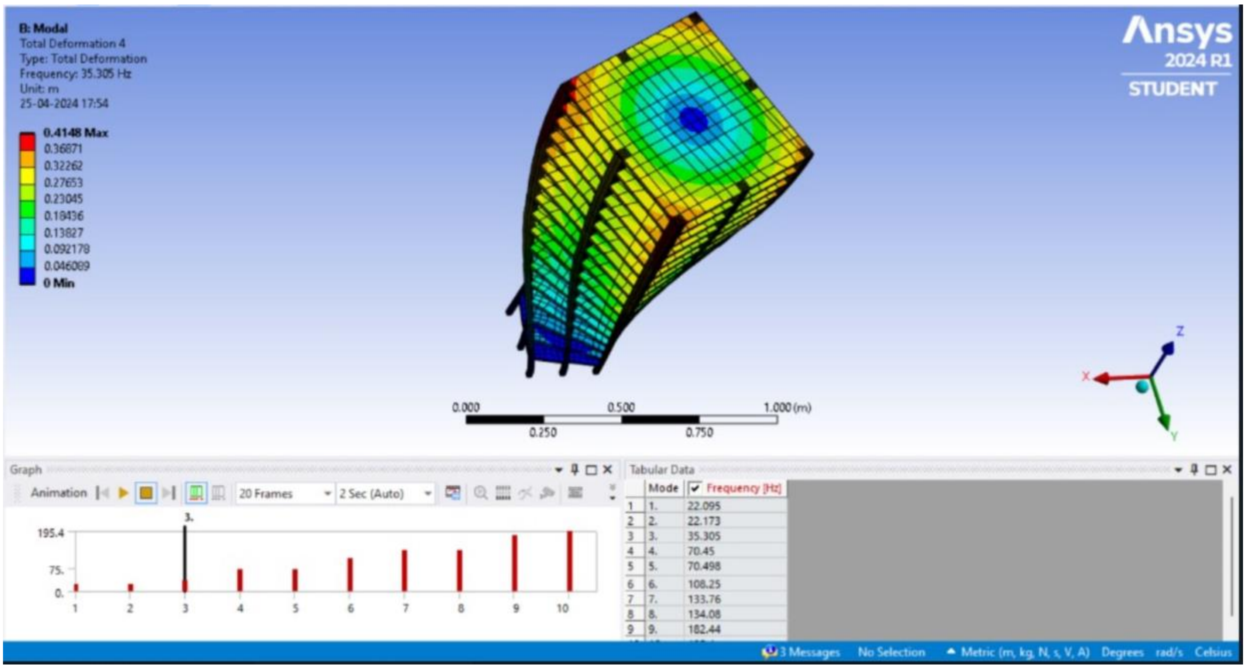


FIG 6.5.2

3)

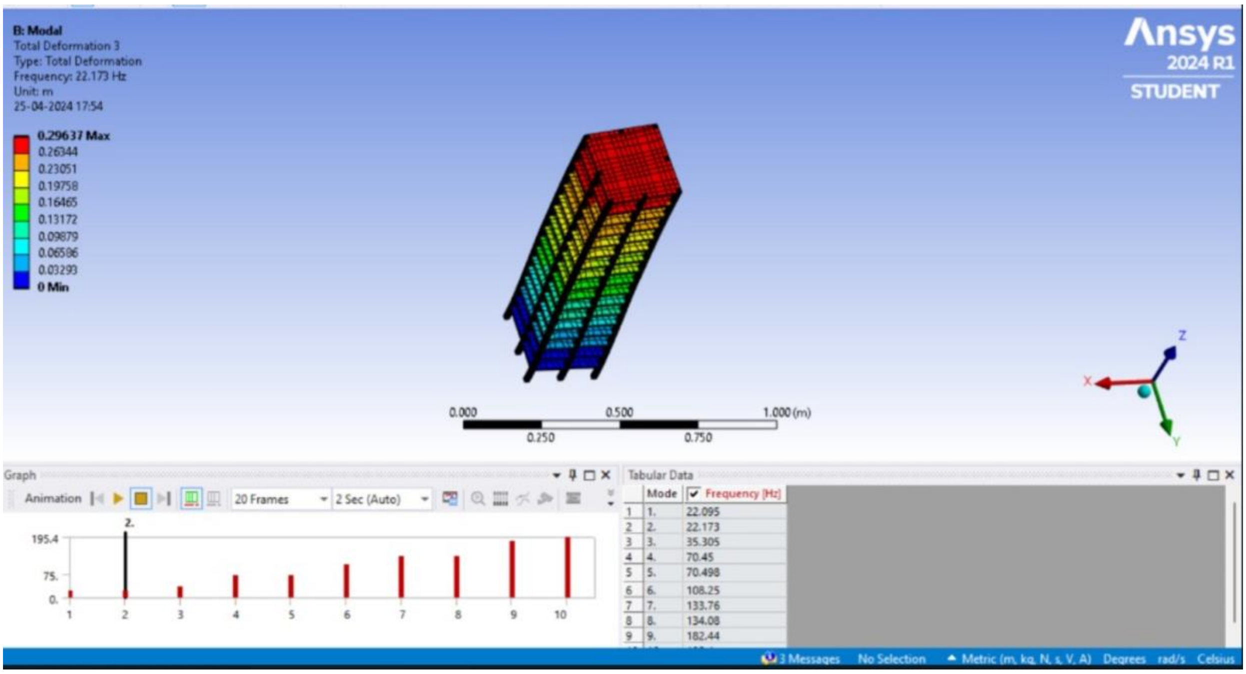


FIG 6.5.3

4)

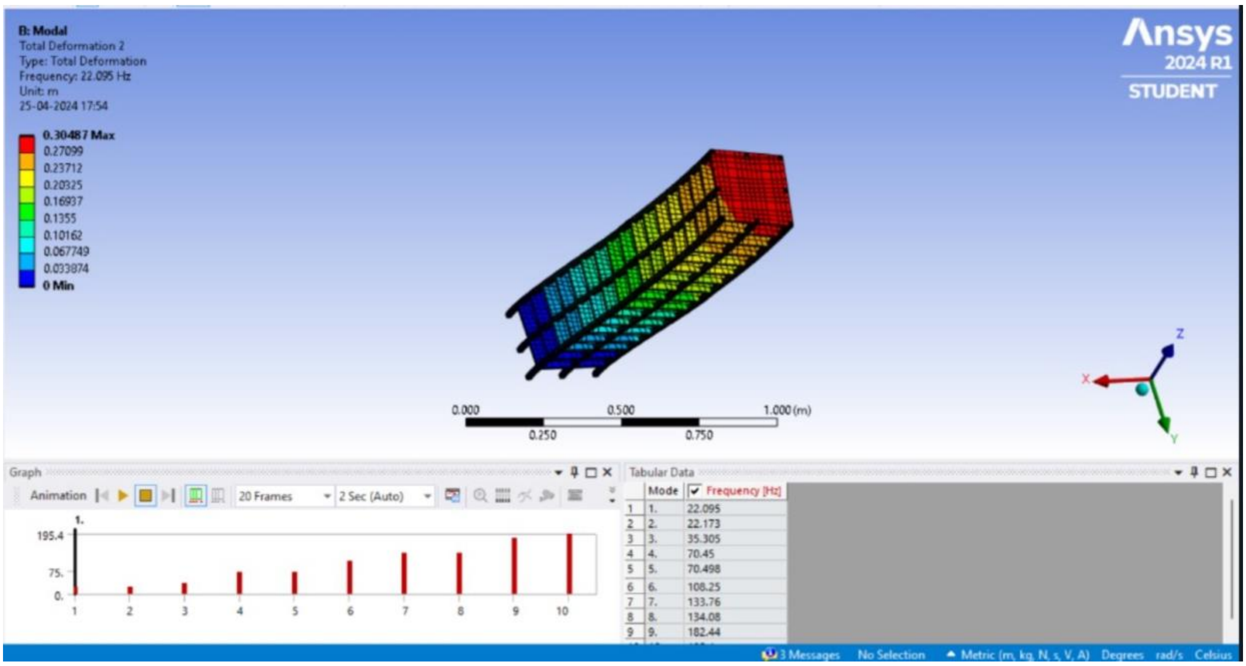


FIG 6.5.4

5)

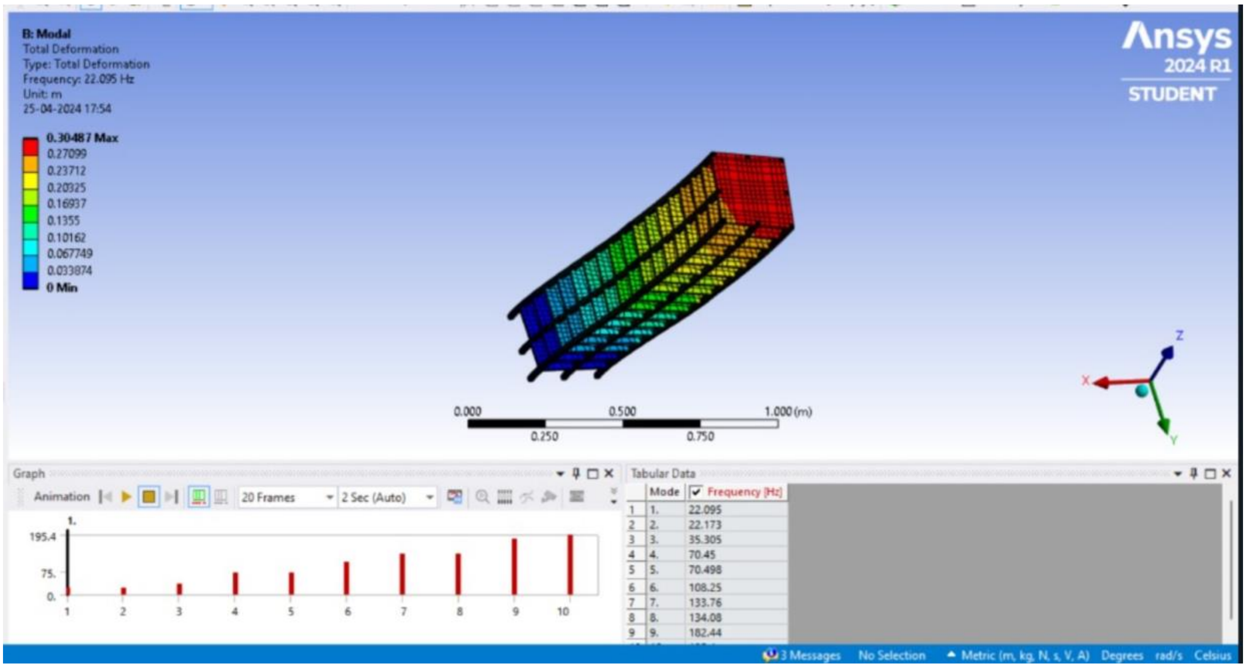


FIG 6.5.5

6)

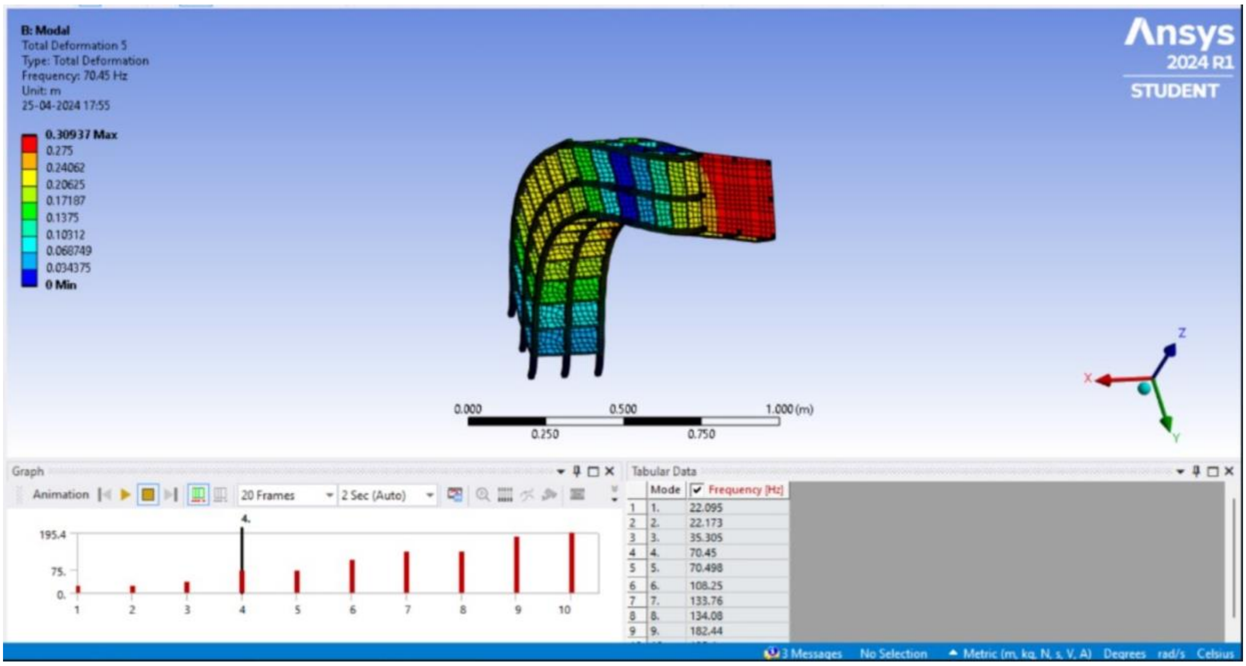
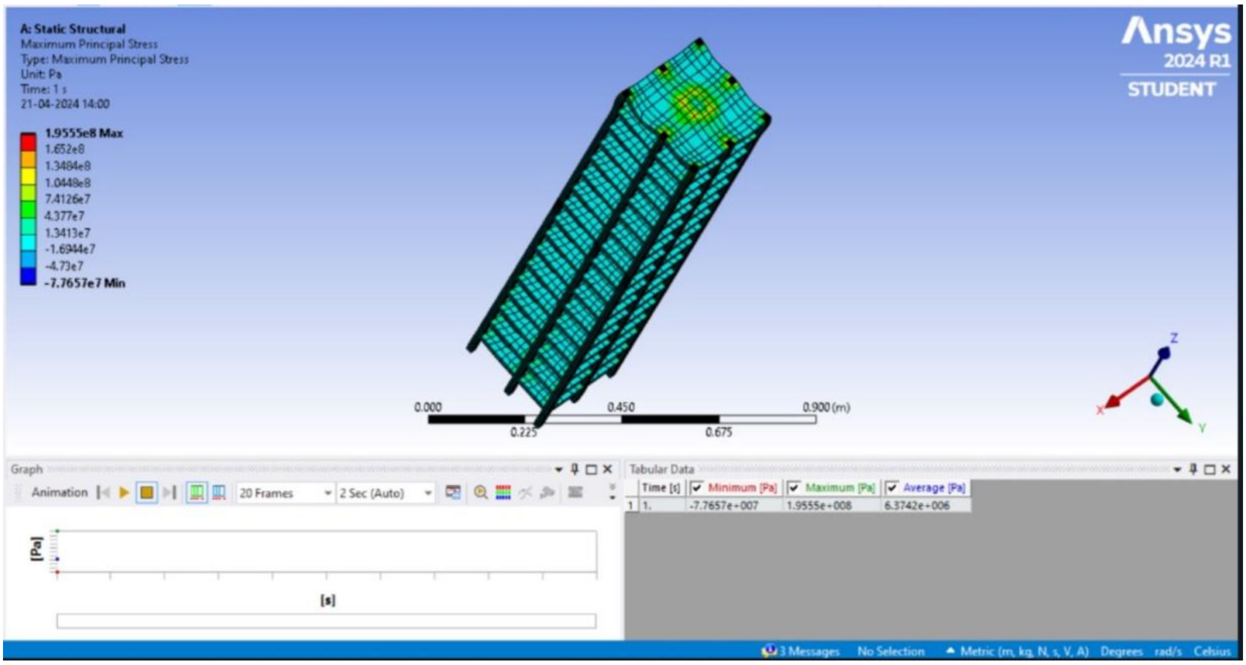


FIG 6.5.6

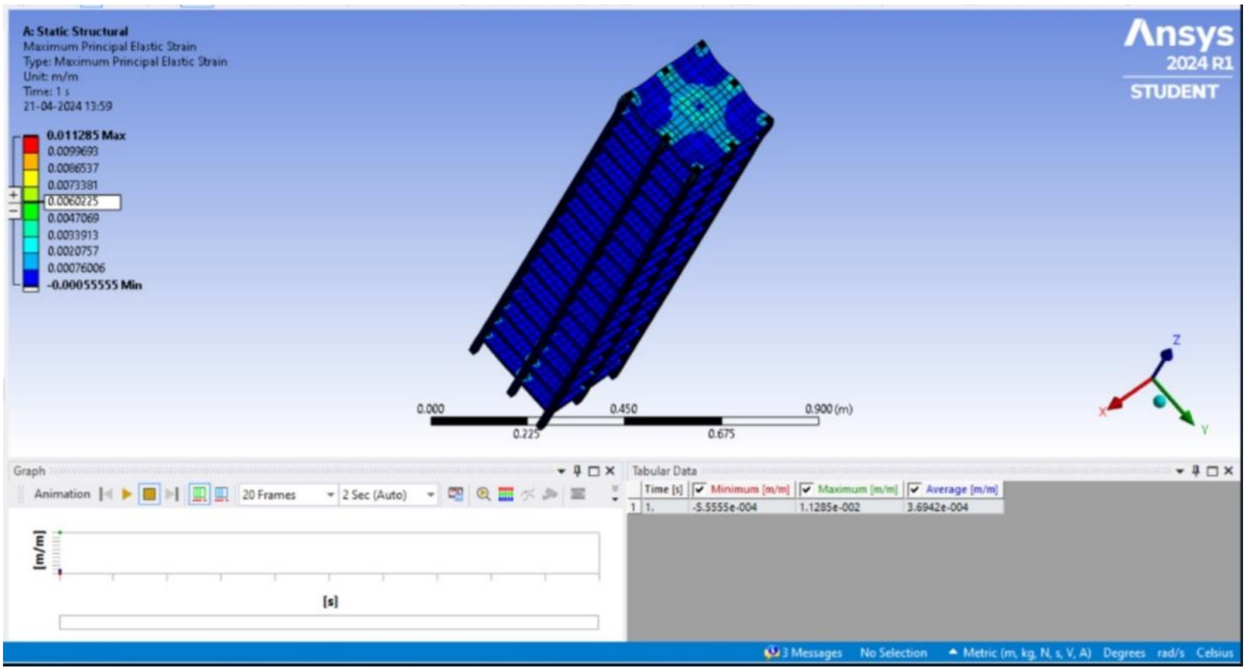
CHAPTER -7

RESULTS

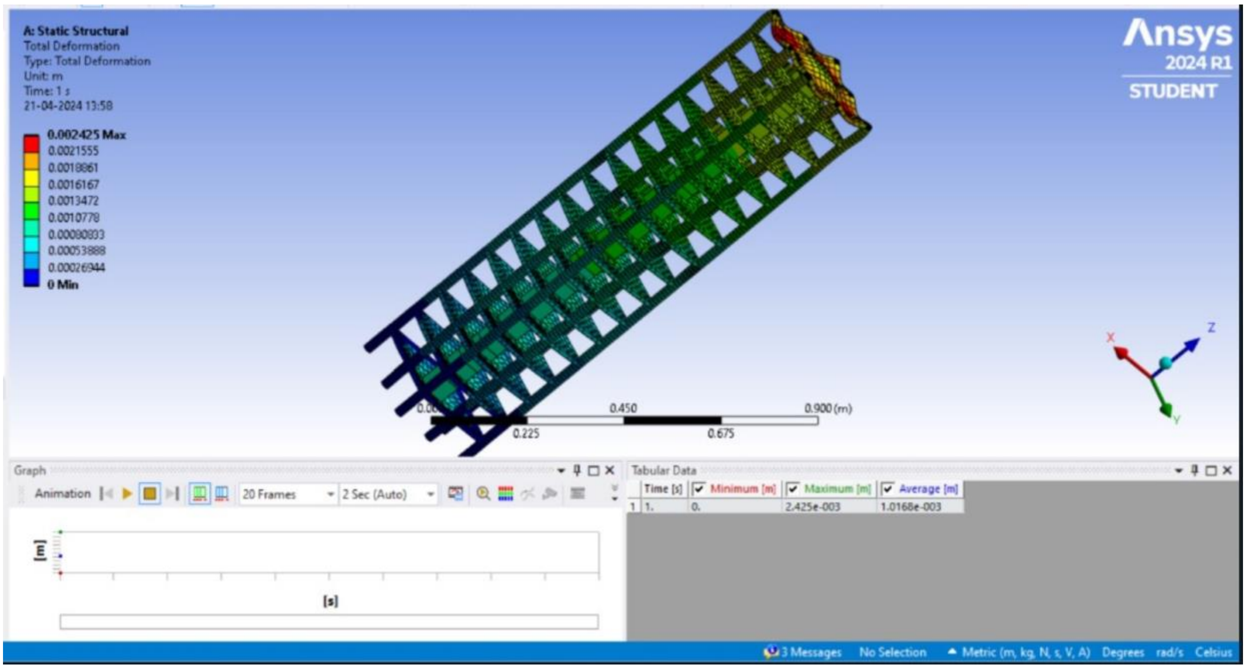
STRESS:



STRAIN:



DEFORMATION:



CHAPTER -8

CONCLUSIONS

Our exploration of response spectrum analysis has unveiled its power in deciphering a structure's behavior under dynamic loads. By analyzing the peak responses of buildings with and without core walls, we gained valuable insights into critical frequencies and potential damage scenarios. A single-point spectrum focuses on the response at a specific location, while a multiple-point spectrum provides a more comprehensive understanding by considering the response at multiple critical locations throughout the structure.

6.1 EFFECT OF PRESENCE OF CORE WALL

6.1.1 Enhanced Seismic Performance with Core Walls:

The buildings equipped with core walls demonstrated superior seismic performance compared to those without. Core walls effectively mitigated the lateral displacement and inter-stored drift, reducing the risk of structural damage during seismic events.

6.1.2 Stability and Stiffness Improvement:

The presence of core walls significantly improved the stability and stiffness of the buildings, resulting in reduced structural deformations under seismic loading. This enhancement is crucial for maintaining structural integrity and occupant safety during earthquakes.

6.2 SINGLE VS MULTI POINT SPECTRUM

6.2.1 Single-Point Spectrum Analysis:

Single-point spectra provide valuable information on the maximum response of the structure at a specific period, aiding in identifying critical modes of vibration. Analysis based on single-point spectra highlights the importance of core walls in modifying the dynamic characteristics of buildings and reducing their susceptibility to seismic forces.

6.2.2 Multi-Point Spectrum Analysis:

Multi-point spectra offer a more comprehensive assessment of structural response by considering a range of periods and corresponding spectral accelerations. This analysis facilitates a detailed examination of the building's behavior across different frequency ranges, enabling a more nuanced understanding of seismic performance.

CHAPTER -9

SCOPE FOR FUTURE WORK

7.1 Performance-Based Design Approaches

Incorporating performance-based design approaches can enable engineers to tailor structural designs to meet specific performance objectives, such as limiting structural damage or ensuring immediate occupancy following earthquakes.

7.2 Integration of Other Structural Systems

Delving deeper into the concept of seismic resilience, a particularly intriguing avenue lies in exploring the integration of core walls with other structural systems. Hybrid structural configurations, achieved by combining core walls with braced frames or moment-resisting frames, offer a strategic approach. This method not only enhances a structure's ability to withstand seismic events, but also presents opportunities for optimization. By strategically integrating these systems, engineers can potentially achieve a balance between construction costs and material usage, leading to more efficient and cost-effective designs."

7.3 Soil-Structure Interaction Modelling

Future research can focus on developing advanced numerical models to simulate soil-structure interaction more accurately. Incorporating sophisticated soil models and considering non-linear soil behavior can provide deeper insights into the seismic response of buildings under different soil conditions.

7.4 Dynamic Soil-Structure Interaction Studies

Conducting dynamic soil-structure interaction studies using time-domain analysis techniques, such as finite element analysis or boundary element method, can enhance understanding of the dynamic interaction between buildings and underlying soil layers.

CHAPTER -9

REFERENCES

1) Cosmos Virtual Data Center https://www.strongmotioncenter.org/vdc/scripts/default.plx

2) NPTEL Lectures https://youtu.be/x8CtDnVQb5c?si=-PViFBH3ZySYeSwa